REPORT ITU-R SM.2130

Inspection of radio stations

(2008)

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1 Introduction

This Report presents an overview of Inspections Procedures in response to Question ITU-R 225/1 regarding inspection techniques and procedures. The Question relates to how administrations proceed in planning and conducting radio station inspections. The purpose of this Report is to provide general guidelines for planning and performing inspection activities on various types of radio stations. Inspection activities often include review and verification of both technical and administrative conditions assigned to a radio station or other spectrum user. Although the term "licensed" is used throughout the document, this term can be considered here to include not only stations with licences issued by the regulatory authority, but also other authorized spectrum users (such as those operating with "licence exempt" devices like low-power radios and RF devices operating under equipment standards approval). The primary focus of this report is to consider inspections that are conducted *"on-site"*, by visiting the transmitter location. Included in Annexes are some specific examples in certain services, to provide examples of how the general guidelines can be applied. This Report should be considered a general guidance document for inspections planning.

1.1 Role and organization of inspection activities

The value of radio spectrum has become increasingly important to the economic and social development of many countries. Control of the radio spectrum by telecommunication regulatory authorities has become even more important, as national administrations seek to maximize the efficient use of spectrum, control interference, and promote new technologies without adversely affecting existing ones.

A few administrations for various reasons do not conduct radio inspections. In the long term, however, the absence of an inspection programme can lead to several negative consequences. Without inspections, the completeness and reliability of a national frequency assignment register cannot be guaranteed, since one purpose of the inspection is to verify that the radio station is actually installed and operating in accordance with its assigned parameters. Valuable reference data for subsequent spectrum monitoring (such as reference field-strength values) often cannot be easily obtained. These two factors considerably decrease the effectiveness of automated spectrum management systems in detecting infringements and unauthorized use. From an administrative point of view absence of inspections provides a corrupting influence on spectrum users because they may come to believe that they can ignore compliance with their licensed parameters since the risk of detection is lower without on-site inspections. In this respect even limited inspections can considerably increase spectrum users' responsibility.

The technical and administrative radio regulations of an administration help ensure that radio services can operate on a non-interference basis. Spectrum users who operate outside their authorized parameters can generate interference to other users by various methods (such as co-channel and adjacent channel interference, harmonics and other spurious emissions). Regulatory authorities typically use various methods to help ensure that the spectrum is used properly and efficiently. These methods include spectrum monitoring/measurements made at a distance, radio station on-site inspections/measurements, and enactment of compliance specifications for certain equipment (both radio and non-radio equipment which generates RF spectral energy). Some combination of these methods, followed by the application of enforcement sanctions (formal notice of violations) to problems discovered, have been used successfully by administrations to help control the efficient use of spectrum.

Depending on the administration, all these functions may be:

– all in one unit of the regulatory authority/organization (such as a field enforcement force who conducts monitoring, conducts inspections, and issues enforcement sanctions), and

– in different parts of the same regulatory authority/organization (with a separate monitoring unit, an inspections unit and a sanctions unit), or sometimes in different organizations (for example, broadcast inspections may be carried out by a totally different authority/ organization than inspections and monitoring for other services).

How this is organized within an administration is often determined by national regulations, the number of licence holders or other authorized spectrum users, the number of private versus government-operated stations and for other reasons. In addition, inspection activities should be supported by relevant legislative acts and officially approved regulations that provide detailed implementation of the legislative acts. The regulations should include coverage of the organization, technology, and procedures of inspections, the rights and obligations of inspectors and spectrum users, and provisions for resolving disputes between inspection authorities and spectrum users, etc. Obligations of spectrum users should include provisions to ensure free access to radio installations by inspectors and measures to prevent any obstacles to their work. These provisions are usually part of national regulations. The credentials an inspector carries to identify himself as authorized to conduct inspections on behalf of the regulatory authority are usually based on these regulations.

The inspection function, at least during the initial stage of its implementation can be effectively combined with the "over-the-air" (distance) monitoring function based on the uniformity of the monitoring and measurement equipment and other facilities used for both the monitoring and on-site inspection tasks. While some efficiency can be achieved if all of these functions are in the same unit or sub-unit, the most important factor is that the different parts of the organization responsible for each area communicate and coordinate with each other on identifying, prioritizing, conducting and reporting the work.

The remainder of this Report focuses primarily on the planning details and conduct of radio spectrum user inspections conducted on-site.

1.2 Organization of the Report

The Report is organized into the following sections:

Section 2 – Questions addressed in the Report identifies four main points which are the basis for inspections planning, and discusses the factors that influence each area. The goal of § 2 is to provide a general outline of the factors that need to be considered in an inspections plan. Where appropriate material was contributed, brief examples are included in the main body of § 2, with the intention that the main document could be used by some administrations that have minimal requirements due to the number of licences they administer. Additional, more detailed, material which may be appropriate for larger administrations is discussed here, but the detailed contributions have been placed in an annex for further reference.

Section 3 – Detailed procedures and information for the optimization and rationalization of inspections activities discusses the use of a formal structure for inspection activities management, a statistical method for inspection activity planning, and criteria for spectrum monitoring versus on-site inspections. The body of the document contains an overview, with details provided in the annex.

Section 4 – Conclusions provides some general conclusions.

Section 5 – Specific inspection procedure examples provides short descriptions of specific inspection procedures used by some administrations, and where they can be found in the annexes.

The remainder of this Report will:

– discuss the four parts of the ITU Question, summarizing the items recommended for inclusion in an inspection programme, and outlining the factors related to these items which are taken into account in planning;

– present overviews of a formal inspections activities planning structure, statistical methods for sample selection, and various measurement procedures that can be used either "over-the-air" or on-site to streamline inspections planning; and
– provide some examples of inspection procedures used for specific services by some administrations.

2 Questions addressed in the Report

The following questions are addressed in this section (see Question ITU-R 225/1):

– What *inspection techniques* are used by administrations to determine compliance by the users of the spectrum with national or international requirements?
– What *equipment complement* would be required to perform technical measurements at an inspection?
– What *technical parameters* are measured when an administration inspects a radio system?
– What station *records* are *reviewed* when inspecting a radio station?

These four points are discussed below.

2.1 Inspection techniques

The *inspection techniques* used by administrations can generally be defined as the decision factors, planning steps and implementation methods used by administrations to plan and conduct station inspections. Several decisions must be made about inspections, including – what radio services need to be inspected, how many to inspect, how frequently they need to be inspected, and what level of detail to collect at each inspection. Some of these factors may be defined in national regulations. Several factors are generally considered, including:

– national and international regulations or other requirements;
– work priorities set by administration;
– past compliance history;
– interference complaints/interference potential;
– density, location and number of stations;
– class of station (e.g. private mobile, broadcast service);
– newly licensed stations as compared to existing stations (those which had licence renewed);
– station licence terms.

There are a range of techniques used by administrations in organizing their inspections plans, ranging from inspecting all stations to inspecting a few or none. The techniques could be grouped into five groups: "all stations" inspections, triggered inspections, sampling, "limited" inspections, or "risk-based" inspections.

All stations inspected – Some administrations set as a goal (or have as a requirement in regulations or policies) the inspection of all stations in selected or sometimes all services. This requirement is often further limited in the following ways: inspecting only "newly licensed" stations (prior to starting operations), inspecting all stations annually, or inspecting stations at least once during their licence term (which could be more than one year). One administration reported that they inspect all new business/private land mobile stations for compliance with national regulations and also to ensure that the radio equipment meets national approvals.

Triggered inspections – Triggered inspections are initiated by specific impetus such as interference complaints, non-compliant parameters discovered by spectrum monitoring or any other indications of possible infringements. Furthermore, inspections may be triggered by special events (for example major sport events) or by the need to determine the compliance level of one particular item (for example, tower coordinate accuracy). This would also serve requests from other departments of the regulatory authority that have an interest in this item.

Sampling – Inspection selection by sampling is based on statistical measures. In its simplest form, by inspecting a small sample of all stations, the overall compliance can be inferred by the compliance rate in the sample. Some administrations use statistical methods and risk analysis to estimate overall compliance rates, with the results being used to plan future inspection levels. For example, a high rate of compliance might result in fewer inspections (lower sampling) in that radio service in the next year. A further discussion of sampling criteria for inspections planning is found in § 3 – Detailed procedures.

Limited inspections – Limited inspections may check only a specific item which is of interest to the regulatory authority, e.g. a certain station administrative record, or the transmitter output power. Also, some administrations restrict their inspection programme and the verification of station licence parameters to spectrum monitoring activities. Although no visit to the station is made, several key technical parameters, e.g. frequency, bandwidth, frequency deviation and e.i.r.p., can be measured by just monitoring the emissions. Some parameters like the e.i.r.p. may possibly be measured even more accurately from an appropriate distance. Non-compliance of monitored parameters could then be a trigger for conducting a more detailed on-site inspection.

Risk based inspections – Some licences can be considered “high risk”. These licences are related to radio stations having a greater potential to create interference than others. Such “high-risk” licences could include those at sites with a high concentration of RF transmitters, licences on frequencies adjacent to safety services or licences in spectrum with both high and low-power level transmitters. Administrations may put a greater emphasis on inspecting stations with a “high risk licence”. Based on similar considerations administrations may concentrate their inspections to sites with are heavily used for radiocommunication purposes, so called “high risk sites”.

In addition to these general planning steps, the inspection process includes several factors which are considered in implementation of the plans, including:

– equipment availability, readiness and calibration status;
– equipment manuals and measurement procedure guides;
– inspection forms and inspection guidance documents;
– travel requirements;
– pre-inspection records checks (e.g. licence record, location, compliance record);
– agreements on cooperation with other governmental bodies (police, etc.), if necessary.

A brief example of an inspection programme structure, plan and decision priority is shown below, to illustrate a way that many of the factors above may be applied:

Administrative guidelines for inspections planning

– Inspect at least 15% of the radio base stations of the mobile personal services (SMP), trucking and paging.
– Inspect at least 15% of the transceivers used by the public switched telephone networks (PSTN) and SMP.
– Inspect at least 15% of the fixed and mobile stations of the radio taxi services.
– Inspect 100% of the scientific research services.
– Inspect at least 15% of the satellite earth stations.

– Inspect 100% of the authorized stations used for fixed and mobile services whose licences are expired or will expire in the current year.
– Inspect at least 20% of the technical parameters of fixed and mobile stations.
– Accomplish, in a maximum of 30 days before licensing, the inspection of new or modified stations.
– Inspect, or check for continuing operation, at least 15% of all stations whose licences have expired/been removed from the national database system.
– Terminate operations of, in a maximum of 45 days, providers operating without licences.
– Inspect, quarterly, at least 4 companies that manufacture, distribute or trade telecommunication products subjected to compulsory certification.

In this example, one can see some elements of the above categories are taken into account, and how some of the factors can be based on an administration's regulations, government policies and results of past inspections. Typically, the guidelines would be evaluated and adjusted yearly, based on the results of the previous year's inspections programmes.

Also in the above example, we can see that the sample sizes are different for different categories of stations. This may be due to several factors, including the number of stations authorized in the service, past compliance history, or administration goals or policies in the specific radio service class. A detailed example for a procedure for determining the sample size and sample selection for inspections planning can be found in § 3 – Detailed procedures.

2.2 Equipment complement

The following items comprise a recommended list of equipment that is commonly used during a radio station inspection:

Primary equipment:

– Frequency meter
– Power meter/directional couplers
– Spectrum analyser/measurement receiver
– Antennas.

Key parameters of operating frequency, transmitter power and RF spectral properties can be evaluated with these instruments.

Additional equipment:

– Radiocommunications analyser
– Field-strength meter
– Power flux-density meter with isotropic E and H field sensor
– Modulation analyser (TV, digital or other types)
– Rangefinder/telemeter
– Distance measuring tapes
– Compass
– GPS
– Antenna supports/tripods
– Power resistive load
– Cables, connectors, accessories.

Some of these items are used in confirming tower heights/locations, antenna orientation, and measuring special parameters unique to a particular communications service (for example, a GPS, or a TV or digital modulation analyser).

Administrations have noted that additional special measuring equipment may be necessary for some inspections, depending on the emission types, assigned frequencies, introduction of new communications technologies and inspection tasks. For example, a recent model of radiocommunications analyser with advanced digital modulation features may be necessary in some inspections in order to properly detect and measure digital carriers using new modulation/spectrum access techniques, if that type of measurement is a requirement of the administration. Also, some existing measurement equipment may not be suitable for use at newly authorized frequencies, requiring the replacement or augmentation of existing equipment. Going further, new developments in telecommunication technology will require regular review of measurement capability against station licence parameters and inspection requirements.

An important factor to be considered in using any instrumentation is the calibration accuracy and measurement uncertainty of the equipment. Equipment manufacturer guidelines should be consulted in determining calibration requirements. General measurement practices include applying tolerances to inspections measurements based on the measurement uncertainty/repeatability of the measuring instrument. A recommended practice in inspection planning is to assemble the equipment to be used (along with its operating manuals and measurement procedure guides), and verify proper operation in advance of the inspection work.

Equipment control software can be used as a “measurement assistant” to capture standardized, repeatable measurements at inspections. The “measurement assistant” can be a useful tool for ensuring that all considerations about measurement tolerances will be taken in account. The software, running in a notebook or handheld computer, helps the inspection agent during the measurement process. Using an interface, like GPIB, RS-232 or USB, the measurement assistant can communicate with the measurement equipment and gather all data needed, and then automatically compare the results with the licensed data and prepare a report.

2.3 Technical parameters

Generally, any item specified on a station’s licence or operating conditions may be an item to be measured or verified during an inspection. The operating parameters of a station are important in controlling interference, allowing multiple stations to coexist on the same frequencies and/or in the same geographic areas, and are useful in ensuring the efficient use of the spectrum. Specified parameters are important in determining a station’s coverage area and the amount of spectrum occupied. The following list comprises technical parameters that may be checked during inspections.

– Frequency (offset and stability)
– Transmitter output power
– Geographical coordinates
– Harmonics, intermodulation products and spurious emissions
– Electric, magnetic and electromagnetic field strength
– Bandwidth
– Height, and azimuth of the antenna
– Antenna pattern
– Modulation parameters

– Noise level at site
– Power flux-density.

The specific items to be checked will vary by type of station/radio service, radio regulations of the country and regulatory administration policies. Other factors affecting what is checked could be: problems discovered previously, items judged to have interference potential, or items related to actual interference reported. Indirect factors could be the regulatory administration's staffing/workload issues or availability of equipment. Administrations planning inspection work will typically focus the items to be checked based on these factors.

Table 1 summarizes the equipment complement and parameters measured as discussed in § 2.2 and 2.3 above.

TABLE 1

Summary of equipment and parameters measured

Equipment	Measured parameter
Spectrum analyser/measurement receiver, antenna	Frequency, bandwidth, field strength, harmonics, intermodulation products and spurious emissions
Signal analyser, antenna	Frequency, bandwidth, power, harmonics, intermodulation products and spurious emissions, modulation parameters
Frequency meter, antenna	Frequency and frequency offset
Power meter, directional coupler, resistive load	Transmitter output power (direct and reflected)
Field-strength meter with calibrated antenna/cable	Field strength
Power flux-density meter	Electric, magnetic and electromagnetic field strength
Modulation analyser	Modulation parameters of specific types of signals and presence of additional signals
Distance or range meter	Distances, including antenna height
Measuring tapes	
Compass	Antenna azimuth
GPS	Site location

2.4 Records reviewed

The station licence and conditions of operation are some of the main administrative records reviewed when stations are inspected. These texts need to be studied before the inspections are carried out because the required measurement equipment depends on the technical parameters. Some technical parameters cannot be derived from the licence documentation, e.g. the type of connectors used on a high-power transmitter, and therefore need to be determined by additional investigations. An important goal of the inspection is to confirm that the station is operating in accordance with the parameters assigned by the administration for the use of the frequency spectrum. Measured or observed parameters are compared to the licensed parameters to determine if the station is in compliance. Other records reviewed include: certifications/approval status of installed equipment, records related to daily operations (such as transmitter operating logs and programming logs), and other special records that may be required for certain types of stations.

Inspection results are typically captured on an appropriate form or checklist designed to collect the information of importance as determined by the administration. Typically this will include verification of the licence parameters discussed previously, notations regarding any non-compliance or deviations from licensed parameters, transmitter site description (with photos if necessary), personnel present during inspection, equipment used, and inspector's comments with a description of further action that is needed. Out-of-compliance conditions are brought to the station's attention for correction, as well as being recorded on the inspection report and elsewhere in the administration's inspections or compliance database. Information from these records (compliance levels or other inspection results) may be used to adjust the inspection plans for the future.

The inspection results are also useful to some administrations for verifying or improving the accuracy of existing licence databases. This can be helpful when the administration's database is missing information, or contains information that is different from what is observed at the inspection, and the database is determined to contain the error.

Finally, as discussed in § 1.1, national administrations may be organized in different ways with different functions in different departments. Depending on the organization of the administration's inspection service, other technical and administrative items (such as electrical safety, radio-frequency radiation hazard conditions, tower safety and other items) may also be checked.

3 Detailed procedures and information for the optimization and rationalization of inspections activities

When an administration commences with inspection activities, especially in the situation of absence of experience, it is helpful to focus inspection resources into several areas which will have the greatest benefit to the administration in terms of efficient spectrum utilization. Some suggested priorities for inspections planning are:

– Inspections of all newly installed stations; these activities can be combined with acceptance tests of installations. Also, by combining inspection data with spectrum monitoring results, initial reference data on relevant emission parameters (field strength, frequency, bandwidth and modulation) can be associated with the station facilities and stored in a database for subsequent comparisons during routine monitoring station operations.
– Inspections of the most powerful transmitters (such as broadcast transmitters), preferably under similar cooperation with monitoring assets to capture field strength and other parameters.
– Inspections of those services where statistics show greater number of violations. Based on the experiences of other administrations, these are typically PMR (private mobile radio) stations. Again, the support of monitoring assets will aid in improving the licence database and establish a reference for future monitoring for compliance.

3.1 A formal structure for inspection activities planning

The benefit of a formal structure for inspection activities management is to have a broad view of all factors that can influence inspection planning and to improve the results of these activities.

The structure can be divided into functional or process areas as follows:

– Reference data
– Documentation management
– Resource management
– Inspection activities management.

Comprehensive reference data is necessary to support the inspection activity planning, consisting of a reliable licence database, a reliable and continuously updated historical database, operational plans and national regulations.

A documentation management system should be installed to guarantee that the inspections procedures, the national handbook, the reports models, the enforcement documents and the calibration equipment certificates, are kept up to date.

The important resources to be considered are personnel, equipment and financial resources. Any on-site inspection is heavily affected by the working force professional skills, including regulatory and technical knowledge about the inspection issues, measurement techniques, ethics and behaviour of the inspecting agent. The selection of the equipment to be used depends on the set of parameters of interest and associated tolerances based on national or international regulations. The equipment must be calibrated to ensure repeatability, reproducibility and reliability. Resource planning is needed to have personnel and equipment available at the required moment.

The inspection activities management includes the quality requirements standardization, the inspection activities planning, the inspection procedures updating, the measurements results recording, and the control and planning adjustment. This also includes travel management.

This formal structure can be adjusted to accommodate other processes or planning factors that may be specific to a particular administration. Annex 1 presents an example of a formal structure for the inspection activities used by the Brazilian Administration. A process model for inspections planning has the benefit of providing a consistent procedure for inspections planning. The process model shows the important factors that should be considered, as well as the relationships between the various factors and how they affect each other.

3.2 Statistical criteria for determination of inspection sample size

The inspection of radio stations is essential for identifying technical problems in radio networks at an early stage and for preventing interference problems from arising. Especially for larger administrations with a large number of stations, the on-site inspection of all stations or a large number of stations is not practical due to budget limitations, staff limitations and other issues. As discussed in § 2, sampling techniques can be used to provide an optimized and traceable strategy for the selection of radio stations/networks to be inspected for compliance.

The premise of sampling is that a subset of the total population (total number of stations in a particular service) is examined for some criteria. The results in the subset, or “sample” are projected onto the total population. The determination of sample size and the selection of the objects to be tested (stations to be inspected) are important to achieving accurate results based on the sample. Annex 2 presents a detailed discussion of a sampling method for inspections planning.

3.3 Decision criteria for inspection methods and spectrum monitoring versus on-site inspections

Some key station parameters such as frequency, frequency deviation, bandwidth and strong power excess and hence the compliance of a station’s parameters with the station licence as well as the operator’s operational discipline can be checked efficiently by using fixed or mobile monitoring stations. Advantages of this method are that several stations may be checked from one location if the signal level is sufficient and that the station operators do not need to be contacted or engaged.

Especially VHF and UHF broadcasting transmitters can be measured effectively from the distance. The measured field strength or receiver input voltage can be compared with the results of a planning tool or even better with previous results which are already stored in a database. Any anomalies are disclosed immediately. It should be noted that varying propagation conditions should not be neglected, especially at lower frequencies.

It should be noted that spectrum monitoring results cannot always be regarded as legally valid. Instead they may have to be verified by supplementary on-site inspections.

3.3.1 Accuracy considerations

Some types of stations have complex filter and combining networks which make direct connections of instruments difficult, and measurement results sometimes uncertain. Further, direct connections to the transmitter output do not comprise the antenna pattern and thus usually do not reveal any anomalies with antenna systems. Measuring the maximum frequency deviation or the multiplex power at FM broadcasting stations requires low reflections and sufficient attenuation of other broadcasting signals. For obvious reasons these measurements are carried out by spectrum monitoring without participation of the operator.

There are several different types of inspections to obtain, for example, ERP and other basic transmitter parameters. Table 2 shows the most common ones for ERP measurement estimation. Each method has its own advantage and obtainable accuracy.

TABLE 2

Type	**ERP result**	**Accuracy (2 ρ) 95% confidence**	**Independence**
Monitoring along a route	ERP and antenna diagram	8 dB	Yes
Long-term monitoring	1 or 2 directions	5 dB	Yes
On site inspection	Max ERP only	2 dB	No (extra uncertainty is up to 7 dB)
Helicopter measurement	ERP and antenna diagram	1.4 dB	Yes

It should be noted that in the case of physical inspections an additional uncertainty is added. This could justify another type of inspection than an on-site inspection in this case.

3.4 Integrated software and hardware for improvement and standardization of inspection data collection

One way to improve efficiency and accuracy in inspections data collection is to use a combination of software and hardware to assist the inspection agent in completing the assigned inspection tasks such as capturing measurement data. Annex 3 contains a description of how “measurement assistant” software can be used to gather measurement results and other data at inspections. The use of such software can have the benefit of: standardizing measurement procedures, allowing the accurate application of uncertainty factors, and making inspection data collection and reporting more efficient.

4 Conclusion

This Report provides information to be considered by administrations in planning radio station inspections. It should be recognized that it is not possible to develop a detailed, specifically-defined inspections plan that is suitable for all administrations, over all radio services and in all circumstances. Rather, it is the goal of this Report to present general guidelines for planning, examples for specific cases, and a procedure for inspections planning that administrations can use to tailor to their specific requirements.

The information presented thus far contains the core elements for inspections planning. The examples in § 5 contain additional information on procedures used by specific administrations and/or procedures for specific inspection types. Section 5 is intended to be expanded as additional detailed inspections examples and procedures are contributed.

5 Specific inspection procedure examples

This section contains descriptions of general and specific inspection procedures that may be used for inspections programme management or for inspections of certain types of stations. The contributions may be examples of general or specific procedures used by a particular administration, or examples of detailed procedures for a specific inspection type, or both. These examples are intended to provide complete outlines and/or detailed examples for specific cases, and should not be considered to be a comprehensive compilation of all types of inspections. Some of the information described in the examples may be applicable, with or without modification, to inspections in other services.

5.1 Example of a formal structure for the inspection activities used in Brazil

Annex 1 contains an example of a formal structure used in the Federative Republic of Brazil. For more information see also § 3.1.

5.2 Example of a of a sampling method for inspections planning

Annex 2 presents a detailed discussion of a sampling method for inspections planning as also described in § 3.2.

5.3 Use of "measurement assistant" software

Annex 3 contains a description of how "measurement assistant" software can be used to gather measurement results and other data at inspections (see also § 3.4).

5.4 Example of national inspection methods used in Brazil

Annex 4 contains an example of an inspection procedure for AM broadcast stations used in the Federative Republic of Brazil. The on-site inspection procedure covers activities related to technical parameter measurements, licence record reviews, visual checking and other law enforcement requirements. An example of the reporting form used is also included. This example is drawn from Document 1C/43 (4 October 2004).

5.5 Example of national inspection methods used in France

Annex 5 contains three examples of inspection procedures that are used by the French agency (Agence Nationale des Fréquences (ANFR)):

– Radio station inspections for PMR (Private Mobile Radio) stations

– Radio station inspections at “Concentrated RF Sites”
– Radio station inspections for special events.

“Concentrated RF Sites” are generally locations where strong concentrations of RF transmitters are licensed. These are often tall buildings or high hills which are favourable for RF communication antennas. The concentration of transmitters presents special problems of interference between stations (e.g. intermodulation, receiver overload), and some administrations place special emphasis on careful management of the site by its owners or licensees to control interference. Special events present a similar problem, where a high concentration of radio emitter operation is expected in a defined or congested area (such as a sports stadium and surroundings). Please see Annex 5 for examples of these types of inspections. This example was contributed to the Rapporteur Group by France.

5.6 Example of national inspection methods used in New Zealand

Annex 6 contains an overview of inspection, or “audit” procedures that are used by the New Zealand regulator, the Radio Spectrum Management Group (RSM) of the Ministry of Economic Development. The document provides some information on the compliance and enforcement strategy, statistics on the scope of the programme, and a detailed description of the audit procedures.

5.7 Example of national inspection methods used in Brazil

Annex 7 contains an example of an inspection procedure for satellite earth stations used in the Federative Republic of Brazil either for national trunk system earth stations or for very small aperture terminals (VSAT), presenting procedures for measurements of geographic coordinates, height, azimuth, elevation of parabolic antenna, including the frequency and power of HPA.

Annex 1

Structure for inspection activities management as used in Brazil

This annex describes a structure for the inspection activities management. It could be implemented step-by-step from any existing model.

1 The inspection service – functional areas

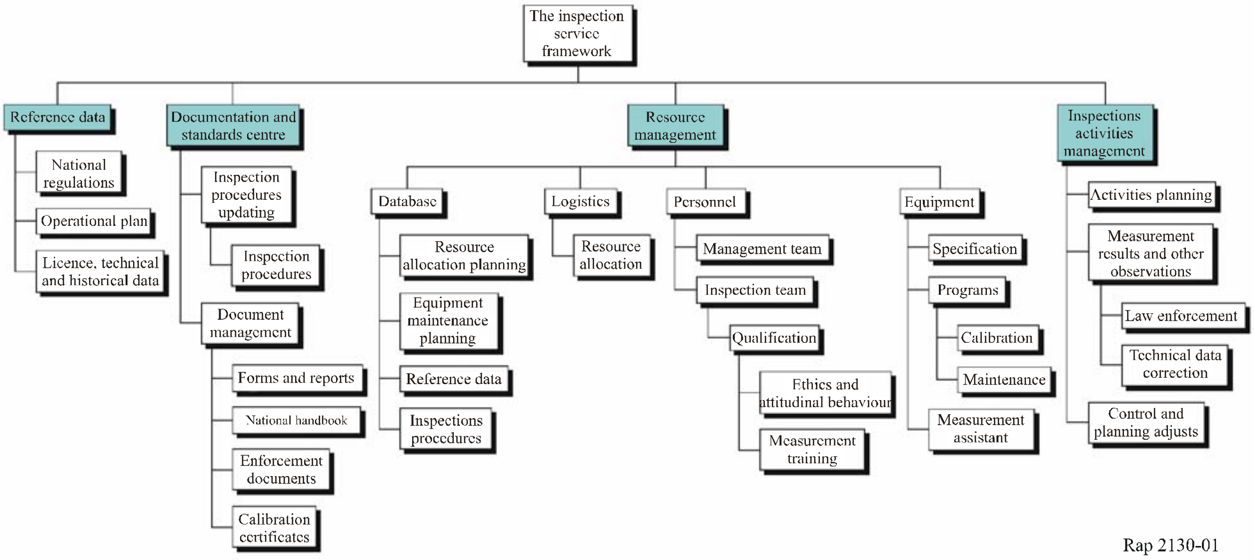
To certify the conformity of a station or service to the licensed parameters, administrations should consider that inspection activities should be performed under the following functional areas:

– Reference data
– Documentation and standards centre
– Resource management
– Inspection activities management.

Figure 1 illustrates the interrelation between the referring four areas, concerning the functional and main process:

FIGURE 1

The management inspection service process



1.1 Reference data

As for the monitoring service, it must be considered consistent reference data in support to the inspection service that comprehend the following requirements:

– A reliable licence database

– A reliable and continuously updated historical database

  – Databases should be fully accessible to all inspection teams. To accomplish such an objective, modern network services are advisable, e.g. web services, intranet remote access.

– Operational plans

  – Administrations may have their own operational plan, determined by means of logistics and strategically elaborated. Such plans must be considered in inspection activity planning.

– National regulations

  – Additionally, the requirements established in the national regulations must also be considered in any inspection activity.

1.2 Documentation and standards centre

There is a need to establish an area responsible for guaranteeing that the inspections procedures, national handbook versions, the reports models maintenance, the enforcement documents conformity regarding the national regulation and calibration equipment certificates, are kept continuously updated.

– **National Inspection Handbook**

Each administration should gather its inspection procedures in an "Inspection Handbook" which comprises all procedures and methodology, which must be continuously updated (inspection activities management).

– **Report models**

Each procedure must have a set of standard documents to be filled in, mainly for registering measurements and effecting comments. Such documents must be kept updated and always available for the inspection teams.

– **Enforcement documents**

Each procedure has a set of standard documents to be filled in. These documents refer to relevant elements of the national legislation that may have been infringed, such as specific parameters of a station which should be checked to identify whether they are in compliance with the national regulations.

– **Calibration certificates**

The results of equipment calibration validation tests should be registered in a calibration test report. This calibration test report must be available to the inspection teams so that values of uncertainties, errors and other parameters of the equipment can correctly be considered in the measurements. When using standardized measurement software such as a measurement assistant, the calibration report for instruments used must be loaded in the software, so it will be able to ensure the precision of measurements results.

1.3 Resource management

The most important resources are considered to be personnel and equipment.

a) Personnel:

Qualification – Any on-site inspection is heavily affected by the workforce's professional skills. These skills include: regulatory and technical knowledge about the inspection issues, measurement techniques, ethics and attitudinal behaviour towards the inspection team.

– A regular qualification plan is fundamental to promote the organization of knowledge development.

b) Equipment:

Specification – The minimum specifications for equipment required to perform the on-site inspection depends on a set of interest parameters and associated tolerances based on national or international regulations.

Calibration and maintenance programmes – All equipment must be appropriately selected and used to ensure repeatability, reproducibility and reliability. A calibration and maintenance annual plan is highly desirable to support the inspection service in order to keep equipment and artefacts performance adherent to the adopted specifications.

– *Calibration validation*. Tests must be carried out by experienced and specially trained members of the proper inspection team in order to validate equipment calibration and to prevent the use of all equipment which had presented any non-conformity. The results must be registered in an appropriate report document (calibration certificates).

– Administrations should also consider implementing at least a minimum structure to perform interim calibration checks (conformity check of test equipment between full calibration cycles), preventive tests (quick functional tests before operations) and pre-maintenance tests (detailed tests before requesting any outside service).

– An intranet-based software application is desirable to manage all data produced on this plan execution, including operational restrictions, calibration expiration dates, maintenance follow-up, segregated equipment, etc. The current operational status and equipment availability is provided by this on-line system, allowing the administration to optimize its logistics and new equipment biddings.

– *Measurement assistant*. In order to speed up the measurement process and guarantee that measurement equipment uncertainties and errors found in the calibration certificate and equipment specifications are properly taken into account, a software program running in a notebook or handheld computer can be used. The software has to be loaded with the station and equipment calibration data prior to the mission start. Using RS-232, GPIB or other available interface, the software will automate the measurement data gathering, make comparisons with the station licence data and indicate each parameter status (Pass or Fail). After the inspector validation the inspection results report form will be automatically completed and available for printing.

c) Logistics:

In conformity with organization guidelines, national telecommunication policies and established priorities for enforcement actions (RFI complaints, non-licensed stations, formal complaints of unlicensed stations, etc.), administrations should develop an operational inspection plan for a specific period (for example, an annual plan). This plan will be a reference for the inspection activities identifying needs of personnel training, resource sharing (personnel and equipment), equipment maintenance and calibration tests or replacement, inspection procedures updating and others.

– An intranet resource-allocation managing tool is desirable for planning, controlling the performance and evaluating the inspection activity results.

1.4 Inspection activity management

Quality requirements – This process reveals over all a great relevance for dealing with the core of the inspection model. Inspection activity quality requirements are affected by the way they are performed. Thus, it is necessary that procedures be standardized for utilization all over the entire country, by as many as possible, and by different teams at the same time.

a) *Inspection activity planning* – Inspection planning should be ordered by an operational plan and its revisions. It must be comprised of availability of written procedures, skilled human resources and calibrated equipment. It should also be supported by means of those tools indicated in the session related to resource management (see § 1.3 c)).

b) *Inspection procedure updating* – The inspection procedure comprises all activities done on-site, such as technical parameter measurement methods, availability of the required documentation and certification, visual observations, emission record and any additional information that might be used to enforce the law. The continuous technological development, the alteration of technical regulations or the use of new equipment implies the need for updating the inspection methods. Each administration should gather its procedures in a national "Inspection Handbook".

c) *Measurement results and other observations* **–** To support inspection, a report should be specifically designed to record the inspection results, according to the used methodology, also including any regulatory infraction and reference to the equipment and personnel.

– *Enforcement* – The report must be accurately filled in because of the importance to legalize this process.

– *Technical data correction* – The report will also subsidize alterations in the technical database (data reference).

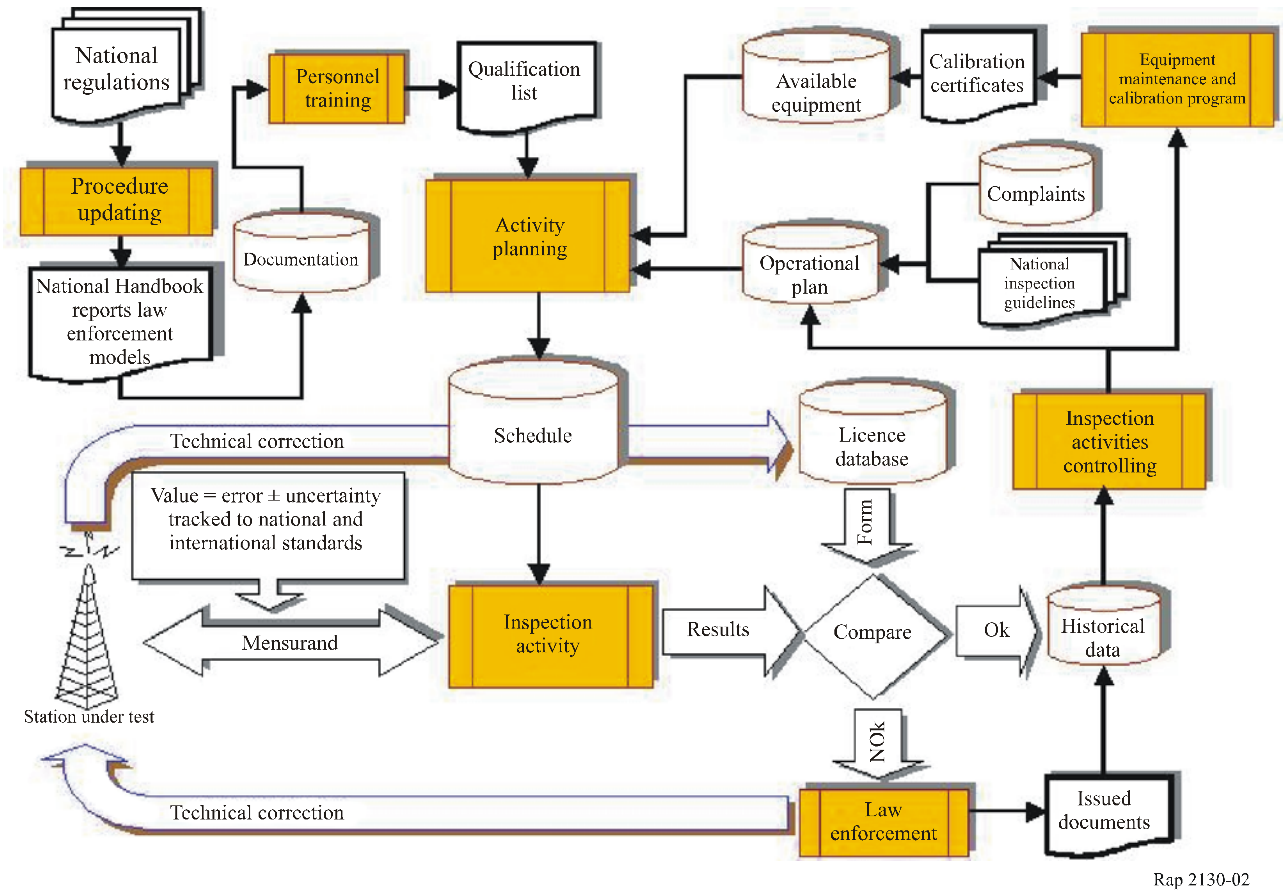
d) *Control and planning adjust* – Besides this, it should be useful for corrections in the reference database. The results coming from all generated reports should be registered in the intranet-managing tool as mentioned in § 1.3, in order to allow adjustments in the operational plan.

2 The inspection service – interrelation between main processes

The inspection service's view from Fig. 2 is presented as a functional interrelation between its main processes. To illustrate such interrelation the inspection activity management process is used and its requirements of input and output related sub-processes and products, as described below.

FIGURE 2

The inspection service from processes point of view



2.1 Inspection activities planning

Inputs: Operational plans, available qualified personnel and equipment resources list, updated procedures and technical database, national regulations.

Output: Inspection activities schedule.

Based on operational plans the inspection activity manager should select trained personnel, depending on the nature of work to be performed. Besides, it is necessary to verify the needs of previous existence of appropriate methodology or measurement procedure (see § 1.4 b)).

The inspection team should consider calibration conformity aspects when selecting the equipment to be used, preventing the use of inadequate devices. All the activity of the inspection only must be performed when the attendance of such requirements can be assured. After that, an inspection activity schedule can be stated.

2.2 Inspection activity execution

a) Requirements:

Procedure updating, forms and reports, national regulations, national handbook **–** Before departure on an inspection mission, the assigned team must ensure that the up-to-date versions of methodologies, national regulations, forms, models of reports, including the national inspection handbook, at least, of all the necessary documentation, are at hand. A good tested and trustworthy way to assure such requirements is to make such documents available, using resources of a website – intranet.

b) Calibration aspects

The inspection team should consider calibration aspects of mean, uncertainties and error aspects tracked to national and international standards, when measuring. Such parameters must be considered to compose the final results. Results have a crucial importance because they are used as support for fees; considering that measurement results are subject to further technical questioning on the part of the entity whose station is under inspection. Another important aspect is that these results could eventually imply changes to the reference database.

c) Using the measurement assistant

When available, the inspection team should follow the instructions presented by the measurement assistant software and use it to help in the station technical data gathering. The inspectors' validation of the collected information is the final, crucial step when using a measurement assistant and cannot be disregarded.

2.3 Document inspection results registering

Enforcement procedures and database correction

During the inspection activity, and also after, the team must make sure that all documental proof of inspection activity, such as forms, reports, etc. are correctly filled in, so that they can instruct appropriately the enforcement procedures and subsidize reference database alterations.

2.4 Control and planning adjusts

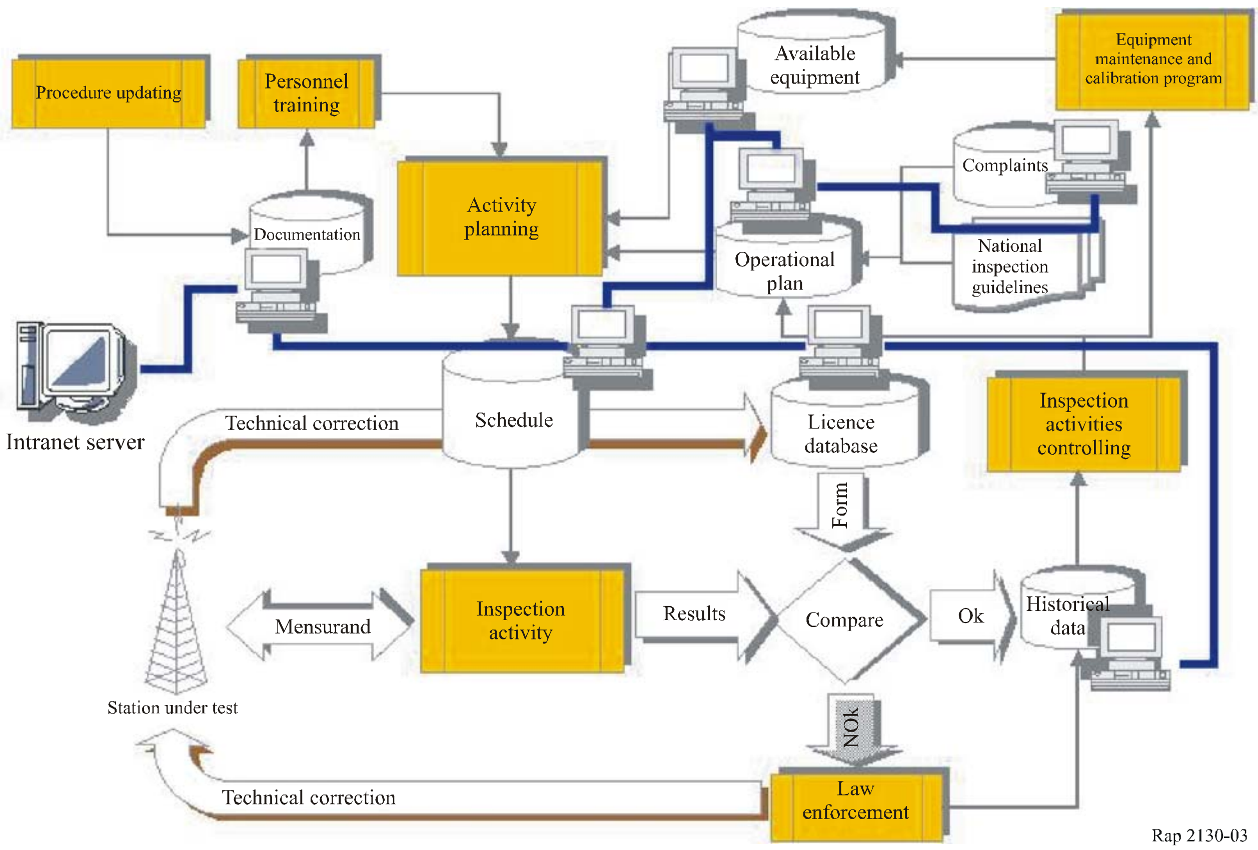
There must be a periodical evaluation if inspection activities performance has achieved compliance with the general national inspection guidelines. Depending on the results, it might be necessary to revise the operational plan to eventually include additional scheduling for new missions, or to visit those stations presenting a necessity for technical correction.

3 The inspection service – support resources, using a network

Figure 3 shows, in a simple way, how the previously mentioned functional interrelation between the main processes could be performed in practice. All databases related to licence characteristics, general documents (such as national regulations, national handbook, law enforcement document models), complaints, schedule activities, operational plans, available equipment, inspection activities schedule and historical data, should be accessible by means of the interconnection of appropriate interactive software based on Internet platform (e.g. intranet – represented below by blue line).

FIGURE 3

The inspection service supported by interactive software based on Internet



Annex 2

Criteria for determination of sample size for inspections planning

1 Introduction

Of course, it is not possible for example, to examine all equipment of all users within a single year. Giving due consideration to economic aspects (investment in terms of costs and time) and the target of obtaining definitive results, the application of sampling for verifying frequency usage is deemed expedient. The method described below is used by the German Federal Network Agency. It allows consequences to be drawn on the overall set from the results of a partial examination (sample). The question that needs to be answered here concerns the size of the sample and how the objects to be examined should be chosen.

2 Method for the determination of the sample size

The determination of the sample size and the selection of the objects to be tested is to be based on a recognized statistical method yielding regular and precise information about the adherence to assignment conditions within a radio application. In principle, such a method can be applied to all radio applications. The sampling method is an economic test method for determining the status quo. Prerequisite for the application of the method is the specification of the following boundary conditions:

Equipartition of the samples:

To ensure a representative selection, it must be possible to select each element (assignment) of the overall set (number of assignments) with the same probability.

Temporal aspects:

The period in which the sample is to be tested and the survey frequency must be specified. This has a decisive impact on the personnel expenses.

Spatial criteria:

There is a difference between an outcome relating to the entire country and one relating to individual regions. The sampling quantity increases considerably if the result is intended to illustrate regional differences.

Statistical criteria:

The result of the analysis yields the percentage, P, of radio networks with shortcomings. The requisite minimum sample size is largely dependent on the specified certainty probability, S, and the value of the tolerable error, e.

Tolerable error

An error of, say, 5% means that each sample value (e.g. 30%) can deviate up or down by 5% from the actual value of the basic certainty, i.e. the actual value may lie between 25% and 35%.

The certainty of a sample indicates the number of cases in which the sampling method yields “correct” and precise results. A certainty of, for example, 90% implies that a 100-fold application of the method will only lead to “incorrect” results in 10 applications but these results are nevertheless fairly close to the “correct” value, e.g. ±5%.

3 Number of necessary samples

The minimum number of samples needed to achieve this precision is calculated with the following formula:

$$n \geq \frac{N}{1 + \frac{(N-1) \cdot e^2}{z^2 \cdot P \cdot Q}}$$

where:

- n: minimum sample size needed
- N: overall number of assignments
- e: selected tolerable error
- z: value of the specified certainty probability, S, calculated from the central probability of the standard normal distribution

$$\Phi(z) = \operatorname{erf}(z) = \frac{1}{\sqrt{2\pi}} \cdot \int_{-\infty}^{z} e^{-t^2/2} \, \mathrm{d}t$$

$$S(z) = 2 \cdot \Phi(z) - 1$$

- P: number of assignments in which the assignment conditions are not fulfilled (fail)
- Q: $Q = 1 - P$, number of assignments in which the assignment conditions are fulfilled (success).

For infinite population (N large), the equation vanishes to:

$$n \geq \frac{z^2 \cdot P \cdot Q}{e^2}$$

It can be seen from the formula that the minimum sample size required is highly dependent on the product $P \cdot Q$. The highest possible product value is obtained when $P = 0.5$ and $Q = 0.5$.

At the German Federal Network Agency, the following values are assumed:

Certainty probability:	90%
Tolerable error:	5%

Example:

Within a certain area there are 8 000 radio networks of a specific radio application. From earlier investigations it is known that about 30% of the radio networks do not comply with requirements. How many radio networks need to be inspected to be able to identify the proportion of faulty networks among these 8 000 networks with a probability of 90%? The error rate of the outcome should not exceed a maximum of 5%.

$S(z) = 90\%$ yields $\Phi(z) = 0.95$. For this, the value $z = 1.645$ can be taken from the relevant mathematical table or calculated with a spreadsheet program. If $N = 8\,000$, $e = 5\%$, $P = 30\%$ and $Q = 70\%$, then $n = 221$ samples.

4 Number of samples within a radio network

If the above reflections were consistently applied to the number of radio installations within the individual networks, unreasonable test volumes would be obtained. In the case of a network with 20 radio installations, 19 networks would have to be tested and even in the case of a network with 100 radio installations 73 units would still have to be tested.

It therefore makes more sense, for example in the case of private mobile radio (PMR), to test all fixed radio installations and only a limited number of the mobile installations. Should it turn out that the number of shortcomings exceeds the average value noticeably, the number of checked installations could be increased.

5 Selection of objects to be tested

Although each sample should be randomly selected without reposition from finite or infinite population, indeed a totally random selection of objects to be tested is not possible in practice. For this reason a systematic selection method is used. If N is the overall quantity of assignments and n the number of networks to be investigated, each k-th element is selected from the database with $k = N/n$. This method requires the elements in the database being arranged in line with a certain criterion, e.g. according to the assignment holder's name.

Experience has shown that it is not possible to test all selected networks within the test period. Some of the frequency assignments had meanwhile been returned to the agency or the radio network had been taken out of service without the frequency assignment having been returned. To achieve the required statistical accuracy in spite of this, in such cases it is necessary to select further objects to be tested. It has happened in practice that double the number of networks had to be selected before being able to achieve the necessary number n which could be checked.

6 Impact of the parameters on the test volume

Figure 4 illustrates that the number n of necessary samples barely changes within the range beyond N = 2 000. By contrast, the requisite certainty probability has a considerable impact on the test volume.

FIGURE 4

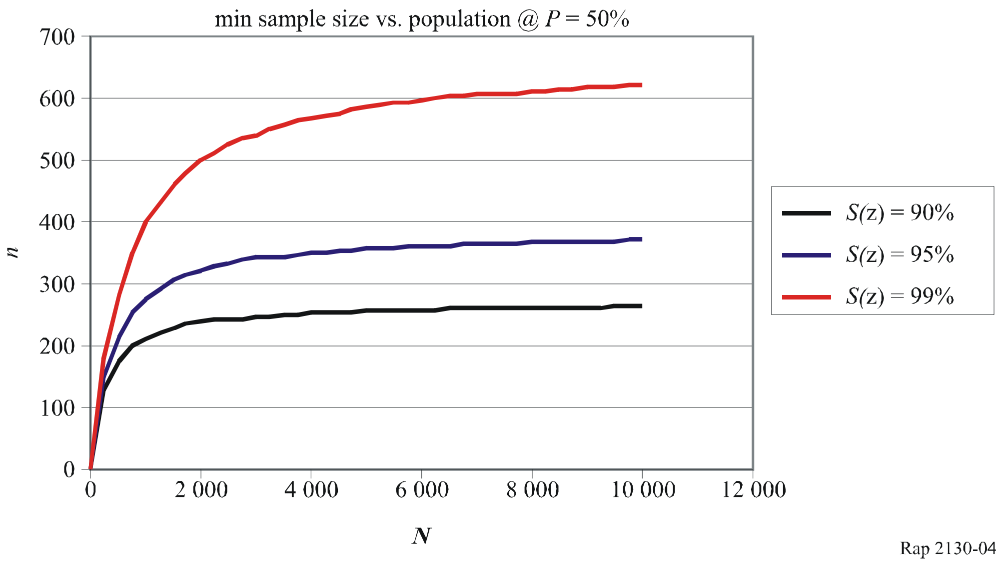
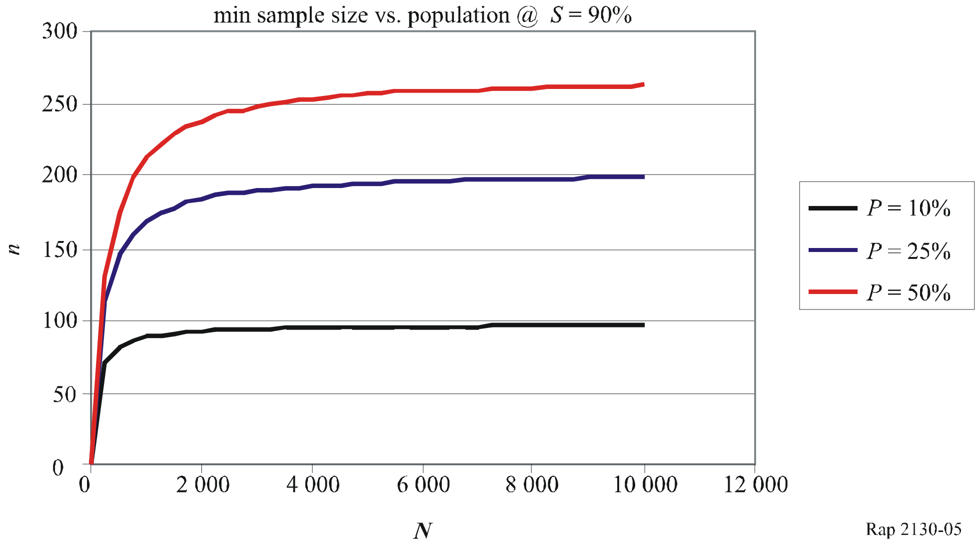


Figure 5 shows the number of samples needed for the various values of P.

FIGURE 5



7 Strategy

The method described above primarily serves to determine the status quo. It is therefore important not only to incorporate the results in the calculation of the test volume for the following test period but also to draw further conclusions.

First of all, the question must be asked as to whether the result is satisfactory or not. Are the assignment conditions for the most part being adhered to or is the rate of deficient networks so high that corrective action needs to be taken? A deficiency rate of 30% in PMR is certainly realistic. But if approximately every third radio network evinces shortcomings, then the result is not satisfactory.

The following corrective actions are merely examples for possible measures:

– additional testing;
– inspection of all new radio networks within a year;
– repeat inspection of those networks where shortcoming had been identified as early as in the following year;
– information for frequency users and radio equipment dealers.

When evaluating the shortcomings for different regions, it may, for example, turn out that the monitoring or enforcement staff in the various regional offices uses different working methods or evaluate deviations differently. But it is also feasible that frequency users in mountainous regions often use higher powers or excessively high antennas to extend their range. In the wake of such a result the frequency assignment method should be examined. Are the applicant’s requirements adequately met or should changes be made?

The assignments in the database are sorted according to regional office, postal code and name. The assignments to be tested are selected by means of a random generator. Assignments which have already been examined in the past two years are excluded. A sample is surveyed within a period of three months. Three samples are surveyed per year.

As a rule, the holder of the frequency assignment is informed at an early stage of the measurements so that the radio equipment is indeed accessible.

Annex 3

The measurement assistant implementation in Brazil

1 Introduction

In order to minimize the time spent on inspections tasks and the error from human sources, the Brazilian administration is exploring the use of special software, called "measurement assistant", to collect measurement results and other data during the inspection process.

The "measurement assistant" will control measurement instruments or measurement interfaces and takes care of repetitive measurement/data tasks, allowing the inspection agent to focus on the results analysis.

Following is a general description of the "measurement assistant".

2 The measurement assistant set

There are several options for the measurement assistant hardware setup. The choice between options is a trade-off between cost, portability and hardness/ruggedness.

Generally, the options consist of the use of a computer (laptop) interfaced with a measuring instrument. Regardless the setup chosen, the computer has to be able to remote control the instrument via a RS-232, GPIB, USB or LXI. If it is necessary to print documents in the field a printer can be added. In some cases, it is desired to transmit the measurement data immediately to a central database, or to provide a means for the measurement assistant software to extract information from a central database. In this case, a radio modem or wireless network connection can be added which provides that connectivity.

Figure 6 shows a typical configuration.

FIGURE 6

Measurement assistant set

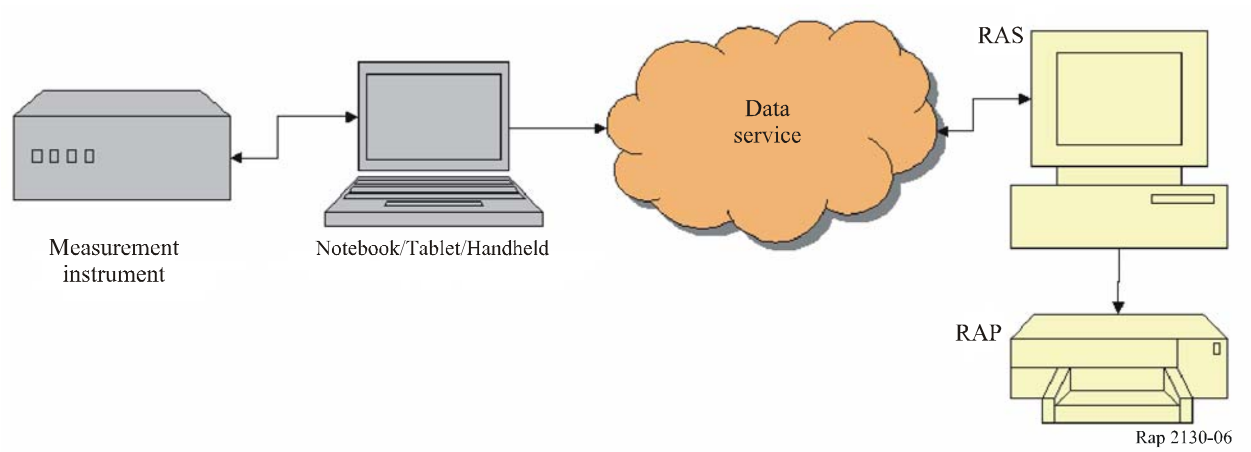


Figure 7 shows a measurement assistant currently used in Brazil. It consists of a notebook computer linked to a spectrum analyser by a GPIB interface.

FIGURE 7

Example of measurement assistant set using GPIB interface

Rap 2130-07

3 Preparation for the inspection activity

Still in the office, the measurement assistant interacts with the inspection activities schedule database and search for the licence data needed for the next activities. The system also loads the technical specification and calibration data of the instruments to be used.

4 Real-time advice

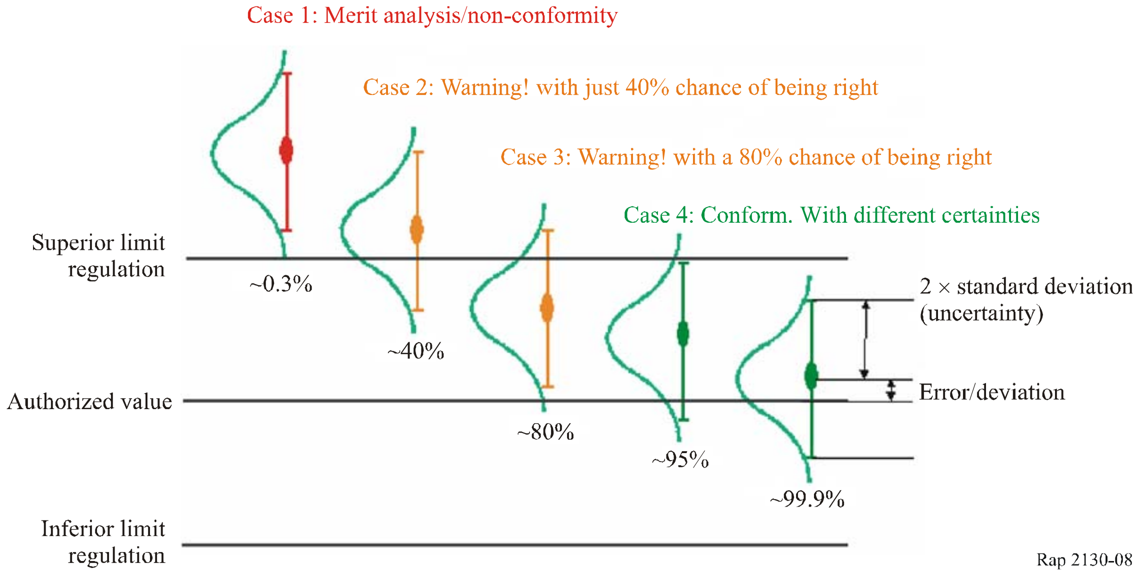
Based on the inspections activities plan, the system asks the inspection agent to answer a checklist before the activity starts. During the inspection the system guides the inspection agent in completing each inspection element step-by-step in order to standardize the inspections procedures throughout the country.

5 Metrological guarantee

The measurement assistant gets the raw readings from the instrument and corrects it considering the uncertainties and errors identified in the process, including the statistical dispersion inherent to the measurement process and the instrument metrological characteristics found during the calibration. Up to five situations can be found in practice, as shown in Fig. 8.

FIGURE 8

Example of metrological considerations in a measurement process



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To check the conformity of licensed technical parameters with the measured ones it is mandatory that the regulatory body issue an official metrology document establishing suitable and tangible rules and limits to be met by the different actors involved and to be applied by national and regional offices as a standardized procedure. Obviously, these rules may change dynamically in time and from service to service, depending on the impact created by the expected (but undesirable) non-conformities.

6 Report automation

The inspection form/report can be very extensive. To avoid errors and speed up the process the measurement assistant automatically accomplishes this task.

Based on national regulations regarding the specific service under inspection, the system classifies each parameter as regular or non-regular. If the system finds a non-regular item, it displays a short description of the broken rule and asks the agent confirmation.

The report automation also improves the inspection reports, easily including the results metrological calculation.

Back at the office the inspection results data collected in the field can be uploaded to the historical database.

Annex 4

Inspection procedures for AM broadcast in Brazil

TABLE OF CONTENTS

1 Introduction

The inspection is carried out at an AM broadcast station at the transmitter site. Table 3 presents the main parameters measured and the equipment used.

TABLE 3

Technical parameters versus measurement instruments

Measured parameter	Instrument
Site location	GPS receiver
Antenna height	Laser range finder, measuring tapes and compass
Azimuth of antenna	Compass
Output power (direct and reflected)	Power meter
Frequency	Frequency meter/spectrum analyser
Effective radiated power, out-of-band emissions, harmonics, coverage, radiation pattern	Field-strength meter/spectrum analyser

The next section describes typical procedures for AM broadcast site evaluation considering the technical parameters listed above.

2 Site location measurement

The objective of this measurement is to obtain the exact geographic coordinates (latitude, longitude and elevation) of the AM station.

Geographic coordinate measurements are generally made with GPS receivers. A set of the main guidelines governing the use of such equipment can be described as follows:

2.1 Measurement procedure

Before using the instrument for the first time or after replacing the batteries, the inspector should configure the unit. This process is also necessary when the user does not know its current instrument configuration.

In configuring the GPS receiver, the user must select the proper geographic region and the geodesic model.

The geodesic model adopted in Brazil for on-site inspection is the WGS84. Conversion to the official geodesic model (Geodesic Coordinates) is made through the use a special database function. The elevation is usually expressed in meters.

The inspector should make sure that the placement is suitable for the equipment operation, assuring good sky clearing to the antenna. Better results usually can be obtained by operating the receiver on open areas, where it is less affected by signal reflections and shadow zones.

GPS measurements are affected by adverse environmental conditions like heavy clouds, buildings and forests, which cause signal obstructions.

Special GPS functions such as “Location” and “Position” display a diagram of the identified satellite system, where a valid measurement denotes the decoding of at least three satellite signals.

The GPS track time may vary from a few seconds to some minutes, depending on the specific location, meteorological conditions and the equipment characteristics.

The GPS receiver helps the operator when the measurement is achieved, and this is clear from the moment that the indicated measurement becomes visible, constantly updating its readings.

Once measurement is accomplished, it is recommended to wait about ten (10) minutes to take note of the measured position. This settling time is required due to averaging and filtering processes needed to reach prescribed measurement accuracy.

Some GPS receivers also provide an estimated accuracy value, which can be used to ascertain if the current result is within the required tolerance.

3 Antenna height measurement

This task objective is to measure the antenna height from its base insulator up to the highest active part.

3.1 Measurement guidelines

The procedures used for antenna height measurements are based on the use of typical dimensional measurements instruments, such as measuring tapes, laser range finder and inclinometers (measuring the vertical angle vernier). The use of such equipment must consider the antenna site conditions, such as accessibility and flatness. Advanced equipment such as Laserhypsometer, Electronic Theodolites or Total Stations provide more reliable results. However, the instrumentation is more expensive and specialized training using surveyor's instruments may be required. Issues to be considered include the minimum/maximum distances to be measured, views toward the object to be measured, and instrument accuracy. All compasses used by Anatel are equipped with a mechanical vernier for vertical angles measurement. This kind of vernier has a scale with half-degree precision and an aiming sight. We will classify this equipment as a protractor, since the needle aligning with the magnetic field of Earth is not used.

The vernier can also be used to determine the horizontal line of sight. The aiming window to find the zero degree indication point can do this.

The horizontal line of sight is critical to define the procedure for measuring the antenna height.

4 Azimuth measurement

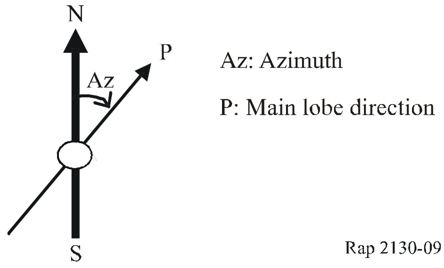
This measurement is to ascertain the geographic azimuth where the main antenna lobe is pointing. This measurement procedure is used in AM broadcast inspections only when AM directional antennas are used.

4.1 Measurement guidelines

Antenna azimuth is the angle measured clockwise between the geographic north direction and the main propagation lobe direction. This concept is described in Fig. 9.

FIGURE 9

Azimuth measurement diagram



The geographic north, also called “real north” or “true north”, is mostly presented on modern maps, and approximately corresponds to the Earth rotation axis pointing in the magnetic north direction.

The most commonly used instrument to measure the azimuth is the magnetic compass. This type of instrument does not point to the geographic north, but to the magnetic north, which lies at a position on the earth that is west of Greenland, at approximately 77° N/102° W, which is quite far from the geographic north. Therefore, compass readings need to be corrected for this error, called magnetic declination. As this error changes slowly with time and location, current sources of information (such as surface magnetic field maps or software calculators) should be consulted to obtain an accurate value for the area where the compass measurement is made.

In Brazil, the National Observatory provides both the regional magnetic maps and the software. New maps with referenced data are released each five years. This information is collected from 110 measurement locations and there are two observatories providing continuous measurements.

Anatel’s Department of Instrumentation and Metrology is responsible for standardizing through the Intranet the new software releases and reference data issued by the National Observatory for internal use.

4.2 Measurement procedure

It is important to consider that the magnetic field is not flat over the Earth’s surface and has an inclination component that might affect the measurement. Theoretically, over the North Pole, a compass needle would point downwards, while over the South Pole, upwards, following the magnetic field lines.

If the compass is not properly levelled or adjusted to the local conditions, this component can cause the needle of a standard compass to get stuck or affect the reading of an electronic compass.

Hence, the compass should be placed on a tripod or plane surface that enables it to be suitably levelled to allow the needle to move freely and approximately parallel to the Earth’s surface. To ensure that the equipment is levelled, the compasses used by Anatel are equipped with a built-in bubble leveller.

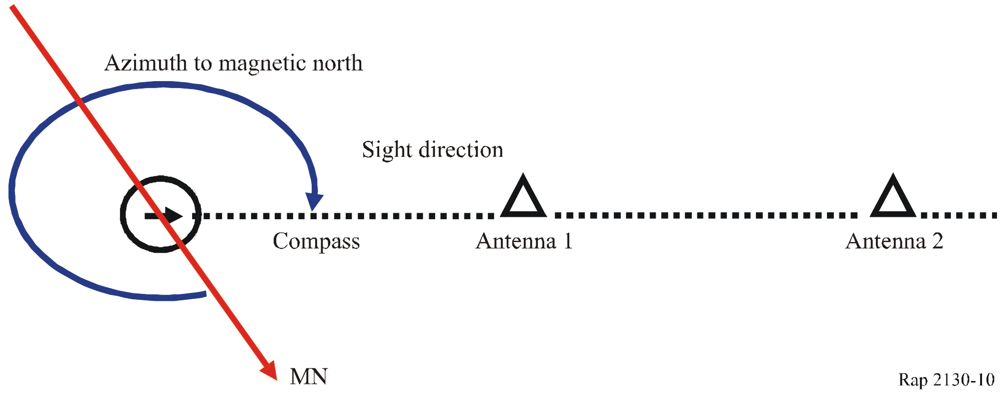
The measurement location should be free from any ferromagnetic material, since it can strongly affect the pointer of the compass.

This location should be chosen in front of the main antenna lobe, from where the inspector can use the compass aiming window to determine the antenna direction in reference to the magnetic north, as described in the above guidelines.

Some AM broadcast stations operating in the band 525-1 705 kHz employ an antenna array to create a specific radiation pattern. In this configuration, the direction stated in the licence corresponds to the line defined by the two antenna masts.

FIGURE 10

Azimuth measurement in AM broadcast antenna array



The magnetic declination can be determined using a GPS receiver and an updated map or software to find the current location coordinates. The azimuth value can be obtained by subtracting the declination value from the compass reading.

Care should be taken with the compass reading because some equipment are available with scales from 0° to 360° and others with four quadrant scales, defined from 0° to 90° each. Corrections should be made in accordance with the selected equipment.

5 RF power measurement

The objective of this task is to measure the nominal RF power of the AM broadcast station transmitter.

5.1 Measurement guidelines

There are mainly two ways used by Anatel to measure an RF transmitter output power.

a) *Indirect method*: The output power is calculated by multiplying the voltage and current meter readings at the transmitter's output stage by the system's rated efficiency, as established in the Brazilian broadcast regulations.

b) *Direct method*: Measurements performed by the physical connection of a feed-through power meter and the RF transmitter output connector, as detailed below.

The indirect method is straightforward and will not be included here. On the other hand, the direct method is performed by the Brazilian Administration on radiocommunication stations operating in the range 30 mW to 1 950 W, with frequencies between 200 kHz and 4 GHz, according to the parameters of the currently used equipment. To this end, the instrument probe must be properly selected to work with the mainframe, but the safety issues must not be ignored. The instrument probe has two ports: one input and one output.

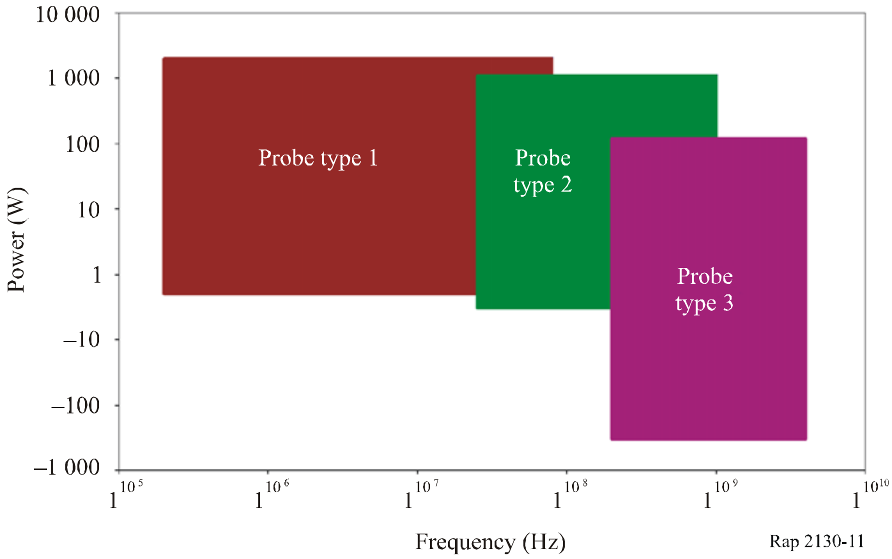
The use of directional couplers and power load can also enhance the capability of direct method measurements. These devices must be carefully handled, since they usually have restricted operation conditions, both in frequency and power.

5.2 Measurement procedure

Before starting any activity, an adequate probe must be selected, taking into account the frequency and power characteristics of the transmitter under test. Figure 11 shows the operational ranges for the power meter probes described above.

FIGURE 11

Power meter probe characteristics



The user must also ensure the appropriate connection between the power meter, RF transmitter output and antenna cable or RF load. This implies using adequate connectors and flanges to ensure efficient impedance matching.

Damage to the equipment can be prevented by keeping the power meter's AC mains cable unplugged from the power source and powered by its internal batteries, provided that they are properly charged.

Risks of electric shock may be reduced by ensuring that the transmitter is grounded, which can be checked with a voltmeter before any measurements are made. In addition, unshielded (aerial) transmission line power measurements may not be performed using through-line wattmeters due to impedance mismatch and shock hazards caused by accidentally touching a live line.

If any of the above instructions are not being properly followed, the measurement should be disregarded.

The following step-by-step procedures must be followed for measurements of up to 500 W using power meters:

a) Turn off the transmitter and fully discharge all reactive storage devices located in the power supplies, exciter and output stages, using the station's dummy load.

b) Then, disconnect the antenna transmission line from the transmitter.

c) Turn on the power meter and make sure that it is properly configured, including correction factors, forward and reverse power readings, scale ranges and measurement units.

d) Insert the power meter between the output of the transmitter under test and the antenna transmission line or RF power load.

e) Turn on the transmitter with no modulation, set it to its nominal power, and wait for the warm-up time, according to its specifications.

f) Take at least three readings, then turn off the transmitter, disconnect the power meter and re-establish all connections.

g) Average out the values and record the final result after all uncertainties of the measuring process have been accounted for.

6 Frequency measurement

The objective of this task is to measure the AM broadcast transmitter frequency.

6.1 Measurement guidelines

The frequency measurement can be performed on direct mode by connecting the frequency meter or spectrum analyser to the transmitter test point (see Fig. 12), or on remote mode by detecting the radiated RF signal with a probe or test antenna connected to the instruments (see Fig. 13).

FIGURE 12

Direct frequency measurement

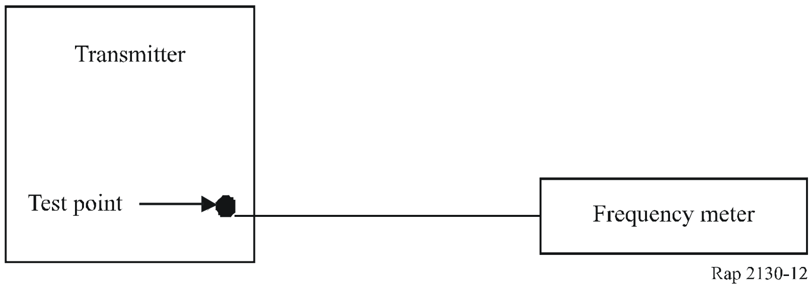
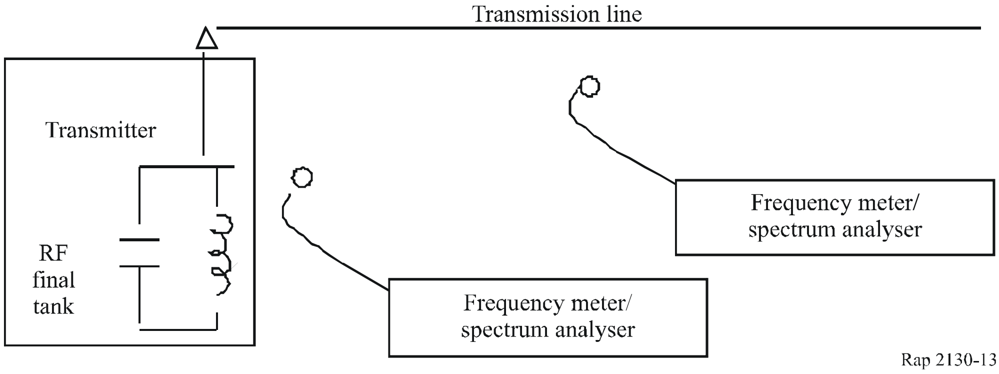


FIGURE 13

Remote frequency measurement



The mode to be adopted will generally depend on many factors, including the instrument's sensitivity, the signal-to-noise ratio, *S*/*N*, the time base accuracy and the station's frequency tolerance.

The instrument's time-base accuracy is particularly critical and should be compatible with the station's required tolerance. In general, an OCX is the minimum requirement for this type of measurement. Whenever needed, the administration could use external frequency references with higher stability to improve the measurement accuracy.

6.2 Measurement procedure using a frequency meter

The following guidelines should be checked before making any measurements:

a) The expected signal level should be within the safety operating range of the frequency meter.

b) The AC power plugs should be within the power supply range of the equipment. If operating with batteries, check if the available charge is compatible with the expected measurement time (from 10 to 30 min).

c) The output connector and impedance of the transmitter's decoupled measuring port must be compatible with the available connectorized cables, adaptors and measurement equipment.

d) The calibrated frequency meter should be operating properly. To check this, turn it on and wait for the usage signal (audio or visual) or for the auto-diagnose run routine.

e) The voltage between the transmitter chassis and the measurement instrument body should be null. To ascertain this, the inspector must use an AC voltmeter.

The general guidelines for using a frequency meter are as follows:

a) After turning the power on, wait until the frequency meter warms up and self stabilizes according to the operation manual (approximately 5 to 10 min).

b) Connect the instrument to the test port, adjust the gate time so that the frequency reading is in accordance with the expected frequency tolerances.

c) Take at least three readings, average out the values and record the final result after all uncertainties of the measuring process have been accounted for.

NOTE – Whenever the frequency meter is connected to the transmitter and whenever it is necessary to disconnect some of the station parts for measurement purposes, a station technician should perform these operations.

6.3 Measurement procedure using a spectrum analyser

The following guidelines should be checked before making any measurements:

a) Same as sub-items a) through e) of § 6.2.

b) Special checks may be made, such as visually observing the stability of the "zero frequency" peak reference and the 10 MHz self test source, as described in the operation manual.

The general guidelines for using a spectrum analyser are as follows:

a) After powering the instrument, wait until it warms up and stabilizes according to the operation manual (approximately 5 to 10 min).

b) Connect the instrument to the test port using adequate connectors/adaptors.

c) Use the counter mode function of the spectrum analyser considering the appropriate resolution bandwidth (RBW) so that the frequency reading is in accordance with the expected frequency tolerances. Markers should not be used to measure frequency since they do not provide the required accuracy.

d) Take at least three readings, average out the values and record the final result after all uncertainties of the measuring process have been accounted for.

6.4 Specific performance guidelines

The direct operation usually provides a better signal-to-noise ratio, so its use is recommended whenever the proper RF plug is available.

If the RF plug provides only modulated signal or the remote procedure is performed, the modulation should be taken off, so that only the carrier remains.

On the remote method, the probe or test antenna can be placed near the final RF tank circuit or to the transmission line. Care should be taken to not close contact with such circuits and not to induce excessive field. The best practice is to start the measurement from a safe distance and do a slow approach to increase the signal/noise ratio to the desirable level. Remember that the level changes with the distance square, few steps can make a big difference.

7 Field-strength measurements

The objective of this task is to measure several station parameters related to the spectral characteristics of an emission source, e.g. effective radiated power, out-of-band emissions, harmonics, coverage area, radiation pattern, etc.

Although mobile monitoring stations can more easily perform most of these measurements, this kind of equipment might not be available or able to reach certain locations, when the use of field-strength meters or spectrum analysers turns a valid and sometimes good alternative.

The field-strength unit is given in volt per metre (V/m). Submultiples are commonly found, such as millivolt per metre (mV/m) and microvolt per metre (μV/m) or using the logarithmic scale (dBμV/m).

7.1 Measurement guidelines

Before making any measurements, care should be taken to select the proper antenna model and assembly, according to the transmitter signal or field polarization under analysis.

For VLF and HF frequencies, surface waves maintain the same polarization as the transmitted signal wherever the wave front is gently inclined.

Due to ionosphere reflections, except for certain distances and frequencies, the incoming signal will be a combination of vertical and horizontal polarizations.

Services like AM, SW and LW radio broadcast suffer from ionosphere phenomena, especially in the morning and afternoon, so measurements are prejudiced due to the presence of out-of-phase co-channel signals incoming from distant transmitters.

The place selected for measurements must lie at a certain distance from natural and artificial structures like electrical power lines, big trees, buildings, mountains and many other objects which could severally distort the wavefront. This is especially critical at frequencies near 30 MHz.

For AM broadcast, it is highly recommended that the distance between the measuring and transmitter antennas be in the range 700-1 000 m, achieved with a GPS. This distance relates to the geometric region where the emission field can be found.

Below 30 MHz ($\lambda > 10$ m), antenna lengths are small when compared with the signal wavelength, the use of loop antennas being a common practice. Many times this kind of antenna is built in the field-strength meter.

For signals below 30 MHz, the following criteria must be followed:

– Choose areas where surrounding terrains are nearly flat.

– It is desirable that the soil be homogeneous, having good electrical conductivity and free from detritus and rocks.

– Aerial power lines must be at least 100 m far away from the receive antenna.

– At low frequencies, where a half wavelength is equal or less than 100 m, the distance from antenna to aerial lines is calculated multiplying the antenna height by 20 and adding a half wavelength to the result.

The site survey must be far away from natural or artificial obstacles where proximity to electrical power lines, buildings, mountains and many other obstacles may alter or even distort the wavefront. The quality of the results concerns many factors including the frequency band being analysed, the antenna type (unidirectional, directional, active or passive, etc.) and the placement (height, azimuth, tilt). The antenna gain at the operating frequency must be high enough to preserve the signal path; otherwise only noise will be received.

Although the measured field strength is due mainly to the electrical field component (E field) resulting from the electromagnetic phenomena, measurement instruments with loop antennas may nevertheless retrieve it from the magnetic field component (H field). So, the loop antenna must be properly coupled to the wavefront in order to improve the sample signal level.

The technical parameters (UIT) of the emission must be known prior to the field test. These include the occupied bandwidth for the service and channels, modulation type and emission designation.

Choosing a loop measuring antenna means that a lower number of samples are required to finish the tests when compared to a dipole antenna, once it works based on magnetic rather than electric field, thus being less sensitive to reflections and to re-radiations.

On the other hand, when directional antennas are pointed to the transmitter’s antenna azimuth and the measured field does not reach maximum value, perturbation like reflections are suspected to occur in the site. In this case, the wrong place must be abandoned and another one selected.

Example – AM Broadcast Inspection Form

NATIONAL TELECOMMUNICATION AGENCY

ANATEL

TECHNICAL INSPECTION REPORT AM BROADCAST STATION	REPORT N°

INSPECTION OBJECTIVE	☐ ROUTINE ☐ R.I.F. COMPLAIN ☐ NEW LICENCE	☐ TECHNICAL CHARACTERISTICS ☐ LICENCE RENEWING ☐ OTHER	SERVICE TYPE (BAND) ☐ MEDIUM WAVES ☐ TROPICAL

1 – IDENTIFICATION OF THE ENTITY

1.1 – NAME ____________________

1.2 – ADDRESS: ____________________ ZIP CODE __________

CITY: ____________________ STATE __ CALL FONE: __________

DESCRIPTION			STATUS	LEGAL FRAMING	
2 – TECHNICAL CHARACTERISTICS					
2.1 – FREQUENCY (KHZ)	AUTHORIZED	VERIFIED			
2.2 – ADDRESS					
AUTHORIZED ______					
CITY ______ STATE __ ZIP CODE ______					
VERIFIED ______					
CITY ______ STATE __ ZIP CODE ______					
2.3 – GEOGRAPHICAL COORDINATES	AUTHORIZED	VERIFIED			
LATITUDE					
LONGITUDE					
2.4 – RADIANT SYSTEM					
2.4.1.1 – OMNIDIRECTIONAL)	☐ SIMPLE				
	☐ FOLDED				
2.4.1.1.1 – HEIGHT (m)					
2.4.1.1.2 – PROTECTION FENCE AROUND TOWER BASIS					
2.4.1.1.3 – PICTORIAL WARNING AFFIXED AT THE TOWER BASIS					
2.4.1.1.4 – GROUND SYSTEM – RADIAL WIRING					
2.4.1.1.4.1 LENGTH (m)					
2.4.1.1.4.2 – AMOUNT					
2.4.1.2 – DIRECTIONAL					
2.4.1.2.1 – ELEMENT HEIGHT (M)					
2.4.1.2.2 – SEPARATION BETWEEN ELEMENTS (m)					
2.4.1.2.3. – ORIENTATION AZIMUTH (°) (*Element 01 as reference*)					
2.4.1.2.4 – PROTECTION FENCE AROUND TOWER BASIS					
2.4.1.2.5 – PICTORIAL WARNING AFFIXED AT THE TOWER BASIS					
2.4.1.2.6 – GROUND SYSTEM – RADIAL WIRING					
2.4.1.2.6.1 – LENGTH (m)					
2.4.1.2.6.2 – AMOUNT					

2.5 – EQUIPMENT					
2.5.1 – MAIN TRANSMITTER	AUTHORIZED	VERIFIED			
2.5.1.1 – MANUFACTURER					
2.5.1.2 – MODEL					
2.5.1.3 – CERTIFICATION					
2.5.1.4 – OPERATIONAL POWER[KW]					
2.5.1.5 – final stage (COLLECTOR OR PLATe) rf amperimeter					
2.5.1.6 – FINAL STAGE (COLLECTOR OR PLATE) RF VOLTMETER					
2.5.1.7 – MODULATION AND FREQUENCY MONITORING EXTERNAL CONNECTION					
2.5.1.8 – SECURITY DEVICE THAT HINDERS THE FUNCTIONING TRANSMITTING IT IN THE LACK OR INSUFFICIENCY OF SYSTEM OF FORCED COOLING (WHEN TO EXIST).					
2.5.1.9 – ANATEL ID ☐ ABSENCE ☐ INCOMPLETE					
2.5.1.10 – CARRIER STABILITY (± 10 Hz)		MEASURED			
2.5.1.11 – DEVICES THAT INHIBIT ANY EXTERNAL CONTROLS THAT CAN ALLOW TO EXCEED ADJUSTED VALUE OF AUTHORIZED OPERATION POWER.					
2.5.1.12 – DISCHARGE DEVICE FOR CAPACITORS BANK					
2.5.1.13 – PROTECTION DEVICE(DISCONNECTION) IN DOORS AND COVERS WHERE EXIST TENSION OVER 350 VOLTS.					
2.5.1.14 –TRANSMITTER LOCKED UP IN METALLIC CABINET AND GROUNDED METALLIC STRUCTURES					
2.5.1.15 – EXTERNAL ADJUSTMENT OF THE CIRCUITS WHERE EXIST TENSIONS OVER 350 VOLTS					
2.5.1.16 – OVERLOAD PROTECTION FOR HIGH VOLTAGE POWER SUPPLY					
2.5.2 – AUXILIARY TRANSMITTER	AUTHORIZED	VERIFIED			
2.5.2.1 – MANUFACTURER					
2.5.2.2 – MODEL					
2.5.2.3 – CERTIFICATION					
2.5.2.4 – OPERATIONAL POWER[KW]					
2.5.2.5 – FINAL STAGE (COLLECTOR OR PLATE) RF AMPERIMETER					
2.5.2.6 – FINAL STAGE (COLLECTOR OR PLATE) RF VOLTMETER					
2.5.2.7 – MODULATION AND FREQUENCY MONITORING EXTERNAL CONNECTION					
2.5.2.8 – SECURITY DEVICE THAT HINDERS THE FUNCTIONING TRANSMITTING IT IN THE LACK OR INSUFFICIENCY OF SYSTEM OF FORCED COOLING (WHEN TO EXIST).					
2.5.2.9 – ANATEL ID ☐ ABSENCE ☐ INCOMPLETE					
2.5.2.10 – CARRIER STABILITY (± 10 Hz)		MEASURED			
2.5.2.11 – DEVICES THAT INHIBIT ANY EXTERNAL CONTROLS THAT CAN ALLOW TO EXCEED ADJUSTED VALUE OF AUTHORIZED OPERATION POWER.					
2.5.2.12 – DISCHARGE DEVICE FOR CAPACITORS BANK					
2.5.2.13 – PROTECTION DEVICE (DISCONNECTION) IN DOORS AND COVERS WHERE EXIST TENSION OVER 350 VOLTS.					
2.5.2.14 –TRANSMITTER LOCKED UP IN METALLIC CABINET AND GROUNDED METALLIC STRUCTURES					
2.5.2.15 – EXTERNAL ADJUSTMENT OF THE CIRCUITS WHERE EXIST TENSIONS OVER 350 VOLTS					
2.5.2.16 – OVERLOAD PROTECTION FOR HIGH VOLTAGE POWER SUPPLY					

2.6 – OTHER COMPULSORY USAGE EQUIPMENT			
2.6.1 – ANTENNA ELEMENT RF AMPERE METER			
2.6.2 – POWER DIPLEXER RF AMPERE METER (DIRECTIONAL ANTENNAS)			
2.6.3 – MODULATION LIMITER			
2.6.4 – MODULATION MONITOR			
2.6.5 – PHASE METER (DIRECTIONAL ANTENNAS)			
2.6.6 – AUDIO MONITOR			
2.6.7 – RF ARTIFICIAL LOAD (OPERATIONAL POWER OVER *10 kW*)			

3 – STUDIOS						
3.1 – MAIN STUDIO						
3.1.1 – ADDRESS:						
AUTHORIZED						
CITY:	STATE:	ZIP CODE				
VERIFIED						
CITY:	STATE:	ZIP CODE				
3.1.2 – AUDIO RECORDING EQUIPMENT.						
3.2 – AUXILIARY STUDIO						
3.2.1 – ADDRESS:						
AUTHORIZED:						
CITY:	STATE:	ZIP CODE				
VERIFIED						
CITY:	STATE:	ZIP CODE				
4 – OTHER FINDINGS						
4.1 – AVAILABLE LICENCE AT STATION						
4.2 – HARMONIC AND RF SPURIOUS EMISSION						
4.2.1 – MAIN TRANSMITTER	MAXIMUM LEVEL ALLOWED	VERIFIED				
2°HARMONIC	73+P(dBk) UNTIL 5 KW maximum 80 dB, over 5 kW					
3°HARMONIC						
SPURIOUS	SEE ITEM 3.2.5 BATR					
4.2.2 – TRANSMISSOR AUXILIARY	ALLOWED	VERIFIED				
2°HARMONIC	73+P(dBk) UNTIL 5 KW					
3°HARMONIC	maximum 80 dB, over 5 kW					
SPURIOUS	SEE ITEM 3.2.5 BATR					
4.3 – HARMFUL RFI						
4.4 – INSPECTION NOT ALLOWED BY ANY MEANS						

5 – ADDITIONAL INFORMATION

6 – TEST EQUIPMENT USED

N	DESCRIPTION	EQUIPMENT SERIAL NUMBER

INSPECTOR (1): ____________________

SIGNATURE: ____________________ CREDENTIAL N°: ____________________

INSPECTOR(1): ____________________

SIGNATURE: ____________________ CREDENTIAL N°: ____________________

ENTITY REPRESENTATIVE: ____________________ FUNCTION ____________________

ID ____________________ SIGNATURE ____________________

PLACE/DATE:

*BATR – Broadcasting AM Technical Regulation
*BR – Broadcasting Regulation

Annex 5

Example of inspection methods used in France

Inspection of radio stations to verify compliance with licence parameters

1 Introduction

This Report was prepared in response to Question ITU-R 225/1.

Radio station inspection is a regular task done by the Agence Nationale des Fréquences (ANFR). It is divided in three kinds of inspection:

– radio station inspection for PMR stations (private land mobile);

– radio station inspection on sites where several radioelectrical installations are located;

– radio station inspection for special events (e.g. the International Championship of Athletics in Paris in August 2003).

Also, another class of radio station inspections is made, with fewer parameters measured, by the fixed monitoring remote stations.

These radio station inspections could be done in order to verify compliance with licence parameters according to the national, European or international rules.

These radio station inspections are done by a special team included in each of the ANFR six Regional Services which are located in: Villejuif near Paris, Nancy, Lyon, Aix-en-Provence near Marseille, Toulouse and Donges near Saint Nazaire.

2 Administrative procedures

An annual plan is established, previously before the end of the year, in conformity with the priorities, the budget and the workload of each regional service.

Each type of radio station inspection is defined differently.

Radio station inspection for PMR stations:

This type of inspection is made, firstly by choosing 10% of the PMR stations to be inspected. They are advised of the inspection about one month before, and in a second step only 5% are effectively controlled by the ANFR's inspectors.

Radio station inspection for sites of high transmitter concentration:

These types of sites are defined as "Grouping zone" or "High Points" in the French legislation and have a special status. Each site is managed by a coordinator who is:

– the owner of the site or the mast;

– the first radio user of the site; or

– the ANFR in cases where the sites only contain government transmitters.

This coordinator is responsible for the electromagnetic compatibility for all new installations. If there is a possible interference with a user already authorized in such cases, it is asked to ANFR to realize electromagnetic tests with the collaboration of all the users on site. These electromagnetic tests are under the responsibility of ANFR which manages the operation.

These special sites are totally controlled each 3 years, there are about 12 000 sites on the territory.

Radio inspection for special events:

When ANFR participates in a special event, radio station inspections are conducted and all the equipments used in the defined zone are checked.

3 Procedure

Radio inspection for PMR stations

And

Radio inspection of high concentration transmitter sites

Goals of the inspection:

– to have a photo of all the installations and frequencies used;

– to compare the existing equipment on the site with data contained in ANFR databases: National Frequencies Database and Stations Database;

– to establish a dialogue with and between users in order to treat, if possible, interference and find a solution relating to ensure electromagnetic compatibility between the different installations on site.

Results of these inspections are mainly:

- A better reliability of the databases
  - correction of mistakes included in the databases;
  - sanctions against illegal users or illegal installations.
- A better transparency face to face the population
  - publication on the website: www.cartoradio.fr of installations at each site;
  - publication on the same website of the "Health" measurements which are realized by ANFR and also by authorized laboratories.
- A decrease of interference
  - strong decrease of unauthorized installations;
  - better knowledge of the sites by the technical teams of ANFR;
  - better relationship between the various users on site.

Radio inspection for special events

The inspection is processed for all equipment used on site of the event. After the inspection on each piece of equipment a visible sticker (label) is put on it to be sure that this equipment is controlled, further it is a visual monitoring aid for the inspectors to search for unauthorized equipment.

4 Equipment

Radio inspection for PMR station

The inspection to verify compliance of technical parameters of radiocommunication services are done with portable instruments, equipments and artefacts.

Typical equipment used for radio inspection of high concentration transmitters sites, and radio inspections for special events are shown above. The equipment can be found within the list in Table 1, § 2.3, at the beginning of this Report.

5 On-site measurements

For each type of radio station inspection the following measurement are generally set up:

– Frequency (deviation and stability)

– Transmitter power

– Geographic coordinates

– Harmonics, intermodulation products and spurious emissions

– Bandwidth

– Field strength

– Modulation

– Height and azimuth of the antenna.

6 Report of inspection

For each radio station inspection, a report is set up and sent to each ministry and National Authority having radio equipment located on the site. The Report is also studied by the concerned ANFR services.

This Report contains all the information relating to:

– description of the site (with photos if necessary): geographical coordinates, address, access to the site and details of the facilities, buildings, masts and antennas;

– persons attending the inspection;

– list of the equipment used;

– report of the preparation meeting(s);

– actions to be done after the inspection;
– remarks of the users;
– conclusion.

The Report also includes Annexes with the tables of frequencies measured with all the parameters described in § 5.

Annex 6

Example of inspection methods used in New Zealand

1 Introduction

The New Zealand Administration, the Radio Spectrum Management Group (RSM) of the Ministry of Economic Development, administers the radio spectrum under the Radiocommunications Act 1989, and Regulations and Gazette Notices made under that Act.

RSM is responsible for the following functions:

– Granting radio licences, registering management rights and spectrum licences
– Investigating interference complaints
– Conducting compliance audit programmes to maximize the value of the spectrum resource.

As part of the Ministry of Economic Development, we manage the radio spectrum to create a business environment that promotes a higher rate of sustainable income growth for New Zealanders.

Radio Inspections are a part of the work RSM undertakes. Following a management review in 2002 which led to revised business practices and a strong compliance and enforcement strategy (including increased levels of auditing), inspection work has been incorporated in the radiocommunications "Licence Audit" role. Licence Audits are carried out in accordance with a Business Plan.

2 RSM business activity forecasts for 2007-2008

Licensing and registration

– 3 000 new radio licence applications
– 350 new spectrum licences in crown-owned management rights
– 1 000 modifications to radio licences
– 2 000 instrument registrations in crown and private management rights
– All licences will be issued with granting/registration completed and compliance
– Audits made in accordance with established ISO 9001 processes
– ISO certification will be retained following quality audits.

Interference

– 550 TV/broadcasting interference investigations
– 190 commercial interference investigations
– 65 public safety interference investigations.

Audits

– 1 900 licence audits
– 650 product audits.

Compliance

Radio Spectrum Management conducts licence and EMC product audits to ensure compliance requirements are met, thus maintaining the integrity of the Register of Radio Frequencies and minimizing the likelihood of interference.

RSM has produced a Compliance Guide to give radio spectrum users and product suppliers information about:

– compliance requirements;
– compliance audits;
– enforcement;
– appeal procedures.

The Compliance Guide for Users of the Radio Spectrum and for Suppliers of Electrical and Radio Products is available for download at:

http://www.rsm.govt.nz/cms/resource-library/publications/compliance/compliance-guide.pdf

3 Compliance and enforcement strategy

The RSM compliance strategy over the last three years has been very successful. Our efforts around auditing sites to maintain the accuracy of the Register of Radio Frequencies and to ensure that licences comply with conditions, and product audits to ensure compliance with electromagnetic compatibility (EMC) compliance standards, have been well received by the industry.

Since we introduced our programme, we have completed a total of 7 454 audits of licences and 2 014 EMC audits. The compliance rate of licence audits has risen from 88% to 92% while the compliance rate for EMC audits increased from 91% to 92%.

The Register of Radio Frequencies (RRF) is publicly available online through the Spectrum Management and Registration Technology (SMART) website. Not only is it the official record of tradable spectrum rights, but it is also an engineering database for managing interference between radio services.

RSM manages a comprehensive programme of auditing to ensure the integrity of the register.

4 Licence audits

In 2006-2007 RSM conducted a total of 1 781 audits of licences covering individual and multi-transmitter facilities. In licence audits RSM identified 148 offences that resulted in warning notices and 82 offences that resulted in infringement notices.

In 2005-2006 RSM conducted a total of 2 562 audits of licensed facilities and 67 major radiocommunication sites. RSM issued 177 warning notices and 37 infringement notices as a result of licence and site audits.

Unlicensed transmitters accounted for 29% of the notices issued, while fixed links accounted for 24% and FM transmitters accounted for 11%. The remaining notices went to a wide variety of services including land mobile, radio broadcasting, and television broadcasting.

Along with the unlicensed transmitters, non-compliance was primarily found to be over-powered links, incorrect locations, and frequency or bandwidth errors.

Status of licences audited

– Existing licences 76%
– Revoked licences 9%
– New licences 15%

Licence audits per licence type

– Radio licences 80%
– Spectrum management rights (Crown) 10%
– Spectrum management rights (Private) 10%

Licence audits were targeted to those considered to be at greater risk of non-compliance, for example persistent offenders. The result was a decrease from last year in the percentage of licences found to be compliant.

5 Electromagnetic Compatibility (EMC) compliance audits

RSM conducted 676 audits of electrical and electronic products to determine compliance with Electromagnetic Compatibility (EMC) standards in 2006-2007. RSM also conducted 143 audits of compliance folders to determine whether they were properly maintained.

Special attention was given to wireless devices commonly used for Internet service provision.

6 Audits of licensed radio station facilities

RSM will undertake random licence audits accounting for 5% of current licences including existing licences, new licences, and cancelled licences.

7 Who can be audited?

Radio Spectrum Management (RSM) may audit any person, company or organization transmitting radio waves including:

– Existing radio or spectrum licence holders.
– Radio or spectrum licence holders of recently cancelled licences.
– Persons operating under a general user licence.

8 Licence Audit requirements in general

All transmissions of radio waves in New Zealand are required to be authorized by a licence. Every person who transmits radio waves otherwise than in accordance with a licence commits an offence. Note that some general conditions apply to all licences, including the requirement to grant entry to authorized inspectors, at all reasonable times to any place, premises or building for the purposes of ensuring compliance with the licence.

9 Requirements for operation under a general user licence

General user licences provide for certain classes of radio transmitter to be used without the need for the owner to obtain a licence in their own name. Provided the equipment meets the applicable technical standards, operates only on the allocated frequencies and meets any other requirements specified in the licence, the equipment may be freely used by anyone.

10 Requirements for radio licence holders

Radio licences are subject to annual fees. Although no expiry date may appear on the licence, failure to pay the annual fee will result in the revocation of the licence. The contents of a radio licence will at a minimum specify the:

– name of the licensee;
– location;
– frequency(ies) or frequency band(s) that apply to the transmission of radio waves, or the frequency(ies) or frequency band(s) that apply to the protection, if any, afforded from harmful interference from co-channel emissions;
– class of radio licence (category and type of radiocommunication service).

11 Requirements for spectrum licence holders

Spectrum licences are granted for periods up to 20 years and also require payment of an annual fee. Failure to pay the fee will result in the revocation of the licence. The spectrum licence will specify the:

– name of the right holder;
– location of the transmitter or, where the transmitter is not a fixed location, the area within which the transmitter may transmit pursuant to the licence;
– maximum power of emissions permitted;
– unwanted emission limits applying to emissions from the transmitter, expressed as the maximum e.i.r.p for such emissions;
– class of emissions permitted;
– horizontal radiation pattern;
– antenna polarization;
– antenna height (for a transmitter at a fixed location);
– location(s) at the receive coverage location(s) applying to the licence; or an area as the receive coverage area applying to the licence and specifying the maximum permitted interfering signals applying to that location or those locations or that area;
– commencement date;
– expiry date of the licence;
– conditions applying to the exercise of the right holder's rights.

12 Why have audits?

Regular radio licence inspections and site audits are RSM's proactive way of maintaining the integrity of the Register of Radio Frequencies, and promoting voluntary compliance. This minimizes the likelihood of interference as well as the costs associated with legal compliance action.

Proactive auditing provides RSM the opportunity to:

– Ensure that the transmission is authorized by a licence.
– Ensure that licence conditions are met.
– Promote sound management and engineering of radio licences and transmission sites.
– Strengthen relationships with the radio industry.
– Maintain the value and usability of the radio-frequency spectrum in New Zealand.

13 What are the audit selection criteria?

General

RSM will randomly select licences to be audited from the database, but will target "high risk" licences and "at risk" sites. A Radio Inspector may also decide to perform an audit if:

– monitoring or other information indicates an unlicensed operation;
– an interference investigation indicates operation of unlicensed or faulty equipment;
– a previous record of non-compliance with licence conditions or interference history exists;
– a written complaint is received.

High risk licences

"High risk" licences have the potential to create greater interference than others. For this reason, there is a greater emphasis on auditing these services. "High risk" licence services include multi-user sites, typically used for:

– land mobile;
– fixed;
– broadcasting.

At risk sites

RSM has identified numerous "at risk" sites which are being heavily used for radiocommunication purposes. These sites are highly likely to experience interference problems.

14 What is the auditing process?

RSM will randomly select licences to be audited from the Register of Radio Frequencies to target "high risk" licences and "at risk" sites. The audits are planned in advance and the licence holder is normally given at least 10 days notice. A Radio Inspector will contact the licence holder to arrange a time. If a serious risk to radiocommunications has been identified, or interference is occurring, a Radio Inspector may arrange to conduct an audit immediately. These spot audits are designed to avoid any disturbance to the radio spectrum, while optimizing RSM compliance resources and maintaining the integrity of the compliance framework.

If the permission of a land or property owner is necessary to gain access to the property where the transmitters are located, the Radio Inspector will either arrange that permission directly or will ask the licensee to do so.

The Radio Inspector may ask to take equipment off air during the audit. No equipment will be disconnected unless the licensee or agent consents to this requirement.

During the audit, the Radio Inspector may conduct measurements and record details including:

– Check with GPS locations and altitudes to confirm grid references.
– Note of all transmitters, receivers and associated equipment.
– Note of antenna type, polarity and azimuth and height above ground.
– Note of coaxial cable type and length.
– Details of any transmitters found unlicensed.
– Note of all technical parameters.
– Photographs of transmitting equipment or site.

A checklist to prepare the client for an audit of their radio transmitter(s):

– Do you have a current licence?
– Is the transmitter located at the licensed location?
– Are all licence conditions complied with, including frequency, power, bandwidth, emission type, antenna polarization and radiation pattern, number of sets?
– Is site access available?
– Are there any safety issues to be considered?
– Have any other affected parties (site owner, co-users) been notified?

15 Outcome of audits including business objectives

When all elements of the audit have been considered, RSM will advise the client of the outcome.

If the audit is deemed satisfactory, the client will receive a letter indicating that no further action will be required. 90% of clients subject to audit will be notified of the audit outcome in writing within 10 working days.

If the audit is deemed unsatisfactory, the client will receive either a warning notice or an infringement notice. 90% of warning notices or infringement notices will be issued within 28 working days. The Enforcement section of the Compliance Guide provides more information.

AUDIT PROCEDURE

(FOR AUDITING RADIO/SPECTRUM LICENCES AND MULTIPLE USER SITES)

SELECT RADIO/SPECTRUM LICENCES TO BE AUDITED

Radio Inspectors/Contact Centre:

1. At month beginning, generate a report of all new radio licences issued in the previous month for your district.
2. Select at least 5% of the total number of new radio licences from your district. These licences will be audited within the next 12 months.

(a) Licence Selection Factors

There are many interrelated reasons that will influence your selection of licences to audit. Please consider the following circumstances when making your selection:

(i) "High Risk" Licences

Some radio licence services have the potential to create greater interference than others and are therefore termed "High Risk" radio licences. For this reason, a greater emphasis on auditing these services will be applied. High-risk radio licence services include, but are not limited to:

– **Land mobile services** (Two-frequency, simplex, trunk dispatch, trunk service, miscellaneous).

– **Fixed** (Point to point, point to multipoint, radiodetermination, satellite, met aids, radio astronomy, telemetry & telecommand).

– **Broadcasting** (FM, AM, television and any other stations which come under the definition of 'broadcasting' viz. Low-power GURL).

– **Aeronautical** (Aircraft, mobile, land and repeater).

– **Maritime mobile** (ship, mobile, repeater, coast).

(ii) (Removed Nov. 2003)

(iii) Reason to believe: Where you have been informed of unlicensed operation or a potential interference problem an audit may be carried out.

(iv) Previous record: Where a service provider is known to have poor standards or engineering practices a service may be targeted.

(v) Monitoring: If an unlicensed or out of specification service is discovered when monitoring then an audit may be carried out.

(vi) Interference history: Where site users have suffered interference in the past more emphasis may be placed on audits.

(vii) Practical selection: For practical reasons, if other new radio licences exist on the same site as one selected under 2I, then these can also be audited and can be included in the 5% target.

(viii) The apparatus to which the licence relates is not operational; **OR**

(ix) The licence relates to a site that is remote or in a seasonally inaccessible location by Radio Inspectors; **OR**

(x) The process of auditing the licence will cause severe inconvenience to the licence holders business and/or their clients; **OR**

(xi) The licence has passed an audit within the past 12 months.

PREPARE AUDIT VISITS

The following guidelines will assist Radio Inspectors and the Contact Centre to prepare for audit visits.

A pre visit checklist is also provided in the appendices. (SITE AND LICENCE AUDIT CHECKLIST)

For licence audits, create cases to record all work with the SMART audit sampler. The sampler will create cases for each licence to be audited.

(a) The Contact Centre will distribute SMART New Licence reports to offices on a monthly basis.

(b) The Regional offices will indicate on the New Licence reports those licences suitable for audit and return the report to the Contact Centre.

(c) The Contact Centre will undertake to contact licensees selected to ascertain whether licence is operational, obtain details of licensee contact personnel and enter details into SMART thereby creating a new Compliance Case. The licence audit compliance case is then forwarded to the respective Radio Inspector.

(d) All work, including travel relating to the case, is to be recorded in SMART as "time" in the "case details" page:

1. Determine the test equipment required.
2. Estimate the time required for the audit visit.
3. Contact the licensee and site manager to request permission to conduct the audit.
4. Obtain the landowner's permission to access the property.
5. Enter appointments(s) in the weekly planning schedule.
6. Make common appointments for site users where possible.
7. Check site weather conditions – do conditions allow access?
8. If a site file exists then take the hard copy for history/reference.
9. Consider safety and recording aspects to assess the number of Radio Inspectors required for the audit

CONDUCT AUDIT VISITS

1. A checklist for conducting licence and site audits is provided in the appendices. (SITE AND LICENCE AUDIT CHECKLIST). Take this and a copy of the licence with you when you are in the field.
2. As you conduct the licence audit fill out a "SITE OR LICENCE AUDIT REPORT", (refer to the appendices) a spreadsheet report (see R:\Operations\Field\Site Audits\Site audit report spreadsheet), or alternatively endorse licence parameter compliance on a copy of licence.
3. When conducting audits, be aware of any physical and radiation hazards. Use the radiation detector if in doubt.
4. If equipment needs to be taken off air, ensure the licensee/operator is aware of this in advance.
5. If any unlicensed equipment is found, then a full inspection should be done.
6. Photographs: Photograph masts with a reference height at the base so that estimates of heights and cable lengths may be made later if necessary. The Abney level and tape measure may be used to calculate antenna heights. Photograph installations for transmitter/receiver/filter/power supply equipment types so they may be used later.
7. Some buildings may be difficult to access due to size (dog box type). It may be a two-man operation with one testing and the other scribing.

8. There may not be mains power available at the site so ensure you are self sufficient.

9. Remember, the information you collect may be used as evidence during prosecution cases so make thorough and complete records.

POST AUDIT PROCEDURE

1. Post audit visit: Compare all measurements with the licence details and conditions. (Use the SITE OR LICENCE AUDIT REPORTS, a spreadsheet report or copy of licence.)

2. If the operator or user is licensed AND the measurements comply with the licence details and conditions, go to: PASSED AUDITS PROCEDURE.

3. If the operator or user is not licensed OR a measurement does not comply with the licence details and conditions, highlight the discrepancy and go to: FAILED AUDIT PROCEDURE.

4. A post-visit checklist is provided in the appendices. (SITE AND LICENCE AUDIT CHECKLIST.)

PASSED AUDIT PROCEDURE

1. Licence and Site audits are "PASSED" if:
   (a) the operator or user has a valid licence; **AND**
   (b) the operator or user is operating within their rights and in accordance to the specifications and conditions of their licence.

2. Notify the licensee of the outcome within 10 working days of the audit. This may be an interim report if further action is contemplated.

3. Attach an audit report or note the location of the audit report on the case sheet, where the report is attached to a primary case. Any other relevant documents are to be attached to the case as an "event".

4. Record all work as SMART timesheet entries.

5. Close compliant cases as "satisfactory".

FAILED AUDIT PROCEDURE

1. Licence and Site audits are "FAILED" if:
   (a) the operator or user does not have a valid licence; **OR**
   (b) the operator or user is operating outside of their rights or not in accordance to the specifications or conditions of their licence. The cause of failure may be MINOR infringements or MAJOR infringements.

Examples of MINOR infringements include:

(a) Equipment faults (as opposed to equipment installed or operated outside of licence conditions or product standards) causing interference to broadcast or commercial services **(please check with Compliance Officer when safety frequencies have been affected)**.

(b) Small power variations (<6 dB).

(c) Small location variations (<400 m).

(d) Excessive bandwidth (not causing interference).

(e) Frequency tolerance errors (not different channels or causing interference). Any suspicion that it may be a deliberate error should be discussed with the Compliance Officer.

A "minor" infringement will generally be dealt with by the process in BP 01.12.

Examples of MAJOR infringements include:

– Incorrect frequency or channel fitted.
– Significantly incorrect site (i.e. at another location, >400 m distant.).
– e.i.r.p. level significantly greater than that specified (>6 dB above specified).
– Non approved or incorrect specification equipment.
– Operating without a valid licence.
– Continued minor offence not rectified.
– Antenna parameters incorrect.

A "major" infringement will generally result in the immediate issuing of an INFRINGEMENT NOTICE (refer to the appendices).

1. If the audit reveals any discrepancies or licence infringements, make a record of this on the case in SMART.
2. Go to: "WARNING NOTICE" for minor infringements.
3. Go to: "INFRINGEMENT NOTICE" for major infringements.

Appendix A
to Annex 6

Site and Licence audit checklist

Site and Licence audit checklist

Previsit

- ☐ Obtain report on all licensed site services or those licensed in the last 30 days.
- ☐ Choose licences or site to be audited.
- ☐ Create hard copy file for the audit.
- ☐ Generate a Master compliance case to record all preliminary work.
- ☐ Send 'audit request' letter to licensees and obtain contact details.
- ☐ Contact site manager or licensee for permission and access information
- ☐ Check site file for history and reference.
- ☐ Determine the number of buildings and transmitters on site.
- ☐ Generate a compliance case for each licence to be audited
- ☐ Determine which services will be tested for compliance and those to be noted.
- ☐ Obtain landowner's permission if necessary.
- ☐ Arrange access with site manager/licensee or user.
- ☐ Estimate time required before making appointments.
- ☐ Make common appointments with site users where possible.
- ☐ Enter appointments in the Outlook shared calendar.
- ☐ Determine test equipment and vehicle requirements.
- ☐ Is mains power available at the site?
- ☐ Check weather conditions.
- ☐ Assess staff numbers needed for safety or recording.

Site visit

- ☐ Radiation hazards – use the radiation detector if any doubt.
- ☐ Does equipment need to be taken off air? If so, ensure operator/licensee is aware.
- ☐ Complete an inspection report.
- ☐ Note any locations and altitudes with the GPS if only to confirm grid references.
- ☐ All transmitters, receivers and associated equipment should be noted.
- ☐ Any unlicensed transmitters should be fully inspected.
- ☐ Note all technical parameters and compare with the licence. Evaluation of these may be possible only in the office.
- ☐ Note antenna type, polarity and azimuth and height above ground – take pictures.
- ☐ Note coaxial cable type and length – take a tape measure.
- ☐ Is the information you have of sufficient quality to be used as evidence?
- ☐ Photograph masts with a reference height at the base so estimates of heights and cable lengths may be made later.
- ☐ Photograph installations – racks, transmitters, receivers, filters and power supplies.
- ☐ Note that some buildings may be difficult to access owing to size. (dog box type). It may require two people – one testing, another scribing.
- ☐ Ensure self sufficiency if mains power is not available.

Post visit

- ☐ Compare all measurements with the licence details and conditions.
- ☐ Highlight any discrepancies.
- ☐ Open further compliance cases for any unlicensed equipment discovered.
- ☐ Prepare Infringement Brief for Warning Notices and / or Infringement Notices.
- ☐ If no infringements, then arrange the letter confirming compliance and thanks.
- ☐ Close compliant cases in the MIS after recording all information on the case sheet. Retain all photographs on the computer file.
- ☐ If equipment is non compliant then follow the "Failed licence/site audit guidelines".

Appendix B
to Annex 6

Site or Licence audit report

Ministry of Economic Development
Manatū Ōhanga
Radio Spectrum

Site or Licence audit report

Site name:	Grid ref: Correct? Y/N
Licensee name and address:	GPS ref:
	Date of audit:
	Site audit ☐ Licence audit ☐
	Prisms I.D.

	Frequency/Chl	Tolerance	Emission	Specification	Power	Mod%/Deviation	Antenna type	Pol	Gain
Authorised									
Measured									
Complies Y/N									
Licence No:	Equip make:			Case No:					
Remarks:									

	Frequency/Chl	Tolerance	Emission	Specification	Power	Mod%/Deviation	Antenna type	Pol	Gain
Authorised									
Measured									
Complies Y/N									
Licence No:	Equip make:			Case No:					
Remarks:									

	Frequency/Chl	Tolerance	Emission	Specification	Power	Mod%/Deviation	Antenna type	Pol	Gain
Authorised									
Measured									
Complies Y/N									
Licence No:	Equip make:			Case No:					
Remarks:									

Radio Inspector:____________________ Date:__________________ District:______________________

Page 1 of …… pages.

Annex 7

Inspection procedures for earth stations in Brazil

1 Introduction

This text gives an overview of measurement procedures used by Anatel (Brazilian National Telecommunications Agency) to verify satellite earth stations compliance with national radio spectrum regulations.

The procedures presented here are generic either for national trunk system earth stations or for very small aperture terminals (VSAT), taking into account if the link uses a GSO (geostationary orbit) or non-GSO satellite.

2 Geographic coordinates measurement

In the licensing process, computers based algorithm calculates the azimuth and elevation angle of antenna based upon on the geographic coordinates and satellite orbital position.

In regulatory field enforcements, inspectors use GPS receivers to confirm if the real antenna geographic coordinates agree with the licence coordinates. The inspector must be sure that the GPS receiver is operated in accordance to best practices, allowing it to provide an accurate measurement. If possible, should be preferred the use of equipments that provide on screen evaluation of the accuracy in order to ensure that the current result is within the required tolerance.

3 Antenna height measurement

Even though the antenna height may be considered insignificant with respect to the satellite link extension, the height is relevant criteria in a frequency coordination process between satellite and terrestrial microwave links, whenever shadows and obstructions occur causing interference, leakage or signal interruption.

The height is measured from ground to the antenna geometric centre. This task is normally accomplished using a measuring tape or a laser range finder. The main difference between these methods depends on the minimum and maximum distance measurement capabilities, the resolution and accuracy.

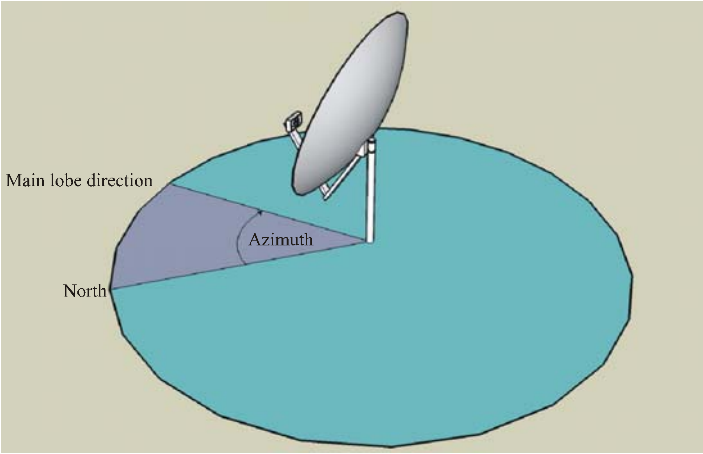
Range finders usually have a limit on the minimum measurement distance. Range finders usually have a minimum distance operating range from 5 to about 20 m and resolution on the meter scale. Measuring tapes can provide measurements up to 50 m on a scale of centimetres or millimetres. For antennas installed near the ground, the measuring tape is usually the best choice.

4 Antenna azimuth measurement

Antenna azimuth is the angle measured clockwise between the geographic north direction and the main propagation lobe direction. In practice the main lobe direction correspond to the axis from the feeder horn through the parabolic reflector symmetry centre.

FIGURE 14

Measuring the azimuth



Rap 2130-14

Generally the instrument used to measure the azimuth is the magnetic compass. Unfortunately, this instrument does not point to the geographic north, but to the magnetic north. The angle between the geographic north and the magnetic north is known as magnetic declination and changes slightly with time and strongly with location. The azimuth value can be obtained by subtracting the declination value from the compass reading.

The two main alternatives to obtain the declination value are the surface magnetic field maps and software calculators. In Brazil, the National Observatory provides both the regional magnetic maps and the software, where new maps with referenced data are released each five years. This information is collected from 110 measurement locations and there are two monitoring stations providing continuous measurements. Worldwide, this information can be obtained from various observatories and organizations, including on-line services provided by different web services.

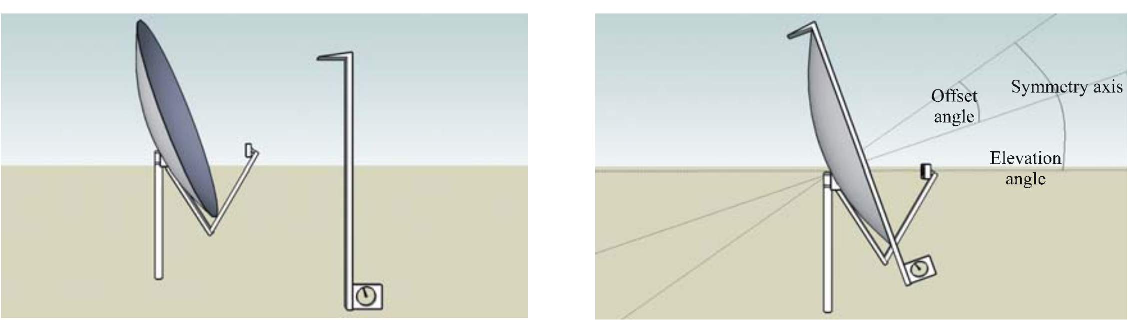
5 Elevation angle measurement

The elevation angle to the satellite is defined as the angle between the horizontal plane and the satellite position in the sky. Although relevant to antennas in general, it has a special relevance to satellite antennas due to their typical shapes and the fact that elevation errors can affect interference. Except in offset antennas, the satellite position is referred to the parabolic reflector symmetry axis.

On the other hand, the angle between the symmetry axis and the horizon can be measured with an inclinometer tied to a rod that should be placed on the parabolic borders. This angle is coincident with the elevation angle in axisymmetric design antennas.

FIGURE 15

Using an inclinometer to measure the elevation angle



Rap 2130-15

Among other shapes, there are practical advantages involving the selection of offset designed antenna, particularly the small dishes. Indeed, for offset antenna, since the reflector is a section of the parabolic and considering that the focal point is below to the symmetry axis, the shadow zone due to the feeder is eliminated. Furthermore, since the elevation angle is greater than the symmetry axis angle, the reflector stands in a more vertical position avoiding rainwater or snow accumulation. In this particular case the elevation angle can be found as follows:

$$\text{Elevation angle}_{\text{offset}} = \text{Symmetry axis angle} + \text{Offset angle}$$

The offset angle can be found on the antenna documentation. As an example, the SKY Patriot.76 Meter Ku-Band has an offset of 22.75°.

6 Frequency measurement

The earth station transmitter frequency measurement procedure can be done using a spectrum analyser in either cursor mode (less accuracy, standard model) or counter mode (high accuracy), or a reference frequency meter. The measuring instrument is usually connected to the attenuated output test point of earth satellite system HPA (high-power amplifier).

Due to practical considerations, for example, in the absence of the HPA test point connector, the measuring instrument RF input may be connected to an antenna or field-strength probe installed nearby in a suitable side lobe of the parabolic antenna under inspection. Hence, the procedure will be affected by the conditions on the installation, taking into account the test instrument's sensitivity and time base accuracy, the signal-to-noise ratio, S/N, and the station's frequency tolerance.

7 Power measurement

In practice, if the station does not have a built-in calibrated output test point derived from a directional coupler inserted between thee HPA and transmission line/antenna, then the power measurement task could be difficult and should be avoided unless the transmission line could be disconnected from the HPA where a digital through-line wattmeter must be inserted between then. To overcome this drawback, the inspection staff may decide to verify only the nominal transmitter power as informed in the station documentation. Otherwise, if the power measurement is strictly required then the inspector has to schedule a test time window with the earth station owner in order to install a directional coupler or trough-line wattmeter sensor to accomplish the measurement.

The effective isotropic radiated power (EIRP) can be found as follows:

$$\text{EIRP} = \text{Forward power} + \text{Antenna gain} - \text{Losses}$$

Care must be taken to assure that the power meter, the sensors and the directional coupler are calibrated at least to the carrier frequency and able to operate within the expected power levels. All electrical connections must be assured with the aid of a torque meter tool prior to power the system.