Spectrum and Propagation Measurements

The radio spectrum is a natural resource that offers immense benefit to industry, private citizens, and government by supporting a wide range of radio and wireless applications for communications and sensing. Unlike many other natural resources, the spectrum is non-depleting so it can be used indefinitely. However, active competition for access to the radio spectrum suggests that its shared use will require increasingly more complex planning and coordination tools to ensure its effective use while avoiding increased levels of interference.

Efficient and effective use of the spectrum is a key element in both the NTIA and the ITS mission. NTIA manages the Federal Government's use of the spectrum to ensure maximum benefit to all users while accommodating additional users and new services.

The Spectrum and Propagation Measurements Division of ITS performs measurements of radio signals to support research and engineering promoting more efficient and effective use of today's spectrum, while opening up more spectrum in the future at ever-higher frequencies. The following areas of emphasis are indicative of the work done recently in this Division to support NTIA, industry, and other Federal agencies.

Areas of Emphasis

Radio Spectrum Measurement System Upgrades The Institute uses its Radio Spectrum Measurement System (RSMS) to make spectrum occupancy measurements, and to help assess interference and compatibility issues. The Institute received funding for a major RSMS system upgrade in FY 2002. Details of the RSMS-4 design and development are described in the following separate sections on vehicle, measurement equipment, and software. The project is funded by NTIA.

RSMS-4 Design and Development — Vehicle A new vehicle for the RSMS-4 will provide multiple work spaces for researchers and up to 3 independent measurement systems, along with multiple antenna towers and a controlled environment.

RSMS-4 Design and Development — RF and Measurement Hardware The RSMS-4 measurement hardware will provide multiple measurement systems having improved sensitivity, bandwidth, and dynamic range. In addition to built-in measurement functions, the system supports powerful digital signal processing capabilities.

RSMS-4 Design and Development — Software The measurement and analysis capabilities of the RSMS-4 will be controlled by a greatly-enhanced set of software that will allow weeks of unattended measurements, flexible field modification of system hardware configuration and control software, remote control and monitoring of field operations, and very powerful digital signal processing capabilities.

Spectrum Compatibility Measurements The Institute participates in measurements of the emission characteristics of new or proposed systems to help determine their compatibility with each other and with existing systems. The project is funded by NTIA.

Spectral Assessment of Government Systems The Institute performs measurements on new and established Federal systems to determine their emissions characteristics, to confirm proper operation, or to identify and mitigate interference or other incompatibilities. Projects are funded by NTIA.

UWB Regulatory Activities The Institute has completed measurements to characterize ultrawideband (UWB) devices and interference to conventional radio systems. Current work includes tutorial and advisory help to spectrum regulators and to laboratories attempting initial UWB device measurements. The project is funded by NTIA.

Radio Spectrum Measurement System Upgrades

Outputs

- Uncertainty analysis of RSMS-3 measurements.
- Upgrade of ITS preselector hardware design.
- Functional Measurement Requirements document for RSMS-4.

The Radio Spectrum Measurement System (RSMS) evolves on a yearly basis. Although the Department of Commerce operated vehicle-mounted radio measurement systems as early as the 1920's (Figure 1a), the first such Department of Commerce system of the modern era (RSMS-1) was developed in the mid-1970's and was mounted in a motor home body (Figure 1b). This system provided the first computer-controlled measurements of spectrum occupancy up to 12 GHz, making a detailed statistical description of mobile radio channel usage possible.

A second version, RSMS-2, was designed and developed in the early 1980's and housed an entirely new measurement system in the same motor home body. RSMS-2 provided improved RF sensitivity and measurement capabilities up to 18 GHz in two independent computer-controlled systems. The current version, RSMS-3 (Figure 1c), holds two independent 22-GHz systems mounted in a smaller shielded 4-wheel-drive vehicular configuration, taking advantage of significant advances in commercially available measurement instrumentation and computers.

The RSMS designs have been continually upgraded to keep pace with developments in radio measurement technology, computer control technology, and the changing environment of the radio spectrum. Since the 1970's each version has lasted approximately a decade before requiring major modifications and improvements. In FY 2002, a new RF front end was designed for the RSMS, featuring improved signal handling capabilities.

ITS is currently developing a fourth generation RSMS (RSMS-4). As described in the following sections of this report, the RSMS-4 ushers in the new century and continues the 80-year-long tradition of Department of Commerce mobile radio systems with the development of a state-of-the-art system.

Figure 1a. Original Department of Commerce Radio Measurement Vehicle, 1927.

Figure 1b. First and second generation of modern RSMS (1970s and 1980s) used the same vehicular chassis.

Figure 1c. Third generation RSMS (1990s onward).

Initial efforts were directed toward developing a Functional Measurement Requirements document, (http://www.its.bldrdoc.gov/home/programs/rsms-4/functional_req_v2.pdf) after which the project was split into three areas of development: vehicle, RF and measurement hardware, and software. The Functional Measurement Requirements spell out the kinds of measurements that are expected and desired for RSMS-4 and provided the foundation for decision making in every aspect of the three areas of development.

In FY 2002, with the RSMS-4 under development, a detailed analysis was undertaken in the RSMS Enhancement Program to quantify uncertainties in the RSMS gain calibration routines. This analysis provides the basic foundation needed to compute the uncertainty of RSMS power measurements. In particular, the analysis is a first step towards quantifying, rather than simply estimating, the RSMS system's ability to perform absolute field strength measurements. A quantitative uncertainty budget is needed when making comparisons between data gathered from independent experiments. Without this kind of information it is not possible to evaluate whether a difference between experimental values indicates a discrepancy, or is an artifact of the test process. An added benefit of this work is that it provides an insight into how the RSMS test equipment and measurement routines can be configured to obtain the best possible system performance.

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RSMS-4 Design and Development — Vehicle

Outputs

- Vehicle System Requirements document (http://www.its.bldrdoc.gov/home/programs/rsms-4/vehicle_system_req.html).
- Vehicle procurement specifications.

As part of the ITS program to upgrade the Radio Spectrum Measurement System (RSMS), in FY 2002 a new measurement vehicle was designed and fabrication is now underway (see Figures 1 and 2). Although the key to the design of this new vehicle/enclosure is (as always) to provide a safe, comfortable, and productive operating environment for the operators and the measurement equipment, this new design provides somewhat different capabilities than the earlier RSMS vehicle. The new design was derived by carefully reviewing the older RSMS measurement vehicle and incorporating many suggested improvements into the new design.

The RSMS program utilizes a movable platform to perform measurements in locations ranging from those with no facilities to those with facilities including security, communications, and electrical power. The major changes from the earlier RSMS vehicle include:

1) the requirement that the enclosure be able to be disconnected from the vehicle and operated in a self sufficient mode. This will allow the enclosure to be shipped or moved without the added weight of the truck.

2) shielding of the enclosure with a minimum of 60 dB of shielding effectiveness over 100 MHz-26 GHz to be tested in accordance with IEEE Std 299-1997.

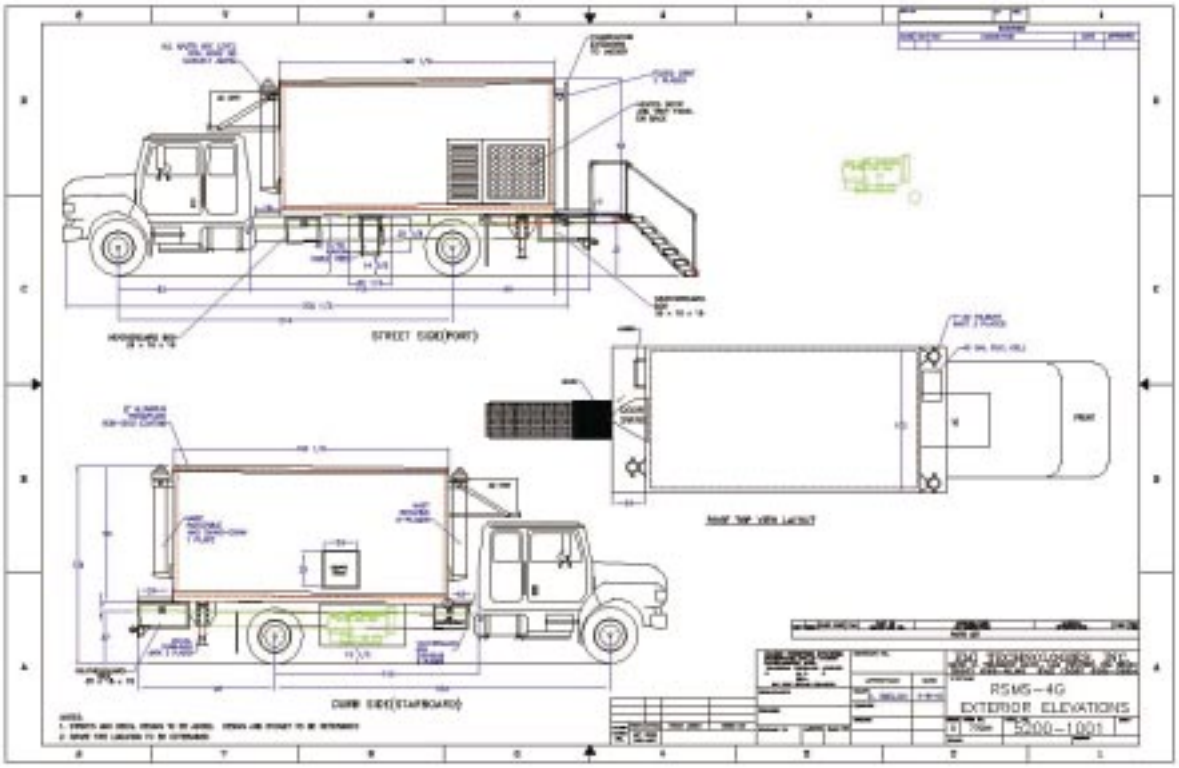

Figure 1. Side view of the RSMS-4 vehicle.

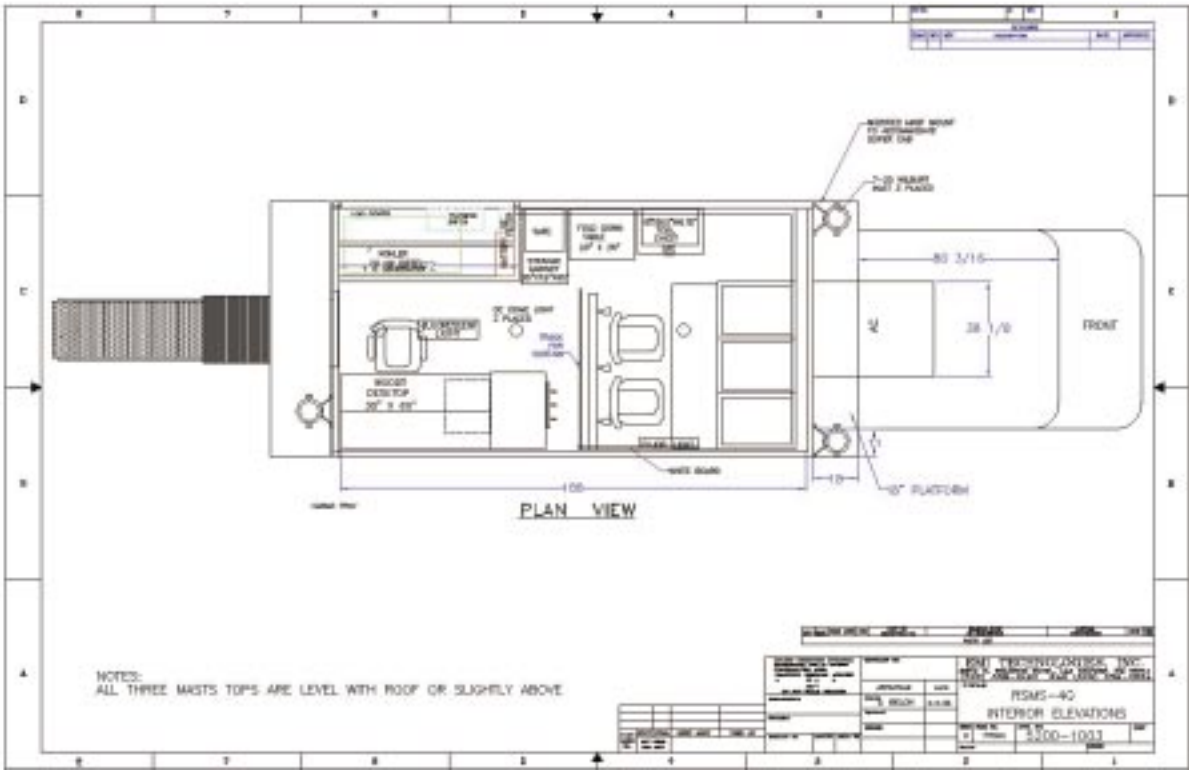

Figure 2. Side and top views of the RSMS-4 vehicle.

3) a dual power system which will operate from 110/220 VAC, as well as deep cycle rechargeable batteries. An on-board generator and fuel system will support 96 hours of continuous generator operation under 3/4 load conditions.

The new RSMS vehicle will support up to three primary operator positions, each with its own measurement system, and three 30-ft rotating pneumatic antenna towers. The technical particulars of the individual measurement systems are included in other articles in this section. The multiple measurement systems will allow efficient simultaneous measurements of multiple bands, as well as intensive multiple-perspective measurements of single-band problems. The shielding and DC power systems are intended to enable uncontaminated local noise measurements.

The vehicle will be based on a chassis with heavy-duty transmission and powerful engine, able to easily climb steep grades to hilltop sites, but also cushioning the ride with an air suspension to protect the electronic equipment payload. Adequate storage for supplies, electronic equipment and antennas, classified records, and measurements will be provided. The entire vehicle and payload must weigh less than 26,000 lb, so that it can continue to be driven by non-commercial licensed drivers.

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RSMS-4 Design and Development — RF and Measurement Hardware

Outputs

- RF and Measurement System Requirements document that defines the design parameters.
- Conception, selection, and acquisition of instrumentation for a measurement system.
- Design of an ITS-built 0.5-26.5 GHz preselector.
- Design of an ITS-built 0.1-1000 MHz preselector.

The RF and Measurements project was a part of the ITS program to upgrade the Radio Spectrum Measurement System (RSMS) to a fourth generation system. The primary goals included identifying and acquiring the instrumentation and accessories needed to create a modern state-of-the-art measurement capability. The need to measure the wider range of RF technologies present today, that is expected to expand even more in the future, demanded a system design that has more versatility, adaptability, and measurement capability. Future measurement needs were compared with current instrument capability to identify what could be achieved with Commercial-off-the-Shelf (COTS) equipment and what would require ITS-designed and -built devices. The result is a new generation RF and Measurement system.

The design effort started with the Functional Measurement Requirements document, which describes the functions that the RSMS-4 shall perform. This set of requirements was global to the entire program. To provide this project with more specific guidance, an RF and Measurement System Requirements document was created. This document applied quantitative specifications to the functional requirements, providing a practical set of measurement parameters for the RSMS-4.

A major task involved the system design and the selection and acquisition of instrumentation for the RSMS-4. The designer had to define a collection of instruments that would satisfy the system requirements shown in Figure 1. Signals enter the measurement system and depending on the frequencies of interest, the High or Low frequency preselection stage is enabled. After preselection, the signal enters the measuring instruments. The Spectrum Analyzer is used primarily to make frequency-domain and time-domain-envelope measurements. The chosen unit is faster, more accurate and has a modern detection capability (root mean square or RMS) that is critical to future spectrum management challenges. Measurement bandwidths up to 8 MHz are available and an IF output provides a downconverted signal with a 30-50 MHz bandwidth. The vector signal analyzer is used to analyze magnitude and phase properties of the signal. It is also capable of analyzing the modulation format and modulation parameters. This "vector" look at signals is a powerful new enhancement that allows for a more thorough characterization of unknown signals. The digital oscilloscope can capture signals directly (in the time domain) for frequencies up to 1 GHz and indirectly beyond 1 GHz using the IF output of the Spectrum Analyzer. Since the RF spectrum is, for the most

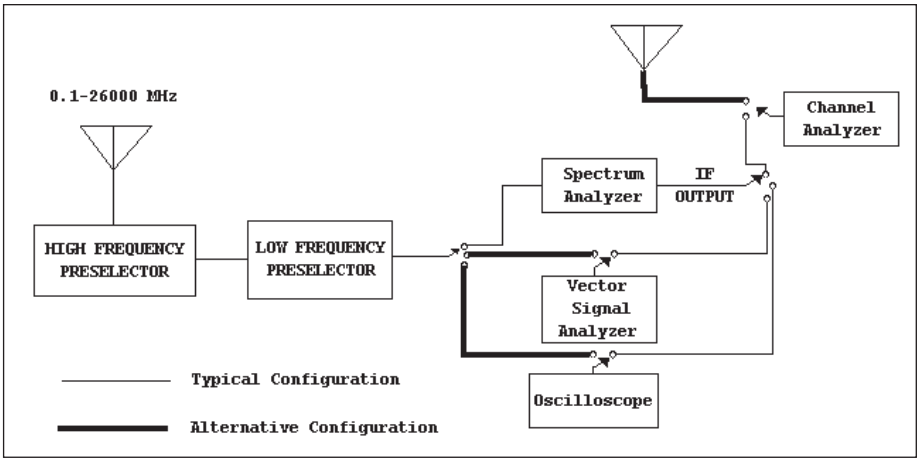

Figure 1. High-level block diagram of an RSMS-4 measurement system.

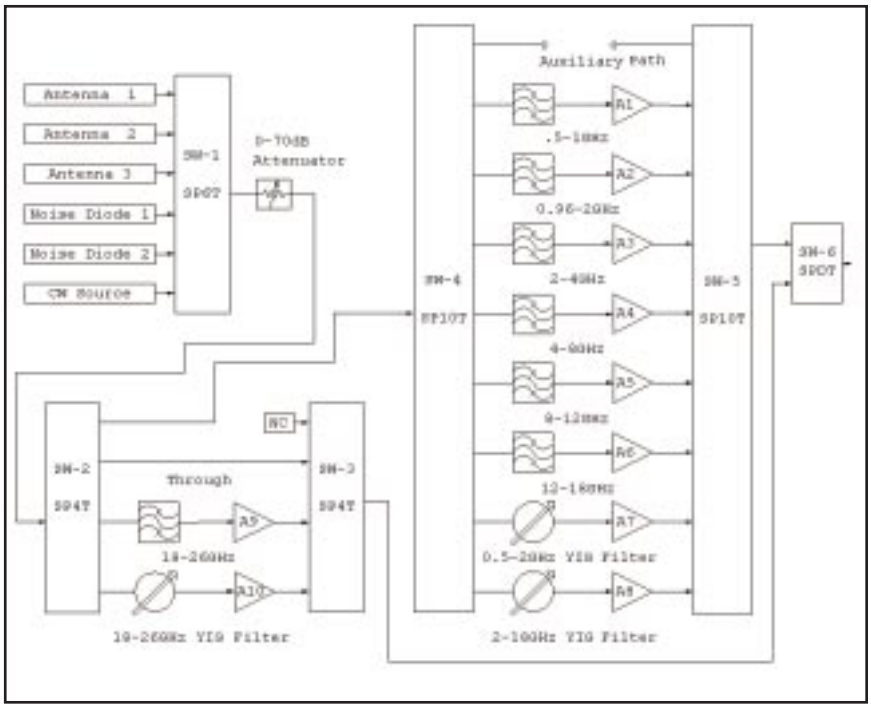

Figure 2. Block diagram of the ITS designed 0.5-26 GHz preselector.

part, divided up into individual channels which are assigned to individual users, the channel analyzer is used to examine the transmissions within these channels. This analyzer is extremely quick at categorizing various parameters of a signal within a channel as well as processing many channels per second to provide accurate statistics. This collection of instruments was chosen to meet the measurement needs of today and the future.

Preselection is the processes of selecting the signal (or a portion of the signal) for measurement, from an environment of multiple signals, and can be used to enhance the measurement system's sensitivity and dynamic range. The block diagram of the 0.5-26.5 GHz Preselector (High Frequency Preselector) is shown in Figure 2. On-board noise diodes and a port for a CW signal are available to calibrate the measurement paths. A stepped attenuator is used to prevent front-end overload and increase the measurement range of the system. Bandpass filtering with amplification is used to optimize sensitivity, selectivity and the dynamic range of the measurement system. A noise figure as low as 3.5 dB was achieved with noise figures under 10 dB available for all frequencies under 18 GHz, providing for a very sensitive measurement system. To handle signals with large amplitude excursions, the dynamic range was kept above 94 dB, rising to 108 dB for some frequencies.

A 0.1-1000 MHz Preselector (Low Frequency Preselector) was designed with similar goals as the 0.5-26.5 GHz Preselector except that it contains some additional functionality. The lower frequency filtering and amplification stages provide noise figures under 10 dB reaching as low as 3.6 dB. In addition to RF preselection, this unit provides some intelligence to the system through the use of a single board computer (SBC) which can accept commands from a controlling computer to set its own and the other preselector's configuration. The SBC is responsible for keeping the tunable filters tracking the measuring instrument while automatically compensating for changing temperature effects and tracking hysteresis to improve the quality and accuracy of future measurements.

Overall, the RF and Measurement team has created a new generation measurement system that will improve the quality of measurements, increase the speed at which information can be gathered, and add new measurement capability, while providing growth potential to meet the future needs of spectrum management.

Recent Publications:

"RF and Measurement System Requirements," http://www.its.bldrdoc.gov/home/programs/rsms-4/rf_meas_sys_req_v4.pdf

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RSMS-4 Design and Development — Software

Outputs

- System Requirements Document (http://www.its.bldrdoc.gov/home/programs/rsms-4/software_sys_req.pdf).
- Use-case Statement that describes how the software will operate from the user standpoint.
- Architectural design that documents the overall structure of the software.
- Data acquisition and analysis software.

The fourth generation of the Radio Spectrum Measurement System (RSMS-4) will critically depend on powerful new data acquisition and processing software to meet the greatly expanded system capabilities (see figure). The new software encompasses many of the strong features of previous generations, as well as incorporating several new features that improve on the current system and allow for substantial future growth.

Major goals in the development of the new software are the ability to easily expand measurement and analysis capabilities and to modify the equipment configuration in the field.

The ability to modify and expand is accomplished by taking a highly modular approach, using an object-oriented (OO) design technique. The software contains a relatively static core program that utilizes various dynamic measurement and instrument modules. By establishing well-defined interfaces and encapsulating the code into dynamic link libraries (DLLs), new measurement techniques can be added without modifying or re-compiling the core program. By establishing command/query interfaces and encapsulating into DLLs, it is also possible to add new models of equipment without the need to change existing measurement code modules. While this requires the use of functional features common to each general category of equipment, the ability to use specialized attributes is also possible by tailoring specialty measurements to make use of specific models.

Hardware flexibility is also enhanced because it is possible to use a variety of instrument models for the same type of measurement via a well-established interface to the general command/query modules. Also integral to the capability for flexible hardware configurations is the ability of the user to dynamically designate the hardware configuration — from the fully equipped measurement vehicle to an abbreviated “suitcase” system. The user also can designate the manual control of some devices and automated control of others.

A script language that gives the user a means to build custom routines for specialized signal measurements provides flexibility in the field. The scripting module utilizes a standard editor, which allows the user to enter specifically defined command text that is interpreted for execution on the targeted instruments. The language is generic for the different generic instrument types (e.g., spectrum analyzer, digital oscilloscope, etc.), and is interpreted in relation to the specific instrument model targeted for execution.

Other features of the new software include:
1) flexible file structures,
2) incorporation of calibrations into the data file,
3) remote measurement/control capabilities,
4) scheduling of measurements,
5) re-measurement capabilities, and
6) high speed signal digitization.

The output data-file format accommodates changes to stored information by adding version markers; these identify the structure of the data and allow backward compatibility despite change. Each module containing the data is responsible for packaging during data writes, parsing the information (according to the version marker) during reads, and documenting the data structure by writing the format for each version to an ASCII file. This allows future format modifications without having to change the core code module. The new file structure adds calibration information into the data files, along with system configuration, measurement parameters, and instrument settings.

The setup and execution of RSMS-4 measurement procedures can be remotely controlled and monitored through the Internet. This minimizes field time for highly skilled employees, permits more opportunistic measurements and improves data quality, and allows the acquired data to be promptly processed in an optimal work environment.

To meet the requirements for expanded capabilities, ITS engineers are developing software for the 4th generation Radio Spectrum Measurement System (photograph by F.H. Sanders).

While previous RSMS generations had the capability for sequential, automated execution of measurements, the 4th generation has the added features of a scheduler. This provides for triggering of measurement routines by external events, repetition and prioritization of a predetermined schedule of planned measurements, and scheduled automation of diagnostic, re-adjustment and calibration procedures.

Because system configuration, measurement parameters, and instrument settings are stored as a part of each data file and linked to the specific measurement routines, it is now possible for system operators to examine measured data and request re-measurement of that data under the same system conditions.

Also incorporated into the new software is the improved capability for digitization of signals in wideband predetection format. This significantly improves the capabilities for software signal processing in ways that are not possible through traditional analog means — for example, very sharp filtering techniques or determination of signal modulation characteristics. Previously, most signal measurements merely extracted the signal magnitude information. With digitization of the raw predetection signal, all of the signal information is retained, allowing the same signal to be processed in many different ways.

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Spectrum Compatibility Measurements

Outputs

- Interference threshold measurements on a variety of Federal Government radar systems.
- Data reports for other US agencies and international forums on results of the interference measurements.

A significant percentage of spectrum between 400 MHz and 18 GHz is allocated for the use of radar systems on a primary basis. Radar receivers are noise-limited in their performance (i.e., radar receivers are designed to be highly sensitive to listen for faint echoes from small, distant, target objects), and external noise sources that exceed critical levels will degrade radar receiver performance. Therefore the bands within which radars operate must be kept as radio-quiet as possible. In recent years spectrum managers and design engineers have experienced pressure to find technical methods by which radar receivers might share spectrum with communication systems. If such proposals are ever to be implemented, it will be necessary to understand precisely the noise levels at which radar receivers begin to exhibit measurably degraded performance. The introduction of new systems into radar bands should result in cumulative noise effects that would stay below the critical interference thresholds of radar receivers.

Within NTIA, the Office of Spectrum Management (OSM) has worked with ITS for the past two years to determine the critical interference levels at which a variety of radar systems experience degraded performance. Some analyses have been theoretical, but a large body of tests and measurements have been performed to verify and enhance the theoretical knowledge.

In FY 2002, OSM and ITS engineers continued this series of measurements in collaboration with other Federal Agencies that included the Coast Guard, the Federal Aviation Administration (FAA) and the National Weather Service (NWS). Radars that were subjected to measurements included maritime surface search and navigation systems, long range air traffic control radars, airport surveillance radars, and a widely deployed model of weather surveillance radar.

At each radar installation, equipment was installed for the generation of a variety of interference modulation types. Analog interference included noise, continuous wave, and a variety of pulsed RF signals. Digital data-type signals included binary and quadrature phase-shift keyed (BPSK and QPSK), and gated QPSK (replicating time division multiple access, or TDMA). All types of interference were normally injected into the radar receivers at their RF input ports via hardline connections. Interference levels were varied by the test personnel to determine levels at which interference occurred.

For each type of interference, radar test targets were injected at controlled levels. Target levels were set close to radar receiver noise, but were kept high enough to provide a high probability of detection in the absence of interference. Baseline probability of detection was recorded in the absence of interference. Interference levels were then gradually increased while target detection probability was monitored.

At the end of each series of measurements, curves were generated showing probability of detection of radar targets as a function of interference level. These curves showed the thresholds at which radar performance began to show observable degradation.

The results of the measurements have been used in US Administration Contributions to the International Telecommunication Union — Radiocommunication Sector Working Party 8B (ITU-R WP 8B). It is anticipated that this work will ultimately result in accurate determinations of interference thresholds for most types of radar in all bands in which sharing with other services is being proposed.

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NTIA engineers from ITS and OSM set up equipment for injection of interference signals into an air traffic control radar (photograph by F.H. Sanders).

Spectral Assessment of Government Systems

Outputs

- Land mobile radio usage measurements in Denver and New York City.
- Maritime radar emission spectrum measurements.

The US Government operates a large number of radio systems, and advances in technology continue to drive the development of new radio systems. In recent years, alternatives to conventional analog FM land mobile radio (LMR) systems have become available. But planning for upgraded networks cannot be accomplished until requirements can be set for the traffic capacity that must be built into the new systems. In FY 2002, ITS performed measurements of traffic levels and message length statistics on existing LMR networks in selected bands in Denver, CO and New York City.

The measurements were designed to show overall usage levels on a channel-by-channel basis in these cities. Since the goal was to establish overall usage across the metropolitan areas, multiple measurement locations were required in each city. The measurement systems were suitcase versions of the NTIA/ITS Radio Spectrum Measurement System, running ITS-developed software.

The measurements were technically challenging for several reasons. One problem was to identify locations in the heart of each city with large radio horizons (Figures 1a and 1b) that were free of local transmitters that would overload the measurement systems. Another problem was to establish measurement rates that were high enough to revisit each channel every second, but not so high as to cause uncalibrated measurements. A test series of measurements was performed in Denver, and a full series of measurements was performed in New York.

Figure 1a. View of downtown Manhattan from one of the New York City LMR measurement sites (photograph by F.H. Sanders).

Figure 1b. View of midtown Manhattan from one of the New York City LMR measurement sites (photograph by F.H. Sanders).

Measurements were performed at three sites in each city for a period of two weeks, running 24 hours per day. The resulting data volumes approached 100 GB for each city. ITS developed new analysis techniques to cope with the volume and provide channel usage and message length statistics. Figure 2 shows an example data output from this measurement series.

In FY 2002 ITS began a detailed study of the behavior of spurious emission spectra produced by radar transmitters. Those emission levels are regulated by the NTIA Radar Spectrum Engineering Criteria (RSEC), but the measured power level of these emissions depends upon the bandwidth in which they are measured. Until recently, measurement bandwidths have been specified to be set equal to the inverse of the radar pulse widths (1/t), but some radar pulse widths are so narrow that no measurement equipment is available with sufficiently wide bandwidth. Thus it is important to understand the exact dependence of radar spurious levels as a function of measurement bandwidth. To begin the study, ITS bought a commercial radar and installed it north of Boulder. The measurement series began in late FY 2002. Results of the measurements will be used in FY 2003 for an NTIA Report and at least one US Contribution for the International Telecommunication Union — Radiocommunication Sector, Working Party 8B (ITU-R WP 8B). The data are needed so that NTIA can provide guidance to domestic and international personnel who are tasked with measuring radar emissions and comparing them to emission masks such as the RSEC.

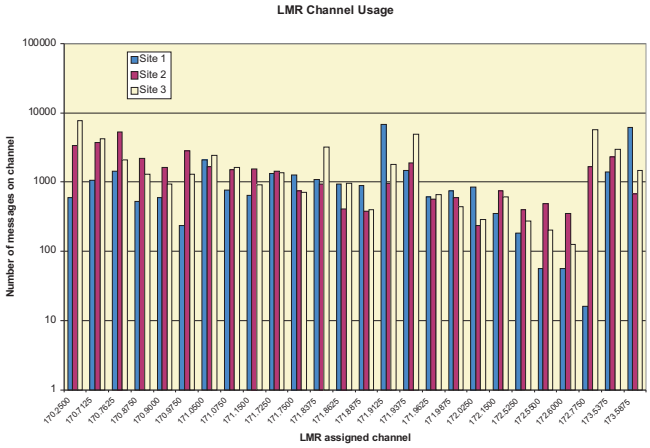

Figure 2. Data output showing land mobile radio channel usage at three selected sites in New York City.

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Ultrawideband Regulatory Activities

Outputs

- Comments provided to NTIA on UWB regulatory proposals.
- Comments on proposed new ITU-R study questions regarding UWB devices.
- Measurement advice to entrepreneurs developing UWB devices.
- Emission measurements of Part 15 devices.

In May 2000, the Federal Communications Commission (FCC) released a notice of proposed rulemaking (NPRM) on ultrawideband (UWB) systems, asking for a wide range of information on UWB systems, interference from UWB systems, and proposals for how they should be regulated. At that time, there was a wide range of technical opinion about how UWB systems interacted with traditional radio systems, and how they should be regulated. In FY 2000 and FY 2001, ITS staff made extensive measurements to characterize UWB device emissions. In addition, ITS made extensive measurements of UWB interference to various types of global positioning system (GPS) receivers. This work was summarized in NTIA Reports 01-383, 01-384, and 01-389. Subsequently, NTIA/OSM engineers used ITS measurements to predict how UWB devices would interfere with Federal systems and GPS. These predictions were summarized in NTIA Special Publications 01-43, 01-45, and 01-47.

Throughout and following the period of measurement and analysis, NTIA and the FCC were closely considering what regulations and numerical regulatory limits would be appropriate for the use of UWB devices. Intensive negotiations generated extensive draft documentation on many contentious and elusive issues, including allowable emission levels in specific frequency bands and special regulations for GPS bands, aimed at creating a new section of Part 15 of the FCC rules. ITS monitored and reviewed this documentation on a daily basis. ITS technical experts provided comments on many aspects of these negotiations, especially with respect to measurement procedures and the changing units of regulatory limits. It was often useful for ITS to comment on a range of topics such as interpreting the results of our laboratory and field measurements. In addition to some 80+ sets of comments sent by ITS to NTIA in FY 2002, many thorough reviews of the document changes resulted in no required comments.

In February 2002, the FCC released a first report and order (FR&O) on UWB device rules. This FR&O included rule-making that followed many of the NTIA recommendations and allowable emission levels (see Figure 1 below). A recommended major change from earlier FCC Part 15 procedures included the adoption of root mean square (RMS) weighting and well-defined integration times and measurement conditions. Such details were particularly important because of the wide range in numerical answers that result from seemingly small details like detector weighting functions. The FR&O stated that the initial regulations would be reviewed in 6-12 months and possibly adjusted according to information that becomes available in the intervening time.

While many observers applauded the new UWB rules, others stated that they were either much too permissive or much too restrictive. One application in particular, ground penetrating radars (GPRs), is subjected to much more stringent regulation under the new rules. This seems strange to some, because

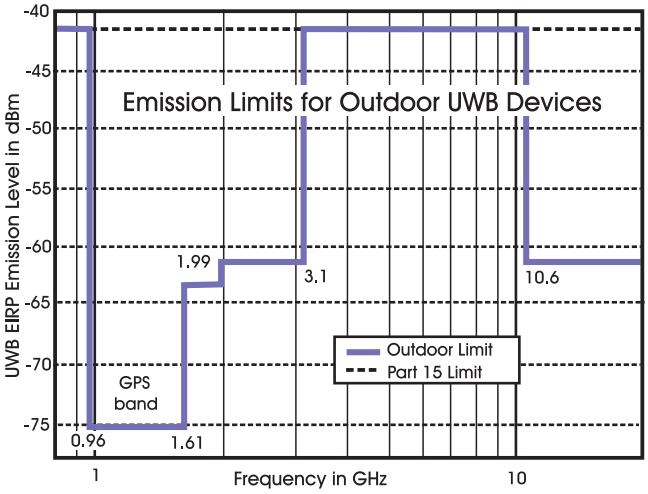

Figure 1. Emission limits for outdoor UWB devices, based on FCC first report and order on UWB device rules.

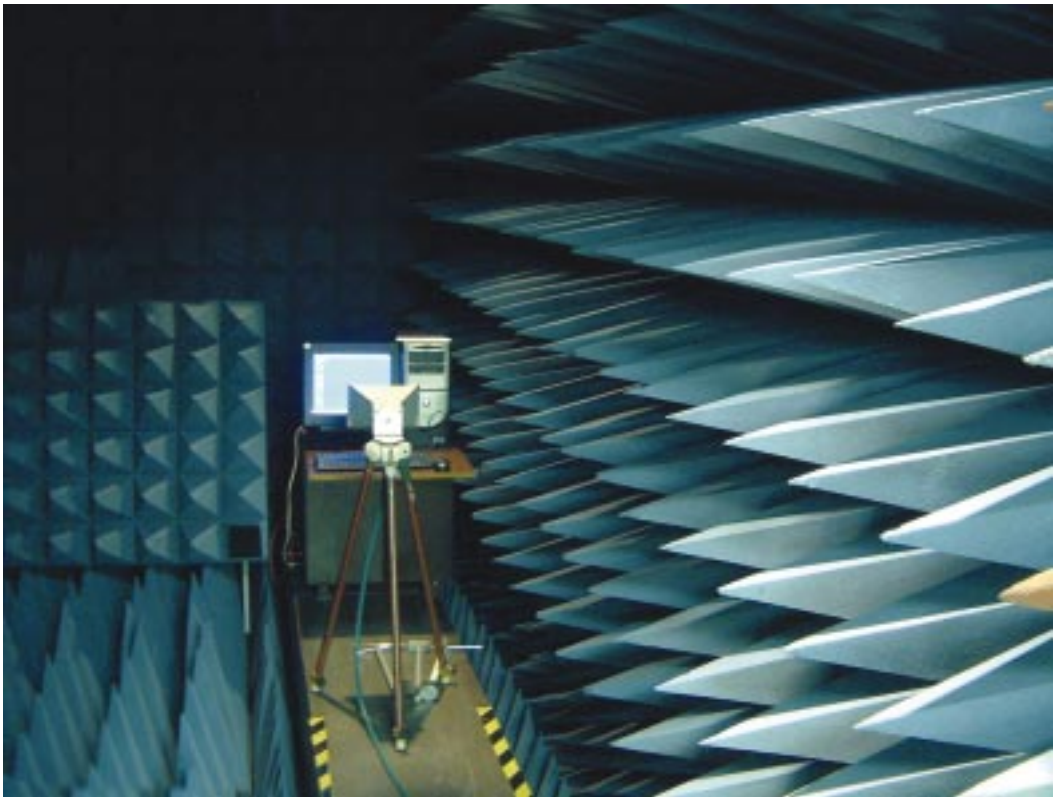

Figure 2. Emissions produced by a personal computer are measured in a NIST anechoic chamber with an ITS measurement system (photograph by F.H. Sanders).

GPRs arguably have the longest history of use of all UWB devices, with apparently few instances of interference. However, many share frequency bands with particularly critical safety and defense systems.

Paralleling U.S. activity in regulation of UWB systems, the International Telecommunication Union — Radiocommunication Sector (ITU-R) has also begun a study program on UWB devices. ITS commented on proposed new ITU-R study questions, which will become a part of ITU-R Study Group 1/8 activities.

Following the release of the FCC UWB regulations, ITS has continued to serve a tutorial and advisory role. Entrepreneurs are developing new UWB devices and are attempting to measure them according to the techniques described in the FR&O. Requests have come from as far away as Germany, where a 24-GHz short-range automotive radar was being characterized according to the new UWB criteria. In this case, peculiar measurement results were traced to inadequate (sub-Nyquist) digital sampling rates in the measurement instrumentation. ITS has investigated the feasibility of making some of the low level measurements required for some frequencies for UWB devices. ITS and other agencies have continued research in areas related to the deployment of UWB devices. ITS has made measurements of the emissions from other Part 15 devices, such as computers, to see how the emissions from such devices compare with UWB emissions (see Figure 2 above). In addition, ITS continues to make a limited number of measurements of environment noise background, part of a “reality check” on interference models that assume kT as the applicable noise background for many radio systems. ITS has also conferred with other Federal Agencies concerning background noise measurements.

It is expected that ITS will continue an involvement in UWB measurement and regulatory activities in the coming year, particularly as new UWB devices appear on the market, and as needed to react to changes proposed in the scheduled 6-12 month FCC review of the UWB rules.

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