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Conatel

THE SPECTRUM MANAGEMENT AND MONITORING SYSTEMS (SAAGER) IN USE IN VENEZUELA

Technical description

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1 Venezuelan Spectrum Management and Monitoring System

1.1 Introduction

This document will deal with the Spectrum Management and Monitoring System presently in use by CONATEL of Venezuela.

The document is divided up into three parts:

- Part one – An overview of the SAAGER system explaining the number of Control Centers and Monitoring Stations available on the network along with a diagram of the system layout.
- Part two – The Spectrum Management System, this is a functional description of the software and contains the make up of the system and its operation. It also contains examples of the types of reports, graphs and screens that are available to the operators.
- Part three – The Spectrum Monitoring System, this is also a functional description and contains the screens, tools and software configuration for the stations.

This paper does not contain the hardware specifications of the antennas, receivers and processors that run the system. The SAAGER system is a fully ITU compliant Spectrum Management and Monitoring system and the hardware used in it meets or exceeds the specifications laid down in the ITU's Spectrum Monitoring and Spectrum Management handbooks.

1.2 System Overview

The Automated Radio electric Spectrum Administration and Management System (SAAGER) allows the Ministry of Infrastructure (MINFRA) acting through the National Telecommunications Commission (CONATEL) to effectively utilize the radio electric spectrum. The system consists of a National Control Center (CNC) in Caracas; five Auxiliary Control Centers (CAC) at regional centers throughout the country; ten Mobile Units (UM); and ten Portable Equipment Sets (EQP); all in a fully integrated system.

The CONATEL system has the following abilities:

Planning and management of the radio electric spectrum.

- Planning of spectrum resources.
- Provides the latest ITU compliant technology that is expandable to permit growth as Venezuela's telecommunications infrastructure grows.
- Enables cooperation with neighboring countries about frequency assignment needs and interference problems.

Monitoring and technical verification of radioelectric emissions.

- Performs all ITU-recommended radioelectric measurements.
- Avoids and resolves interference problems during the installation and operation of critical services such as cellular telephones, terrestrial microwave links, private mobile radio, and wireless local loop.
- Provides CONATEL's monitoring staff with a list of noncompliant signals and their characteristics.
- Identifies and prosecutes illegal operators to collect revenue and protect legitimate operators of the spectrum from interference.

Radiolocation of radio electric emissions.

– Determines lines of bearing and locations of interfering, illegal or other noncompliant signals as an aid to enforcement of the Venezuelan radio regulations.

Standardization of telecommunications equipment.

– Maintains a type-approved telecommunications equipment database so that only approved equipment is licensed in Venezuela.

The system consists of the following:

National Control Center (CNC) **–** Located in Caracas; acts as the hub of the system, housing the Spectrum Management System Database; generates operational tasks, directs and controls operational activities of the stations; receives and consolidates the resulting data.

Auxiliary Control Centers (CAC) **–** Located in Caracas and four other regional centers; provides monitoring and technical verification capability at a defined location.

Mobile Units (UM) **–** Provides HF/VHF/UHF monitoring capability and HF/VHF/UHF (three units) or VHF/UHF (seven units) capability in a mobile configuration, adding flexibility to the system. TCI will provide a total of ten (10) Mobile Units.

Portable Equipment Sets (EQP) **–** Provides technical verification capability in a portable configuration. CONATEL will provide a total of ten (10) Portable Equipment Sets.

2 Spectrum Management System

The SAAGER system described in this paper is a fully integrated and ITU-compliant spectrum management and monitoring system tailored to CONATEL requirements and needs. The Management Application Software has many key advantages that are worth noting before describing the operational functionality of the CNC and CACs:

2.1 Introduction

This section provides the functional description of the Spectrum Management System used in the SAAGER System. The table below contains the section topics.

1) Introduction

2) Application Processing

3) Frequency Assignment

4) Licensing

5) Spectrum Engineering

6) Spectrum Monitoring

2.2 Application Processing

The Automated Spectrum Management System provides for data entry of applications for service. This is an important function of the spectrum management process, enabling the administration to perform frequency assignments and licensing functions. An application can be for new service, modification to an existing license, or modification to a pending application.

2.3 Frequency Assignment

The Automated Spectrum Management System assists the SAAGER operator with the frequency assignment functions:

- Showing possible channels for a particular equipment and service.
- Searching the license database for existing assignments and displaying those for the various possible channels.
- Performing interference calculations between the proposed new assignment and existing assignments.
- Entering new assignments in the database.

The SAAGER System follows the ITU Recommendations and Reports.

2.3.1 Frequency Assignment Process

The System supports the automatic assignment of frequencies, including ITU service designations and national service priorities and footnotes. The software also includes the ITU Frequency Allocation Plan for the Venezuelan Region.

An operator has the system display channels consistent with the Venezuelan national frequency allocation plans, specified equipment types, planned types of services/operations, or operators categories. The system searches its database for existing assignments on these channels and displays them. Interference calculations between existing assignments and a proposed new assignment may be made. The operator may then assign a frequency, which is entered into the database. The operator is able to use a wide range of engineering tools described below in Section 5 for analysis.

If it is not possible to find a usable channel in a particular region, one or more of the ASMS spectrum engineering analysis tools can help the operator to locate an available channel based on geographic area or find a frequency within the region that can be shared based on hours of operation.

2.3.2 ITU and National Frequency Allocation Plan

The System operator has the ability to review and update the frequency allocations to each station class. Parameters include frequency range, station class, channel width, and constraints such as co-channel separation distance.

2.3.3 Border Coordination

The International Coordination module of the SAAGER System includes functions and features for processing of incoming coordination requests and preparation of outgoing coordination requests for frequency assignments with other government agencies, neighboring countries in South America or the ITU Radio Bureau for: HF, VHF and UHF stations, terrestrial microwave stations, and Geo-stationary Satellite Earth stations.

The System is provided with a single database table and form for tracking license applications wherein coordination is underway. In each case, the license application number from the licensing system, the nature of the data, date of submission, party receiving the communication, and the transmission format (paper or electronic) are logged into this database by the individual frequency managers.

2.4 Licensing

The Automated Spectrum Management System automates most of the license processing and issuing functions. As part of the initial system set-up the existing data was transposed into the format required for the new database and installed.

2.4.1 License Process

A license is created after an application has been processed. The System provides a form-based interface supporting the following activities:

- Issue a temporary license or permit.
- Convert a temporary license to a permanent license.
- Renew an existing license for which all conditions of renewal have been satisfied.
- Terminate a license for non-compliance with existing requirements for operation.

2.5 Spectrum Engineering

The Automated Spectrum Management System was built with a set of powerful tools to assist the SAAGER operators in performing Spectrum Engineering. These tools and the reports they produce are described below.

2.5.1 Engineering Analysis Tools

One of the tools is the Engineering Analysis module, which is used for the study of radio link performance, base station coverage and electromagnetic compatibility (EMC) calculations. The analysis tools and calculation algorithms/models are appropriate for specific bands and types of services required for license application, coordination requests and interference complaints.

The Engineering Analysis module uses propagation models recommended by the ITU to calculate propagation predictions in all frequency bands (Table 2-2).

TABLE 2-1

Engineering Analysis Module Propagation Models

Propagation Model	Commentary
GRWAVE	GRWAVE computes the electric field strength and path loss with distance for ground wave propagation along a curved, homogenous, smooth earth. It is also used for the MF band interference analysis.
IONCAP, VOACAP	IONCAP is the name of the original ionospheric analysis program. The most current version, called VOACAP, has been integrated in the Engineering Analysis module. This program can calculate the MUF, LUF and FOT for point-to-point HF communications.
Rec. 435-5	Ground and sky wave propagation program for frequencies between 150 to 1 600 kHz. It uses the sky-wave prediction method described in the Annex of CCIR Rec. 435-5.
TIREM (Version 3.04)	Acronym for Terrain Integrated Rough Earth Model. Developed originally for the U.S. National Telecommunications Information Administration (NTIA) as a part of the Master Propagation System (MPS). MPS is a family of models which stretch from VLF to Millimeter Wave Frequencies.
Longley-Rice	U.S. Federal Communications Commission (FCC) Tech Note 101, documents the use of Single Knife Edge (SKE) and Double Knife Edge (DKE) diffraction models where prominent terrain features are known for a particular propagation path.
SEAM	Acronym for Single-Emitter Analysis model, it calculates propagation loss and field strength for microwave signals using a Free Space or Smooth Earth propagation model.
Appendix 7	Calculates coordination contours for terrestrial stations and Geostationary satellites according to the ITU Radio Regulations, Appendix 7.
Appendix 8	Calculates interference between two Geostationary satellite networks according to the ITU Radio Regulation, Appendix 8.

The Engineering Analysis utilizes a Geographic Information System (GIS) mapping program to display the calculated data in graphical form over a geographic and topographic map. The GIS is integrated into the Management Software, and is automatically activated when needed by the system.

The Engineering Analysis module includes the following features:

- Analysis of candidate frequency assignments selected for applications received.
- Analysis of candidate frequency assignments for incoming coordination requests.
- Automatically uses the correct algorithm/model for the frequency band and type of service being analyzed, including operator requests where appropriate.
- Manually select alternate algorithms/models from a menu of available algorithms and models for use in the analysis of specific cases.
- Displays the results of propagation analysis over a digitized map incorporated in the system.
- Displays potential interference cases in graphical format with operators-selectable map data.

The Engineering Analysis module includes utilities to perform the following functions:

Detailed propagation analysis with results in graphical and tabular report formats.

Calculation of AM, FM and TV broadcast station service zone coverage.

Analysis of both existing and proposed transmitters and receivers as potential sources and victims of interference.

Complete interference analysis report in tabular format identifying all stations with frequency assignments involved in an interference analysis.

Frequency assignment analysis of candidate frequencies for newly received applications.

Analysis of proposed transmitters as potential sources of interference to other transmitters and receivers.

Base station radial path profiles and coverage diagrams.

Co-channel, adjacent channel and interstitial channel interference analysis.

Multi-signals 3^{rd}, 5^{th} and 7^{th} order intermodulation analysis.

2.5.1.1 LF/MF Analysis

The Engineering Analysis module uses ground wave and sky wave propagation models to compute path propagation loss and field strength at frequencies from 0.15 to 3 MHz. The LF/MF Analysis Tools are based on the ground-wave propagation program GRWAVE and the sky-wave field strength prediction program REC435. Using the information from the database about a transmitter, the tool determines the circuit geometry, calculates the electric field strength and basic transmission loss over a homogeneous smooth, curved earth with exponential decreasing refractive index (GRWAVE) and cymovactive forces, polarization coupling loss, hourly loss factors and median field strength using sky-wave prediction methods (sky-wave). The REC435 model uses the sky-wave prediction method described in the Annex CCIR Rec. 435-5.

2.5.1.2 HF Analysis

The Engineering Analysis module uses the IONCAP/VOACAP propagation model to compute propagation loss and field strength in the 2 to 30 MHz frequency band for ground-wave and sky-wave propagation. IONCAP takes antenna gain patterns into consideration in the calculation routine.

The HF Analysis tool evaluates circuit performance parameters to select optimum frequencies, proper antennas, required transmitter power, optimum time of operation and broadcast coverage as a function of time and frequency.

Using the information from the database about a transmitter, the tool determines the circuit geometry, selects areas of the ionosphere to sample, and evaluates the magnetic field in these sample areas. It considers ionospheric parameters and all possible ray paths for the circuit, including high and low angle modes, E, F1, and F2 modes, above the MUF modes, and sporadic E-modes.

2.5.1.3 VHF/UHF Analysis

The Engineering Analysis module provides the following functions and features of special importance for frequencies in the 30 MHz to 1,000 MHz band:

- Calculation of point-to-point link performance.
- Calculation of base station coverage.
- Analysis of potential interference between candidate frequencies and co-channel, adjacent channel and interstitial channel frequencies.

- Analysis of potential intermodulation interference between candidate frequencies and all combinations of existing frequency assignments within search limits which combine to produce multi-signal third order intermodulation frequency products.
- Analysis of potential receiver desensitization and transmitter noise interference to candidate frequencies from adjacent transmitters.
- Calculation of predicted FM and TV broadcast station interference zones.

These tools use ITU recommended propagation algorithms to compute propagation loss and field strength in the VHF/UHF frequency range. These algorithms include the TIREM and Longley-Rice. The models take into account transmitter characteristics, antenna characteristic, antenna height above average terrain, topographic terrain profile, and average soil and climate conditions.

2.5.1.4 Microwave

The Microwave analysis tools compute propagation loss and field strength for signal up to 40 GHz using the Free Space or Smooth Earth propagation model. The calculations are based on the Single-Emitter Analysis Model (SEAM), which perform calculation to determine received signal level at specific propagation distances or the propagation distance at which specific signal levels can be received for point-to-point terrestrial microwave links.

2.5.2 Satellite Analysis

The Link Analysis and Electromagnetic Compatibility for Satellites analysis tools calculate propagation for ascending and descending links among satellites and earth stations. The system will automatically calculate the distance and the angle between the ground station and satellite. The system will also calculate the signal to noise ratio, and the propagation loss in free space between the transmitter and receiver.

The module includes Satellite Appendix S7 analysis tool, which uses the ITU Digitized World Map (IDWM) and the GIS elevation database to find land and sea distribution paths in 72 azimuths around the earth station for the Mode I mixed path propagation calculation.

This module provides the following functions for Satellite Link and EMC Analysis, frequencies from 1 to 40 GHz band:

Calculation of Coordination Contours for Terrestrial Stations and Geostationary Satellites according to the Radio Regulations, Appendix S7.

Calculation of Interference between Geostationary Satellites according to the Radio Regulations, Appendix S8.

Calculation of the Angle Elevation for Geostationary Stations.

Analyze potential Interference between possible microwave terrestrial networks and existing microwave terrestrial networks.

2.5.3 Engineering Reports

The Spectrum Engineering analyst accesses the Spectrum Engineering module to analyze the electromagnetic environment and obtain reports. On selecting a required report, the system presents a screen where the operator enters all the necessary parameters and then may select the format of the report (tabular or graphic). The following reports are available from the system:

1) Link Analysis and Path Loss.

2) Propagation analysis.

3) Field Strength Contour.

4) Shadow Plot.

5) Service Area Analysis.

6) Interference Analysis.

7) Terrain Profile Plot.

8) Intermodulation Analysis.

9) Electromagnetic Compatibility (or EMC) Analysis Tool.

10) Antenna Height Analysis.

11) Microwave Frequency Planning.

12) Satellite Appendix 7.

13) Satellite Appendix 8.

2.6 Spectrum Monitoring

The Automated Spectrum Management System is integrated with a Spectrum Monitoring System to assist the CONATEL administration in performing spectrum control. Integration allows the management system to task and receive reports from the monitoring system, and allows the monitoring system to automatically access the management system's license database.

2.6.1 Management and Monitoring Integration

The software consists of integrated sets of functional modules operating with a common relational database. The fully integrated system is supplies outstanding control, reporting and data-exchange. The management functional modules are organized to comprise a logical basic process for assignment and licensing with functions that also provide data to or utilize data from the database. The modules operate as function supplementary modules for related building blocks in a process, using input data from and providing resultant output data to the database.

2.6.2 Automatic Violation Detection (AVD)

One of the most important advantages of a completely integrated system is the central feature of Automatic Violation Detection. The integrated Spectrum Management and Monitoring System compares measurements from the monitoring system with CONATEL's licensing information to identify frequencies on which there are transmitters that are not included in the license database and to identify transmitters that are not operating within their licensed parameters. Automatic violation detection allows the operator to define a monitored range, by specifying the start and stop frequencies of the band(s) to be searched, and to specify search parameters including the time period over which the search may be done.

2.6.3 Complaint and Violation Investigation

The System is used to manage the investigation of complaints and violations. Complaints are stored in the database for tracking. Once a complaint is determined to be new, the spectrum monitoring software can be used to collect measurements for further investigation. For example, the Automatic Violation Detection measurements can measure license violations corresponding to the frequency in a complaint.

The software provides the query capability to search for similar complaints or violations. There are a number of engineering analysis tools which can be used to analyze the complaint.

The System includes three forms for working with complaint information: a Complaint Form, an Inspection Form, and a Violation Form. The Complaint Form includes information describing both the incident that caused the complaint and the person making the complaint. The Violation Form is used to record information about violations received in connection with a complaint. The Inspection Form is used to record information about inspections in connections with violations and complaints.

The System software allows the review of the complaint, collected spectrum data, and engineering analysis reports. The staff may elect to reject the complaint or to take other action, such as fining a license holder or terminating a license.

3.2 Spectrum Monitoring Stations

This chapter describes the monitoring stations that are part of the SAAGER system presently in use by CONATEL of Venezuela. These monitoring stations perform all of the monitoring and radiolocation functions required of an ITU-compliant monitoring station. Each of the stations has several important features that CONATEL required:

A full 10 MHz of instantaneous bandwidth at VHF/UHF that provides the spectrum monitoring operators with the ability to make measurements over the full bandwidth.

Effective acquisition and measurement of intermittent, broadband and frequency agile signals made possible by the instantaneous bandwidth.

A panoramic display that can show up to 10 MHz of the spectrum allowing the operators to visualize large portions of the spectrum, locate interferors, and identify the types of signals and interference he or she is seeing.

A network architecture that allows any workstation to perform any function in the system. For example, an operator at the management system or at another location can get DF bearing results from monitoring stations and use them for emitter location by triangulation or homing.

Sensitive antennas so the mobile station may be used to collect monitoring and DF measurements while the vehicles are in motion.

Passive rather than active antennas, which is important because active antennas simply do not perform in the strong signal environment present in many areas.

Modern digital signal processing (DSP) techniques, which allow great flexibility in adding capability in the future.

Ability to perform all ITU-recommended electromagnetic monitoring and technical verification measurements.

Avoiding and resolving interference problems during the installation and operation of critical services such as cellular telephones, terrestrial microwave links, private mobile radio, and wireless local loop.

Identification and prosecution of illegal operators to collect revenue and protect legitimate operators of the spectrum from interference.

Radiolocation of electromagnetic emissions; determining lines of bearing and locations of illegal or other noncompliant signals as an aid to radio regulations enforcement.

3.1 Technical Verification and Radiolocation Unit

The Technical Verification and Radiolocalization Unit is one of the bureaus of CONATEL. It is responsible for conducting monitoring and technical verification, spectrum occupancy and radiolocation, including:

Preparation of technical verifications and radiolocalization of radioelectric emission plans.

Analysis and recording of the results of technical inspections.

Generation of technical verification and radiolocalization reports.

Report on occupation of the radioelectric spectrum.

Radiolocalization of authorized and unauthorized radioelectric stations.

The Technical Verification and Radiolocation Unit performs its tasks from the National Control Center, where the equipment to perform the tasks is remotely controlled, or at the Auxiliary Control Centers, where equipment is locally controlled, or from a combination of the CNC and CAC. In any case, whether control is remote or local, the operator positions have exactly the same computer software available to them.

The following sections describe the capability of the Monitoring System, which performs the Technical Verification and Radiolocation functions required by CONATEL.

3.2 Spectrum Monitoring System

The Spectrum Monitoring System is operated from Client workstations accessing the Measurement Servers on the network and installed at each of the monitoring stations. The operator interface uses standard Windows conventions. As this is an integrated system, there is no need to set-up instruments for different measurements or actions, and operators can concentrate on preparing specific tasks and retrieving results. This section describes the main operational features available to the operators.

The Monitoring Server software provides a network connection for the “Interactive” mode and another for “Scheduled” measurements. A third network connection is provided by the Windows NT Operating System to synchronize time service between a Monitoring Server and Clients.

Interactive Mode allows direct interaction with instantaneous feedback, such as monitor receiver tuning, demodulation and spectrum panoramic display selection. Note: Direction Finding actions may be “immediate” or “scheduled”.

Scheduled (Calendar) Mode provides a calendar feature where Monitoring Clients may reserve time slots on a selected Monitoring Server to make requested measurements. A single Monitoring Server is able to handle requests from multiple Monitoring Clients. Note that once the measurement task has been sent to the Server, the Client may disconnect from the link until it needs to retrieve the results.

Windows NT Time Service to synchronize Monitoring Client computer time to Monitoring Server time via the time service available under the Windows NT operating system.

3.3 Monitoring Software

This section of the paper will deal with the “Monitoring” software that is installed at the monitoring stations. The same software is used for all the monitoring stations with limitations set by the types of DF and monitoring systems installed. If only VHF/UHF antennas and receivers are present the system is unable to monitor and display HF frequencies. The section is further divided by the following:

- System Tools
- Monitor Receiver
- Displays
- Pushbutton DF

- Netted DF
- Netted Fix
- Homing DF
- Homing Fix
- Metrics
- Spectrum Occupancy
- DF Scan
- Automatic Violation Detection (AVD)
- Mission Folders BITE
- Monitoring Simulation for Training

3.3.1 System Tools

3.3.1.1 Network Setup

The Network Setup screen shows a list of Available Stations (Servers) to which the operator has access and a digital map display.

3.3.1.2 Map Display and Control

The map window displays network stations (including Mobiles), results of DF operations and location of emitters (with error ellipses). The coordinate display window shows either the Lat/Long or UTM coordinates (selectable) of the cursor. If the system is configured with multiple maps, these may be selected in the Display Control window. The Operator may display multiple layers (cities, regions, rivers etc.) of the selected map. The operators may select zoom in, zoom out, pan, center, or measurement function. Azimuth and distances can be measured with the screen cursor. Two points are selected and the system will display *Azimuth and Distance* (kilometers) between selected points.

3.3.2 Monitor Receiver

Operator control of the Server station receiver is through a monitor receiver screen at the Client workstation monitor, which is shown in Figure 31. This screen has familiar controls associated with typical standalone receivers, providing interactive control of the receiver unit to view the signal being monitored in real-time. Receiver status information and controls for frequency, modulation, and amplitude control are displayed on the same screen.

FIGURE 31

Monitoring client monitor receiver screen

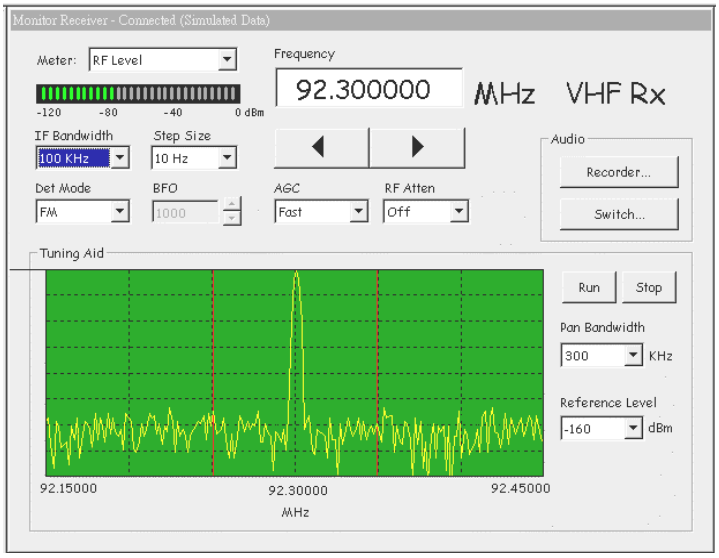

Table 3- lists the facilities available to the Operator when operating the monitor receiver screen.

TABLE 3-1

Monitoring Client Monitor Receiver Controls

Field/Button Item	**Description**
Meter and LED	The LED horizontal bar meter shows the input RF Level to the receiver.
Frequency	This edit field displays the currently tuned frequency. The control can be manually edited, or tuned by step-size with the < > buttons below it.
IF Bandwidth	Provides selections of filters that may be used during monitoring to exclude unwanted signals or noise from the signal of interest. Possible values are: • 300 Hz for HF band • 1 kHz, 3 kHz, 6 kHz for both HF and VHF • 12.5 kHz, 25 kHz, 50 kHz, 100 kHz, 150 kHz for VHF Vertical red lines on the PAN display show the receiver bandwidth setting. All signals outside the red lines will not be heard during monitoring operations.

TABLE 3-2

Monitoring Client Monitor Receiver Controls

Field/Button Item	Description
Step Size	Specifies how much the Frequency will increase or decrease when using < > buttons. Possible values are 100 Hz, 1 kHz, 10 kHz, 100 kHz and 1 MHz. This control is set to "100 Hz" by default the first time the dialog box is displayed after launching the program.
Det Mode	This drop-list provides several demodulation options or detection modes to allow the operator to listen to modulated signals. Possible values depend on the current frequency band. Possible values are AM, CW, USB, LSB and FM.
BFO	Sets the Beat Frequency Offset from the carrier and is displayed in Hz. This control is only enabled when the CW Det Mode is selected. Possible range of values are from –8 000 to 8 000 Hz.
AGC	This drop-list provides control of the receiver's behavior to noise and fading. Possible values and their respective equivalents in units of time are: • Fast = 100 msec • Medium = 500 msec. • Long = 2 seconds
RF Atten	Controls the receiver *RF Attenuation*.
Tuning Aid Run/Stop Bandwidth	This X-Y plot displays frequency versus amplitude. The vertical red lines on the PAN display show the current receiver *IF Bandwidth* setting. The area between the red lines is the receiver passband. The Pan display may be activate or stopped with the "Stop"-"Run" buttons. Vertical scaling is fixed at 10 dB per division.
Recorder	This button activates the Audio Recorder dialog box.
Switch	This button activates the Audio Switch Settings dialog box.
Pan Bandwidth	This drop-list controls how much of the spectrum is displayed by the PAN window. The possible selections are: • 1.25 kHz, 2.5 kHz, 5 kHz, 12.5 kHz, and 25 kHz for HF bandwidths • 5 kHz, 12.5 kHz, 25 kHz, 50kHz, 100 kHz, and 300 kHz for VHF bandwidths. The values in this control are passed to and from the PAN display dialog box.
Reference Level	This drop-list controls the base value of the amplitude (y-axis) in the PAN display. The possible selections are –60 dBm, -80 dBm, -100 dBm, -120 dBm, -140 dBm, and -160 dBm. The value of this control is passed to the Pan display dialog and vice-versa when switching between dialog boxes. The reference line position is fixed at the bottom of the display.

3.3.3 Displays

3.3.3.1 Pan Display

The Spectrum Panoramic (or Pan) display is an X-Y plot of signal amplitude versus frequency and can display up to a 10 MHz bandwidth of IF digital data. This type of display is very useful in viewing and identifying wideband signals, signal relationships in the radio spectrum, and to investigate sources of interference.

TABLE 3-3

Monitoring Client Pan Display Controls

Field/Button Item	Description
Pan Controls – BW	Allows the operators to select the bandwidth from the drop-down list. Maximum Bandwidth is 10 MHz.
Cursor Controls	Activates a marker on the display for frequency, amplitude and peak value. Marker frequency and amplitude values are indicated below the display screen.
Display Control Center Freq Reference Level	Center Freq. displays the current center frequency of the signal. Reference Level allows the operators to change the value of the signal level grid displaying the signal.
Relative Frequency	Toggles the Pan display to show data relative to the center frequency. The center frequency becomes the 0 point.
Plot Type Pan Waterfall Spectrogram	This allows the operators to change the display of the signal being tracked in different graphical displays. The operators can toggle between the Pan, Waterfall, and Spectrogram displays of the data being received.

3.3.3.2 Waterfall Display

The Waterfall Display presents amplitude, frequency, and time information in pseudo-3D on the same screen, with trace shifts on the screen over time.

3.3.4 Pushbutton DF

Direct (Pushbutton) DF is one of the principle tools to:

Locate unauthorized and interfering transmitters.

Locate transmitters in distress situations.

Locate non-radio sources of harmful interference.

The Pushbutton DF screen incorporates several other Client screens and consists of six major parts or display sections. These are DF Setup, RX Setup, Polar Histogram, DF Results, Tuning Aid and Map.

3.3.4.1 DF Setup

TABLE 3-4

Monitoring Client DF Setup Control

Field/Button Item	Description
CF (%)	This field is used to select the minimum confidence factor for cuts to be used in the DF calculation process. Possible values are 0-100.

TABLE 3-5

Monitoring Client DF Setup Control

Field/Button Item	Description
BW (kHz)	This edit field tracks the value selected in 'IF Bandwidth' in the 'RX Setup' group. A manual selection of desired DF Bandwidth is also possible. The operator can input a value into the edit field. Possible BW values for manual input are: 1-10 000 kHz.
Dwell (ms)	This edit field is used to select the amount of time the processor will spend (dwell) collecting data on a signal of interest. Possible values are 1 000-30 000 milliseconds (ms).
Request DF	This button sends a DF Request to the Server with the parameters shown in the 'DF Setup' group.

3.3.4.2 RX Setup

Receiver set-up on the pushbutton DF screen is the same as with the monitor receiver screen described in Section 3. See Table 3-1.

3.3.4.3 Polar Histogram

The Polar Histogram group is used to display the DF cuts collected in a polar chart. The cuts histogram is built from the center towards the edge.

All DF cuts satisfying the CF criteria (as specified in the DF Setup group) are displayed in the Polar-Histogram. The cuts are placed into 1° (one-degree) bins (from 0-359 degrees). The longer the line drawn in any bin, the more DF cuts were collected at that bin's azimuth. The main cluster of cuts is used for the average azimuth calculation and displayed in the small "Az" window.

Clusters of cuts can be selected by using the cursor, and a new azimuth result is averaged from the cuts in the new cluster. This allows the operator to identify the azimuth for different clusters (e.g. from two or more emitters operating in the same radio network).

3.3.4.4 DF Results

In this group, the results obtained after the DF request is processed are displayed. The top line in the DF Results shown in Table 3-6 is the latest result and is highlighted.

TABLE 3-6

Monitoring Client DF Results Field Item Description

Field/Button Item	Description
Time and Date	This field indicates the time and date of the completion of the DF request.
Location	This field indicates the location of the Server that accepted and processed the DF request.
Frequency	This field indicates the frequency used in the DF request.
Azimuth	This field indicates the azimuth calculated for the cuts used in the DF result.

TABLE 3-7

Monitoring Client DF Results Field Item Description

Field/Button Item	Description
CF	This field indicates the lowest confidence factor calculated by the processor for the cuts. It is always equal to or greater than the confidence factor that was selected by the operator in the ‘DF Setup’ group.
Cuts	This field indicates the number of cuts used in the statistical calculation.
Sigma	This field indicates the standard deviation calculated for all the cuts used in the DF result calculation.

3.3.4.5 Map Display and Control

Lines of Bearing are shown as lines emanating from the Server.

3.3.5 Netted DF

Netted DF is the basic tool for locating emitters using the monitoring stations available on the network. In order to use this capability, the Operator must have selected at least 2 Servers from the Network Set-Up Screen .

Netted DF operations are controlled from the screen shown in. Map controls are the same as in other screens. Servers selected for the operation are displayed in green. When an emitter is located (FIXed), it is displayed as a red block.

TABLE 3-8

Monitoring Client Netted DF Controls

Field/Button Item	Description
Fix Results Lat, Long UTM	Displays the Latitude and Longitude in degrees:minutes:seconds or Universal Transverse Mercater (UTM) results of the last FIX obtained.
Track Target	Used for tracking the movement of a target emitter. When this box is checked a LOB is returned without clearing the other LOB lines from the map window.
DF Request	This button sends an immediate request for DF to the measurement service.
DF Measurement CF Identity Freq Bw	The CF, Confidence Factor, allows the operators to set a confidence value. Identity displays the description of the signal. This also displays the currently set frequency and bandwidth parameters as set on the Monitor Receiver.

TABLE 3-9

Monitoring Client Netted DF Controls

Field/Button Item	Description
Station Location blocks and Lines of Bearing	When connection to a Server is made, the Station Location blocks are displayed in green. A Red block and LOB indicate that a target has been intercepted and Fixed. Lines of Bearing indicates where the emitter of the signal of interest lies.
Error ellipse	The error ellipse indicates the most likely area where the emitter of the signal of interest may be.

3.3.6 Netted FIX

The returned DF results are used to perform the Netted FIX calculation when valid LOBs are returned from at least two different sites.

Note – An area is provided to manually enter data received from DF stations not included in the Monitoring network.

3.3.7 Homing DF

Homing DF screen provides the means to quickly and effectively find the location of emitters using the Mobile monitoring station(s) while moving. It is a basic tool to locate emitters in urban environments and for investigating sources of interference around the affected sites.

The direction to the emitter is displayed as a needle pointing towards the emitter, relative to the direction of the Mobile station (Left, Right, Forward, Backward). This provides the operator with a means to maneuver the Mobile Station to obtain the best DF readings toward the target emitter.

The Homing Mode results are also displayed on the integrated map display as lines showing azimuth to true north from the position of the Mobile Station at the time of measurement. The Mobile Station position is shown as a red square on the map and is updated with each measurement, thus showing a track of the vehicle movement.

The software processes the LOB data obtained from DF measurement at different vehicle positions and calculates the position or "FIX" on the transmitted signal. The Global Positioning System (GPS) is utilized to record the Mobile DF station location.

Homing DF may be operated using the Auto-Fix procedure or DF request procedure.

When using Auto Fix, DF measurements are made at regular intervals (usually with the Mobile Station in movement). The interval used is the number of seconds as shown in the Repeat Rate pull-down list. The most recent LOB received is displayed in yellow and the previous four are displayed in Grey.

When using the DF Request, the Operator decides when to make the measurements.

Not all DF results are valid. Signal fadings and reflections are a special problem, especially in urban areas. Successful location of a target transmitter may require that the Operator evaluate the validity of a DF measurement, and decide if it were included in the FIX calculation.

The Homing DF dialog works in conjunction with the Homing FIX dialog. All included bearings are given to the Homing FIX dialog. When a specified number of bearings are included (selected in the Auto-FIX Rate pull-down list), a FIX is automatically calculated based on the most recent, specified bearings. These bearings can be seen and either selected/deselected in the FIX window.

3.3.8 Metrics - Task Calendar

The Monitoring Task Calendar is the basic means for operators to task and schedule precise signal measurements – in accordance with ITU Recommendations – for verifications, documentation, and coordination.

3.3.81 Entering Task items

Task items issued to a Server include measurement setups and measurement results. Each item is placed into the Task Calendar and is viewed from the main Task Calendar screen.

TABLE 3-10

Task Calendar Window

Field/Button Item	Description
Hour Increment Bar (12a to 12a)	This display bar shows all Tasks that have been scheduled to run within the entire 24 hour period of the day. The marker color relates to the status of the Task performed.
5 Minute Increment Task list with Scroll Bar	This display region shows a limited amount of 5-minute intervals for scheduled measurements being performed. The operators may scroll up or down to display any 5-minute period of the day. Desired measurement Tasks are listed with the identification assigned to them and a colored box that displays the Tasks status.

3.3.8.2 Measurements

Central to each scheduled Task, are the measurements the operator wishes to perform. The Operator must specify the following basic signal parameters:

Center frequency (approx), Bandwidth, An identifying name, One or more of the following can be selected for measurement as well:

Occupied bandwidth

Modulation

Field strength

Frequency

Direction

TABLE 3-11

Monitoring Client Task Calendar Measurement Tab screen

Field/Button Item	Description
Frequency	To enter the center frequency (approx) of the signal.
Bandwidth	To enter the necessary bandwidth for the modulation mode of the signal to be measured.
Identity	Allows the operators to enter a name for identifying the signal to be measured.
Schedule (D) – Delayed (I) – Immediate	The *<Schedule>* button allows the Operator to select the time for the Task measurements.
Clear	Clears the entries in all tabs of the currently selected Task.
Remove	Removes the currently selected Task from the schedule.
Check Boxes: Bandwidth Modulation Field Strength Frequency Direction	These are toggle switches that allow the operators to gain access or remove access to the additional entry tabs for specific measurement. Placing a check mark into the box by clicking on it gives the operators access to that entry tab.

NOTE – Measurement default values are those recommended by the ITU.

3.3.8.3 Bandwidth

Bandwidth measurements are used to verify if a signal is operating within the licensed bandwidth and report any over-modulations, which may cause interferences. As digital processing techniques (DSP) are used, the occupied bandwidth for all signal types is measured.

The following bandwidth analysis methods may be selected:

Beta %dB - measures the occupied bandwidth using the ITU recommended RR 147 β method

x dB - measures the occupied bandwidth using the x-dB method per ITU-R SM.328.

Averaging Method - provides options by which to average the measurement data.

TABLE 3-12

Monitoring Client Task Calendar Bandwidth Tab Descriptions

Field/Button Item	Description
Beta %dB Setup Checkbox Y (dB) Beta (%)	Bandwidth is calculated per β method (see ITU Handbook) A typical value for β is 99%. Y dB defines the noise floor below, which all FFT bins rejected. A typical value for Y is 6 dB.
XdB Setup Checkbox X1 (dB) X2 (dB)	This method finds the frequency limits such that all spectrum components outside these limits are at least *x* dB below a 0-dB reference level.
Averaging Method: Mean RMS Max Hold	Selection of averaging methods for results from each measurement repetition. Selection of the Averaging Method in the Bandwidth Tab is independent of other choices of Averaging Method. For example: The operators may set a "Mean" Averaging Method in Bandwidth and an "RMS" Averaging Method in the Modulation Tab.
Measurement Time: Dwell (ms) Repeat	*Dwell* sets the measurement duration in milliseconds. *Repeat* allows the operators to specify how many times to repeat the measurement.

3.3.8.4 Modulation

The Modulation tab allows the operators to set modulation characteristics of the signal in the selected modulation modes.

For AM-, the modulation depth m is measured. (m = (Emax – Emin)/(2Ec).

For FM signals, the primary measurement is the frequency deviation.

For PM signals, the primary measurement is the phase deviation.

3.3.8.5 Field Strength

Field strength measurements provide information to determine power compliance of the transmission source as measured at the Server site. When used in conjunction with a Mobile Station the measurements will provide data regarding emitter coverage and levels of interference signals.

Selecting Average Linear, Average Log, RMS or Peak specifies the type of detector used during field strength measurements.

3.3.8.6 Frequency

The Frequency tab allows the operators to measure the actual center frequency of the signal. This measurement is routinely used to verify if a licensed station complies with the required accuracy requirements. The SAAGER system uses the ITU preferred IFM method.

3.3.8.7 Direction

The Direction tab is used to verify the direction of the emitter in relation to the tasked Server.

TABLE 3-13

Monitoring Client Task Calendar Direction Tab Field/Button Item Descriptions

Field/Button Item	Description
Confidence	The *Confidence* factor allows the operators to set a confidence value in percent. Confidence ranges from 1 to 99, with 99 being high confidence. A typical value for confidence is 80.*
Bandwidth	*Bandwidth* allows the operators to enter the necessary bandwidth for the modulation mode of the signal.
Use this Bandwidth (not Measurement BW)	Check this box to specify whether to use the *Bandwidth* entered into the Measurement Tab or the *Bandwidth* entered above.
Measurement Duration Dwell Cuts	*Dwell* sets the measurement duration in milliseconds. *Cuts* allows the operators to specify how many times to repeat the measurement. Server software will finish the DF measurement when either of those two parameters reaches specified value.

3.3.9 Metrics - Task Results

The operator can retrieve results by selecting the desired Task in the Task Calendar and requesting Task Results on the Metrics tool bar to display the results. The operator can view, print and save a report that summarizes the data that was collected.

Measurement results reports contain all the information relative to a measurement setup, a summary of results and includes the following information:

Task Data, Date, Time, Frequency, Bandwidth, Identity, Requested Measurements, Type, Subtype – various type may have more than one method of measurement, Result, Graphical Data

TABLE 3-14

Monitoring Client Task Results Data Screen Item Descriptions

Field/Button Item	Description
Task Data	Task Data displays the date and time the Task was requested to run, the center frequency, the bandwidth and the Identity assigned.
Requested Measurements	Lists by item all entries made in the Task Calendar tabs and the corresponding results
Screen Display Plot Beta	A graphical presentation of the selected Requested Measurement Type for: • Spectrum Analysis: Beta%, XdB bandwidth • Probability Distribution: AM, FM, PM modulation • Histogram: DF • Polar: DF
Print Preview	Area to preview the printed text or plotted report to be printed.

TABLE 3-15

Monitoring Client Task Results Data Screen Item Descriptions

Field/Button Item	Description
Reports	Select for Text or Plot (graph) report.
Save	This saves the report to disk.
Preview	Select to preview a report. The report will display in the Print Preview area as Text or Plot (selected by Reports).
Print	Prints the results report.

3.3.10 Spectrum occupancy

The Spectrum Occupancy tool is the principal means to verify spectrum usage over time. Reporting periods may range from several minutes to several weeks. Thanks to the SAAGER system's multitasking capability, other tasks may be attended to while collecting occupancy data.

Spectrum occupancy gathers information on the "real" spectrum environment, assists in spectrum planning and assignment, tracks interference or improper spectrum usage and long-time usage of the spectrum channels. The SAAGER system follows ITU recommendations for Spectrum Occupancy. The CONATEL Regulatory Agency uses this facility to collect statistical data continuously from selected monitoring stations.

To get an occupancy report the following parameters must be defined:

One or more frequency bands to monitor.

The channel widths within each band.

The period of time over which to collect data.

Signal collection threshold level.

One or more graphical presentations of the occupancy results.

3.3.10.1 Occupancy results

Partial results may be obtained once the task has been initiated at the Server and its database is being up-dated for the length of time specified for the measurement.

TABLE 3-16

Monitoring Client Spectrum Occupancy Results Screen Descriptions

Field/Button Item	Description
Occupancy Tasks	*A* table that lists the current tasks and their status. Each row displays the following information: Task ID Number, Start Date and Time, Stop Date and Time, and Task Status (such as running, suspended, or completed). On selecting a task, results may be retrieved, the task paused, ended or deleted.

TABLE 3-17

Monitoring Client Spectrum Occupancy Results Screen Descriptions

Field/Button Item	Description
Get Results	To retrieve results for the highlighted task. The graphical representations for the task will load into the Results window. This button will not be enabled until results are available. Monitoring Client will always try to retrieve the latest data available from Monitoring Server. If Monitoring Client is not connected to any Server, the button can still be clicked, however, it will only plot the last retrieved results stored in the local (Client) database.
Pause/Resume	To suspend the highlighted task. Click again to resume.
Terminate	To end the highlighted task. As a precaution, the system asks for confirmation before terminating the task. A terminated task can not be re-started, but any results it may have gathered are available.
Delete	To permanently remove the highlighted task from the table. As a precaution, the system asks for confirmation before deleting the task. A deleted task is permanently removed from the database. This includes its task ID number, its setup parameters, and any results it may have gathered.
Chan	To define the graph horizontal axis in terms of channel. Channel numbering begins at one. The number of channels in a band is determined by the channel bandwidth and frequency range in the *Band Li*st table in *Spectrum Occupancy* dialog box.
Freq	To define the graph horizontal axis in terms of frequency. The start and stop frequencies correspond to the range entered in the *Band List* table in *Spectrum Occupancy* dialog.
Graph Title	The selected type of graph appears in this window. Use the horizontal scroll bar to bring additional portions of the graph into view. Result graphs include: • Field Strength vs. Channel / Frequency • Message Length vs. Channel / Frequency • Occupancy vs. Channel / Frequency • Time of Day vs. Occupancy
Results	This two-dimensional graphical control displays the currently selected graphical result from the results list box. The maximum number of data points displayed is one hundred points. The graph is equipped with a horizontal scroll bar beneath it in order to scroll when more data must be seen.
Results List Box	• Clicking the <**Get Results**> button loads a listing of requested graphs into this window and an item can be selected for viewing.

TABLE 3-18

Monitoring Client Spectrum Occupancy Results Screen Descriptions

Field/Button Item	Description
Band #:	• Click the up/down arrows to choose a band for display. Band numbers correspond to the Band List table on the Spectrum Occupancy screen.
Channel #:	• Click the up/down arrows to choose a channel for display. This control is active only for *Occupancy versus Time graphs*.
Reports Task Info Single Band Plots	To obtain printed reports of occupancy task results or to save them to disk. • Mark this checkbox to request a text report of the task parameters and task results. • Mark this checkbox to request a graphical report. The report pertains to the single band you have chosen in the Band # box.
Save	To save the Task Info and/or Single Band Plot report to disk. A standard dialogue box will appear to designate the destination folder.
Preview	To get an on-screen preview of how the printed report(s) will look. If both Report checkboxes are checked for previewing, selection between the two can be made under the preview screen's Window menu.
Print	To print the Task Info and/or Single Band Plot to the default printer.

3.3.11 DF Scan

The DF Scan screen supports scanning mode DF. DF Scan gives the operator the ability to enter scan band(s). Channel lists are entered to include or exclude frequencies. The operator selects band or channel DF scanning but can not enter both at the same time.

The specific DF screen items are given in Table 19. All other screen entries are similar to other applications:

TABLE 3-19

Monitoring Client Direction Finding Scan Field/Button Item Descriptions

Field/Button Item	Description
Noise Riding	To specify a signal threshold level for the DF Scan measurements. Only signals that exceed this threshold are considered when compiling measurement statistics.
Duration	To set the length of time to run the DF scan.
Storage Interval	To specify the storage interval. Storage interval is the time between updates of the database.

TABLE 3-20

Monitoring Client Direction Finding Scan Field/Button Item Descriptions

Field/Button Item	Description
Number of Azimuths	To select a DF resolution for the Scan data to be displayed in the DF Scan results screen.
Azimuth Range Start / Stop	These edit fields are used together with their respective spin buttons to specify a range of azimuth values of interest. Only azimuth data between these ranges are displayed when data is retrieved. Start azimuth may not be greater than Stop Azimuth. Default values are 0 – 360 degrees.

3.3.11.1 DF Scan Results

Scan mode results are presented in tabular and graphic form and may be printed on the system printer or the operator may copy the image to a Microsoft Word document to include the graphic result in a printed report.

3.3.12 Automatic Violation Detection (AVD)

Automatic Violation Detection *(AVD)* is a powerful tool incorporated in the SAAGER system to allow verification of compliance by licensed emitters and detect unlicensed operations.

AVD operates in conjunction with license data (frequency assignments) downloaded from the Management System database. AVD determines whether a particular transmission complies with tolerances of assigned center frequency and bandwidth, as specified for the allocated band and service in the Venezuelan National Frequency Plan table. It will also report frequencies operated without a corresponding license in the Management database.

AVD measurements can be performed on a single-frequency or on a range of frequencies specified by the operator. The set-up is similar to other measurements with special provisions for importing Management License Information:

- **Last Time Imported:** Displays the last date and time when the license information was imported.
- **Import:** starts the transfer of license information from the external file into the local database.
- **Show Map:** to display the area map with all the licensed sites.

3.3.12.1 AVD Results

The AVD Results Screen shows a list of the frequencies tested and specifies whether they are: Compliant, Non-Compliant, Not Found (signal not found) or Unlicensed. For non-compliant results, the operators can determine whether frequency or bandwidth deviation (or both) is being violated.

3.3.13 Diagnostics – BITE

The Bite is used to verify the technical status of a Server. It tests components of the Monitoring Server with the results displayed in the BITE Status dialog box.

3.3.14 Monitoring Simulation for Training

The Monitoring Software provides for a training mode for new operators. This training mode allows new operators to become familiar with scheduling measurements and controlling the receiver without tying up resources or creating/deleting measurements in the operational monitoring database. With the User's Manual and the on-line help on a laptop or workstation, a new operators can become familiar with the interface, graphical displays, and reports available. The training can be performed without actual monitoring hardware available on the network.

3.4 Spectrum Monitoring System Functions

The SAAGER system performs all of the ITU-recommended measurements, including signal parameter measurements (frequency, field strength and power flux density, modulation, and occupied bandwidth), direction finding, spectrum occupancy, and automatic violation detection, which is recommended in Recommendation ITU SM.1537. The Automatic Measurement Execution System automates this entire process so that operators do not have to learn, remember, or spend time observing the various measurement rules.

3.4.1 Automatic Violation Detection Finds Unlicensed Signals, Sets Alarms

Performing spectrum searches over operator defined frequency bands is necessary for many applications, such as detecting interference, looking for signals that are deviating from their license parameters or looking for unlicensed signals in Venezuela. The automatic violation detection function performs this task. Automatic violation detection allows the operator to define the monitored range by specifying the start and stop frequencies of the band to be searched and to specify search parameters including the time period over which the search may be done. The operators can identify any of the following for purposes of alarms:

Important signal parameters or parameters measured by the system.

Signals that are deviating from their licensed parameters.

Unlicensed signals.

The system will perform a scan over a specified frequency range and for a specified time period. The system uses the measurements obtained from the scan and information from the license database to determine which signals in the measured spectrum are not in the license database and automatically gives a list of frequencies that are being used which are not in the database. The system can also check the most important signal parameters such as bandwidth, and not being on licensed center frequency, and issue alarms where violations are found. Alarms, therefore, alert the operator to unexpected or noncompliant signals based on the search parameters the operator has specified.

3.4.2 Frequency Measurements

Table 3-21 summarizes the measurement performance using the Instantaneous Frequency Measurement (IFM) technique.

TABLE 3-21

Transmitter Frequency Accuracy Recommendation ITU-R SM.377-3

Type of Measurement	Accuracy
1. Measurements of transmitters, except broadcasting stations, in the frequency range 9 kHz to 4 000 kHz	±5 parts in 10^6 or ±1 Hz, whichever is greater
2. Measurement of broadcasting stations in the frequency range 9 kHz to 4 000 kHz	±1 Hz
3. Measurements of transmitters in the frequency range 4 000 kHz to 29.7 MHz	±1 Hz
4. Measurement of transmitters, except TV stations, in the frequency range 29.7 MHz to 2 450 MHz	±0.5 parts in 10^6
5. Measurements of TV stations in the frequency range 47 MHz to 960 MHz	±50 Hz
6. Measurement of transmitters in the frequency range 2 450 MHz to 3 000 MHz	±5 parts in 10^6

Signal frequencies are measured using the IFM vector-data-based DSP method. It is the ITU's most sophisticated and preferred frequency measurement method. This method, in combination with the fact that the time bases of all the receivers are tied to the GPS receiver frequency standard output, ensures that excellent frequency accuracy is achieved.

The IFM method of frequency estimation of modulated signals is accomplished by examining the phase versus time of each time sample of the input signal. A phase ramp occurs because of the difference between the signal's carrier frequency to be measured and the measurement equipment's center frequency setting. A best-fit straight line is calculated for this ramp from which the average carrier frequency is calculated for the time record.

The IFM method is accurate for digitally modulated carriers. The averaging process will converge on the true carrier frequency if the data is random. The random condition is generally met in channels carrying normal data.

3.4.3 Field Strength and Power Flux Density Measurements

Field strength measurements are one of the most fundamental spectrum monitoring parameters and are referenced in Chapter 3.2 of the *1995 ITU Spectrum Monitoring Handbook*. The TCI system is designed to perform accurate measurements to Recommendation ITU-R SM.378-6 over a wide range of signal conditions.

In order to make valid measurements to ITU standards and ensure that everything is working properly, the system is automatically calibrated at every measurement. The instrumentation characterizes signal losses from the RF Distribution Unit (RFDU) to the receiver input. The automation software automatically corrects the data for path losses to provide accurate measurements.

The system also provides measurements of power flux density, which is the preferred emission strength measurement at higher frequencies.

3.4.4 Modulation Measurements

Modulation measurements are essential for checking transmitter compliance and ensuring that adjacent channel interference is minimized. The TCI system is capable of automatically performing AM, FM, SSB. and CW measurements simultaneously or individually. The system measures the modulation depth, deviation, or modulation index by examining the In-phase (I) and Quadrature (Q) components of the signal using DSP techniques. These measurements follow the guidelines of Chapter 3.5 of the *1995 ITU Spectrum Monitoring Handbook*.

3.4.5 Occupied Bandwidth Measurements

Occupied bandwidth measurements are referenced in Chapter 3.4 of the *1995 ITU Spectrum Monitoring Handbook*. The monitoring system uses two ITU recommended methods of measuring occupied bandwidth: the "x" dB and 99% power methods to the accuracy's defined in ITU-R SM.443-2 and ITU-R SM.328-2. For the "x" dB method, the total signal power is used as a reference and the high and low spectral sides are found where the envelope is "x" dB down, typically 26 dB. The occupied bandwidth is then the difference between the high and low side frequencies. For the 99% power method, the measured signal envelope is divided into bins, each with a corresponding power. Bins are then subtracted one-by-one from the upper and lower sides of the envelope until the resulting power falls to 99% of the total power with 0.5% of the power being removed from each side.

3.4.6 Spectrum Occupancy Measurements

TCI provides a spectrum occupancy measurement capability to assist in monitoring spectrum usage, tracking down interference, and performing band-clearing activities. Spectrum occupancy measurements are performed in accordance with Chapter 3.3 of the *1995 ITU Spectrum Monitoring Handbook* and to the accuracy's defined in ITU-R SM.182-4. The system software can measure spectrum occupancy in a variety of ways. For example, the operators can select a "channel scan" to look at specific channels or a "spectrum scan" to scan continuously over a frequency range defined by a start and stop frequency. The system performs the statistical analysis of transmissions and spectrum occupancy.

3.4.7 Direction Finding (DF) Measurements

TCI provides an easy-to-use DF system for determining the Line-of-Bearing (LOB) of a known or unknown (illegal or noncompliant) signal. When more than one monitoring station is assigned, LOBs from each can be automatically combined to determine the source of the signal.

For direction finding activities, the system incorporates digital maps that are overlaid with the line-of-bearing data from the stations tasked with the DF request. For radiolocation, the system provides the capability for coordinated joint operations of multiple monitoring platforms -- Fixed, Mobile or both - usually coordinated by a Control Center.

3.4.8 Reporting Features

The system has flexible text report and graphical report generation capabilities. Reports are based on measurements as well as different data records available in the management and control system databases. The system allows the adaptation or customization of reports according to parameters given by the operators. The system simplifies data with the following variety of reports: raw trace information, carrier analysis by date or band, channel occupancy and availability statistics, message length statistics, channel power statistics, system and alarm logs, and monitoring plan and schedule reports. The following is an overview of the report capability:

Automatic Report Generation

Automatic report generation allows the operator to easily specify reports from any results screen. The operator specifies the report type of interest and the measurement data to be used and uses the “Report” or similar function to generate the text report automatically on screen.

Graphical Reports

In some cases, a graphical report is a preferred method of examining data. Graphical reports provide a view of data, which summarizes the information and makes it easy to identify trends and exceptions. Through the use of color, even more information is conveyed in a single graph. The graphical reports provide a simple and yet powerful method for analyzing and communicating measurement information.