ITS Tools and Facilities

Advanced Antenna Testbed

The advanced antenna testbed (ATB) is a multi-channel test facility based on ITS digital sampling channel probe technology (see "Advanced Antenna Testbed," pp. 52-53). The system can simultaneously characterize eight wideband radio channels (expandable to 16 with multiplexing). The received signals are digitized for flexible post processing. The table below summarizes the range of permissible values for the ITS channel sounding system, as well as giving an example of a measurement system configured for 2.3 GHz and 10 Mb/s operation.

Configurable Testbed Parameters

Parameter	3G Example	ITS System
Receiver Channels	8	1-8 (expandable to 16)
Carrier Frequency	2.3 GHz	.45 – 6 GHz
Bit Rate	10 Mb/s	.1 – 50 Mb/s
Resolution	100 ns	20 ns – 10 µs
Code Type	Maximal Length	Programmable
Code Length	511 bits	Programmable
Acquisition Mode	Burst	Continuous or Burst
Positioning	GPS/Dead Reckoning	GPS/Dead Reckoning
Transmitters	16	Multiple
Data Processing	Post	Post

The ATB provides common reference sites for evaluating next-generation antenna systems. Data from multiple channels can be used to test the diversity gain resulting from various signal combining algorithms. Digital beam forming and multiple input, multiple output (MIMO) techniques may also be examined by simultaneous digitization of signals from multiple antenna elements.

Sites in Boulder and Denver, Colorado, serve as known environments for evaluating 3G components and systems. Alternately, the ATB system may be van-mounted for site mapping studies at any required location.

Contact: Peter B. Papazian (303) 497-5369
e-mail: ppapazian@its.bldrdoc.gov

Audio Quality Measurement System (AQMS)

The Audio Quality Measurement System (AQMS) acts as a tool for evaluating the voice quality of Voice over IP (VoIP) systems, wireless systems, and combination systems consisting of both VoIP and wireless infrastructure. Instead of using an actual panel of individuals to score the audio quality of a particular speech file, an audio quality estimator algorithm, known as PESQ (Perceptual Evaluation of Speech Quality), can be used to provide an estimated mean opinion score (EMOS). The scores are assigned on a scale of 1 – 5, with 1 being the worst and 5 being the best. The extensive research performed by Stephen Voran in the Audio Quality Research Laboratory acted as a springboard for the development of the AQMS. A block diagram of the AQMS is shown in the figure below. The core components of the system are the custom graphical user interface (GUI), the PESQ algorithm, and an audio mixer. The spectral analyzer and the network impairment emulator can be thought of as auxiliary components of the AQMS.

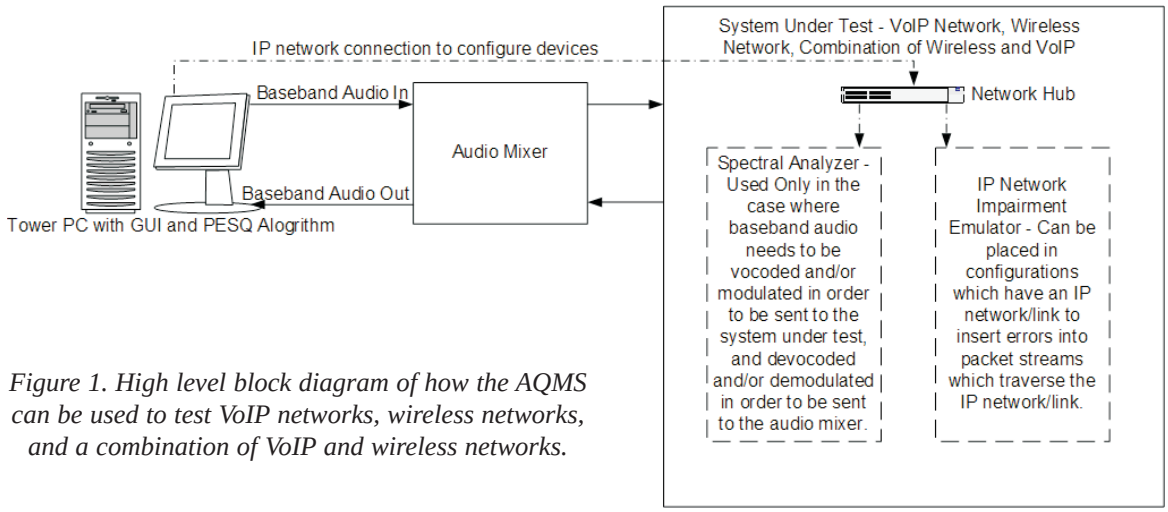


Figure 1. High level block diagram of how the AQMS can be used to test VoIP networks, wireless networks, and a combination of VoIP and wireless networks.

The system works by playing a group of 40 Harvard phonetically balanced speech files into the system under test (SUT). The speech files are started through the GUI. Before playing the speech files into the system, the user can invoke the documentation feature of the GUI interface to record the audio levels of the mixer, the IP impairment levels of the network impairment emulator, the spectral analyzer's settings, the type of equipment under test, and the configuration of the equipment under test. The GUI also provides the ability to remotely interface to and configure the spectral analyzer and the network emulator before the 40 speech files are played into the SUT. The final feature of the AQMS is that it generates a two-dimensional plot where the x-axis (range is fixed from 1 to 40) represents the speech files and the y-axis represents EMOS. This two-dimensional plot contains other important information such as the median EMOS, average EMOS, the IP impairments selected, and their respective levels.

So far this system has been used to evaluate the voice quality of a Project 25 VoIP combination system comprised of two UHF/VHF repeaters with the capability to transmit over IP links, and it has also been used to evaluate the voice quality of VoIP-capable telephones that require the use of session initiated protocol (SIP) or H.323 to make a telephone call. The next step in the evolution of the AQMS is to add an acoustic coupling feature. This involves the use of soundproof chambers with head and torso simulators (HATS). This feature will allow mobile handsets/radios to be used during testing rather than using a piece of test equipment, like the spectral analyzer, to modulate/demodulate baseband audio.

Contact: Kameron A. Behnam (303) 497-3830
e-mail: kbehnam@its.bldrdoc.gov

Audio-Visual Laboratories

The ITS Audio-Visual Laboratories offer a wide range of audio and video recording, storage, processing, reproduction, objective quality assessment, and subjective testing capabilities. These capabilities in turn support the development and verification of new quality estimation techniques for compressed digital audio and video, the development of novel subjective testing techniques for audio and video signals, and the development of new coding algorithms.

Laboratory equipment supports standard-definition (SD) and high-definition (HD) video signals, as well as monophonic, stereophonic, and 5.1 channel audio streams. Signals are acquired with high-quality microphones and cameras. Recording and playback devices include studio-quality analog and digital video tape recorders with two to four audio channels, digital audio tape machines, CD players, and analog audio cassette machines. These systems are augmented with several computer-based digital audio and video systems and a set of high quality Analog-to-Digital and Digital-to-Analog converters. Analog audio mixing, filtering, and equalizing equipment is available. An array of digital audio and video encoders and decoders are available as well as an HDTV modulator and demodulators. Analog and digital audio and video routing switches and patch-panels allow for nearly arbitrary interconnections between the various pieces of equipment.

Reproduced signals are presented through studio-quality video monitors, monitor loudspeakers, headphones, or handsets. Two separate rooms with controlled acoustic and visual environments are available for the subjective testing of audio and video signals. These environments are specified in International Telecommunication Union — Telecommunication Standardization Sector (ITU-T) Recommendation P.800 and ITU-R Recommendation BT.500 respectively. These specifications address background noise levels, wall colors, light levels, room dimensions, and other properties. A third room is used exclusively for the presentation of high-definition video signals. Finally, the labs feature an array of audio and video signal generators and analyzers to support laboratory measurement and calibration activities.

Computers play a key role in laboratory operations. Two systems offer the ability to record and playback uncompressed digital audio bit-streams together with synchronized SD video bit-streams that conform to International Telecommunication Union — Radiocommunication Sector (ITU-R) Recommendation BT.601 (i.e., Society of Motion Picture and Television Engineers SMPTE 259M/272M specification) and synchronized digital audio streams to and from a high-speed workstation with over 1 TB of hard disk storage. Another computer-based system can record and playback uncompressed HD audio and video bit-streams in accordance with the SMPTE 292M format. Much audio and video processing is performed on a cluster of four high-performance

workstations, supported by 6 TB of disk storage. Other available storage peripherals include a 12-GB 4mm tape drive, an 8-GB 8mm tape drive, and a 40-GB digital linear tape drive.

Lab activities include objective estimation of audio and video quality, and subjective testing of audio and video quality. Random access digital audio-video playback systems coupled with discrete-time and continuous-time electronic data entry systems greatly facilitate many of the subjective testing activities. Because multiple subjective testing rooms are available, the laboratory can support conversation, teleconferencing, and video teleconferencing tests as well as viewing and listening tests.

Objective video quality estimation software, written in C++, processes video signals in accordance with American National Standards Institute (ANSI) T1.801.03-2003 metrics, resulting in estimates of video quality that show good correlation with subjective test results. Several different objective speech and audio quality estimation algorithms are available, including those defined in ANSI T1.518, ITU-T Recommendation P.862, and ITU-R Recommendation BS.1387. The labs support both batch-mode and real-time objective quality estimation.

Contact: Stephen Wolf (303) 497-3771 (Video)
e-mail: swolf@its.bldrdoc.gov
Stephen D. Voran (303) 497-3839 (Audio)
e-mail: svoran@its.bldrdoc.gov

Digital Sampling Channel Probe

The digital sampling channel probe (DSCP), designed and patented at ITS, is used to characterize the wideband propagation characteristics of the radio communication channel. The probe, consisting of a transmitter, receiver, and data acquisition system, is used to make complex impulse response measurements. Unlike traditional analog sliding correlators, the DSCP digitizes a received pseudo-noise signal at an intermediate frequency (IF) and then post processes the data. Relative to the sliding correlator, the time over which the impulse is generated is less, and therefore, the probe is better suited to mobile applications. Historically the DSCP has been employed extensively for channel characterization of cellular and personal communications services (PCS). ITS has expanded the probe to 8 channels capable of mobile phased array or multiple input, multiple output (MIMO) measurements. Also available is a wide-bandwidth, high-frequency probe, particularly suited for high resolution requirements such as wireless local area network (LAN) applications up to 30 GHz. For a more detailed description of the measurement systems and applications, see the following website: http://flattop.its.bldrdoc.gov/rcirms/

Contact: Peter B. Papazian (303) 497-5369
e-mail: ppapazian@its.bldrdoc.gov

Green Mountain Mesa Field Site

The main Department of Commerce Boulder Laboratories campus contains a field site used for outdoor wireless network research. The site is connected to the ITS laboratories via both fiber optic and 802.11 links. The fiber optic link is currently providing access to the ITS local area network (LAN) while the 802.11 link connects this field site to the ITS Wireless Network Research Center (see p. 79). The site can provide six independent duplex fiber channels to the ITS lab. This allows research to be conducted over an isolated 1-mile outdoor Wi-Fi link. The fiber connectivity provides a LAN connection to the outdoor wireless router and for capability to operate remote data collection equipment. The outdoor router, located on an 80-foot tower, provides long range 802.11 links to other Commerce field sites. Currently these links provide 802.11b services and are also used for network performance testing.

The site's unique geographic location, several hundred feet above the main Department of Commerce campus, allows for the provisioning of wireless test links over a large portion of eastern Boulder county. The site is operated year round.

Contact: Christopher J. Behm (303) 497-3640
e-mail: cbehm@its.bldrdoc.gov

Interoperability Research Laboratory (IRL) and Mobile Radio Communication Performance Measurements

ITS maintains a test capability for measuring the performance of land-mobile radio systems that comply with the Telecommunications Industry Association's TIA-102 and TIA-603 series of standards through its Interoperability Research Laboratory (IRL). The IRL also supports laboratory investigation of "interim solution" interoperability devices.

The measurement capabilities include the usual receiver and transmitter measurements such as receive sensitivity, co-channel and adjacent-channel

rejection, spurious response rejection, and transmitter emissions mask. Highly accurate measurements are made possible by laboratory grade signal generators, fading simulators, spectrum and vector signal analysis tools, and an RF shielded enclosure. The lab possesses both models of TIA-102 (Project 25) capable communications system analyzers which can decode various aspects of the link control information, such as network access code, talk group identification, and status bit. Demodulated speech samples can also be collected and scored for audio clarity using the ITU's PESQ algorithm.

The primary use for this capability is interoperability testing between TIA-102 radios of different manufacture and backward compatibility testing between TIA-102 radios and legacy FM systems. Other applications may be possible, for example, routine performance measurements or more niche applications, such as VoIP radio repeaters or baseband audio interoperability devices. This capability is available on a first-come, first-served basis by both NTIA and other agencies.

Contact: Val Pietrasiewicz (303) 497-5132
e-mail: valp@its. bldrdoc.gov

ITS home page: http://www.its.bldrdoc.gov

ITS Internet Services

ITS provides public Internet access to NTIA/ITS publications, program information, meeting information, and on-line Telecommunications Analysis Services used by other Federal agencies, research partners, and private industry. Restricted-access services including electronic mail lists are used to facilitate communications with project sponsors and partners, and to support ANSI T1 standards committees. Some highlights of ITS Internet Services include:

- Information about ITS programs and projects. Available at http://www.its.bldrdoc.gov/home/projects.html
- An ITS organization chart and a complete listing of ITS staff with contact information. Available at http://www.its.bldrdoc.gov/home/organization.html
- Recent ITS publications including NTIA Reports, special publications, and journal articles. Available at http://www.its.bldrdoc.gov/pub/pubs.html
- Telecommunications Analysis Services. Available at http://www.its.bldrdoc.gov/tas/
- Radio propagation data. Available at http://www.its.bldrdoc.gov/home/data/ radio_propagation_data/
- Radio propagation software. Available at http://www.its.bldrdoc.gov/home/software/
- Information about ITS-sponsored events such as ISART. Available at http://www.its.bldrdoc.gov/home/conferences/
- Anonymous FTP distribution of some ITS developed software programs. Available at ftp.its.bldrdoc.gov

Contact: Jeanne M. Ratzloff (303) 497-3330
e-mail: webmaster@its.bldrdoc.gov

ITS Local Area Network

ITS maintains a highly flexible local area network (LAN) to support intranetworking services and laboratory interconnection. A structured cabling system interconnects all offices and laboratories with both optical fiber and Category 5 twisted-pair cabling to support high-bandwidth communications on demand. Over 200 devices are supported on 10Base-T and 100Base-TX Ethernet segments. Connections can also be made to laboratory test beds featuring synchronous optical network/asynchronous transfer mode (SONET/ATM). This provides ITS with great flexibility and rapid reconfiguration capability for new programmatic needs.

Contact: Matt Reynolds (303) 497-7513
e-mail: mreynolds@its.bldrdoc.gov

ITS SIPRNET Capability

ITS maintains a connection to the Secret Internet Protocol Routable Network (SIPRNET). This connection allows ITS sponsors and Department of Defense users direct access to ITS tools and facilities in a secure environment, improving the quality of support that the Institute can give organizations with classified needs.

Since many of the planning and associated support activities of the military require a classified channel for discussions and data transfer, the need exists for a secure environment within which project planning and support can be carried on without interruption. ITS maintains several computer systems of diverse types with a variety of software capabilities in order to support propagation planning and modeling, as well as emerging technologies research.

The secure facilities of ITS allow users to import data from many military facilities and support organizations into propagation models and other management software. A complete end-to-end propagation planning capability in a secure environment is available for current and future classified needs. Various research studies that ITS conducts (that are determined as classified information) can also reside on the SIPRNET, allowing access by agencies on a need to know basis.

Contact: Robert O. DeBolt (303) 497-5324
e-mail: rdebolt@its.bldrdoc.gov

Mobile Radio Propagation Measurement Facilities

ITS maintains a measurement vehicle capable of radio channel characterization over a wide frequency range. The vehicle is equipped with on-board power, a telescoping mast, azimuth and elevation controllers, and global positioning system (GPS) devices with dead-reckoning backup. A suite of measurement equipment is also available for use in this vehicle. This includes wideband systems for measuring radio channel impulse response from 450 MHz to 30 GHz. Impulse response measurement capability at 30 GHz with 2ns resolution has been enhanced with the addition of a digital wideband recording system. ITS has increased its mobile channel measurement capability with the addition of an 8-channel receiver and an 8-channel 14-bit data acquisition system. Multi-channel synchronous acquisition can be used for antenna array measurements or multi-frequency broadband measurements. Mobile measurement capability allows space division multiple access (SDMA) algorithms to be studied using data collected in typical mobile environments. This data can then be used to simulate and model radio systems.

Contact: Peter B. Papazian (303) 497-5369
e-mail: ppapazian@its.bldrdoc.gov

Network Simulation System

Data communications networks, both wireline and wireless, continue to grow and evolve. Changes to a network configuration, such as additional users or the implementation of a new transfer protocol, can result in unforeseen problems and situations. Computer simulation of these communications networks, and the proposed changes to them, can help system planners to anticipate and eliminate potential problems. Large networks are so complex that it is only by modeling and simulation that telecommunication planners can hope to predict the effects of catastrophic failures in the infrastructure.

NTIA/ITS maintains a widely held network simulation software package. By using this highly flexible software, trained ITS staff can design, configure, and implement almost any type or size of data-communications network. ITS has several licenses to use the software, including access to the basic package, radio modules, and the traffic importation and analysis module.

ITS staff are successfully using this software in support of both internal and external projects to simulate existing and proposed data communications networks. For example, ITS has built reference network models for use in network survivability and restoral studies. ITS staff also used the simulation system to extract and analyze Voice over IP (VoIP) traffic using Session Initiation Protocol (SIP) in an Internet experiment between Washington, D.C., and Boulder, Colorado.

Contact: Arthur A. Webster (303) 497-3567
e-mail: awebster@its.bldrdoc.gov

Pulsed CW Radar Target Generator

The Pulsed Continuous Wave (CW) Radar Target Generator is an electronic tool that is used to produce targets on a radar screen. The generator produces signals that simulate the returns that would normally be seen by a radar from targets in the environment. The signals are injected into the radar's receiver at the normal frequency of operation. Several parameters of the signals can be adjusted over a wide range to be compatible with several different models of radars. For the same model radar, the number of targets and the range to the targets can be adjusted. Other adjustments include the displayed bearing of the targets and whether the targets are stationary or moving along concentric circular paths. Compensation adjustments can be made for radars that have large tolerances in their operating specifications. The generator can be used to verify operation or troubleshoot the radar under test. ITS uses the generator to provide simulated desired signals in interference studies where interference is injected into the radar and the effect on the targets is recorded.

Contact: Brent Bedford (303) 497-5288
e-mail: bbedford@its.bldrdoc.gov

QPSK/BPSK Generator

The QPSK/BPSK (quadrature/binary phase-shift keying) Generator is an electronic tool used to generate digital signals for testing purposes. The generator consists of software to generate a sampled version of the signal, an arbitrary waveform generator to create an analog version of the signal and a frequency conversion unit to shift the signal's frequency content to the desired output frequency. The ITS written software gives the user control over several parameters of the signal including the duration of the signal, the sample rate, the number of cycles per dibit (which can be an integer to place the bit transitions on zero crossings) and the signal amplitude. The frequency conversion unit mixes the signal to its final value through a frequency agile local oscillator. A bandpass filter removes the unwanted mixer products and an adjustable attenuator controls the output amplitude. The generator has been used to simulate interfering sources, within the reception range of a radar, to record any effects. Because of the frequency agility, detailed waveform parameter control, and amplitude control, this tool can be used in a large number of applications.

Contact: Brent Bedford (303) 497-5288
e-mail: bbedford@its.bldrdoc.gov

Radio Noise Measurement System

The ITS radio noise measurement system hardware consists of an omnidirectional antenna mounted on a ground plane, preselector filter, low noise preamplifier, off-the-shelf spectrum analyzer, digitizer, and computer. Noise samples are digitized prior to spectrum analyzer detection, just after spectrum analyzer log amplification. Spectrum analyzer demodulation circuits are used for aural noise identification during measurements. The measurement system noise figure is nominally 2 dB above the theoretical noise floor. Noise is measurable approximately 15 dB below and 60 dB above system noise.

The noise measurement system uses custom data acquisition software written and maintained at ITS. The software graphical user interface allows the user to customize and notate each measurement. It also displays noise samples and their corresponding first-order statistics. The statistics are revealed through an amplitude probability distribution (APD). The APD is plotted on a Rayleigh graph where the Gaussian noise appears as a straight line with a negative slope. Non-Gaussian noise is easily identified during measurements as a deviation from the straight line or a change in slope. Non-Gaussian noise exists throughout the radio spectrum.

ITS has used the noise measurement system to measure noise at 137.5 MHz, 402.5 MHz, and 761.0 MHz. The noise measurement system can also be used to measure noise at higher frequencies, e.g., at 2.4 GHz in spectrum occupied by unlicensed Part 15 low power communication devices such as wireless local area networks and Part 18 industrial, scientific, and medical (ISM) devices such as microwave ovens.

The noise measurement system can be run from a building or a measurement van. A direct current converter with noise suppressor is used to power the van-mounted equipment if 120 V alternating current is not available. Calibration measurements in radio quiet zones have shown that noise contributed by the noise measurement system and power conversion equipment is negligible.

Contact: Robert J. Achatz (303) 497-3498
e-mail: rachatz@its.bldrdoc.gov

Radio Spectrum Measurement System (RSMS)

The ITS Radio Spectrum Measurement System (RSMS) is a state-of-the-art measurement system designed for gathering information regarding spectrum occupancy, equipment compliance, electromagnetic compatibility, and interference resolution. Its purpose is to provide NTIA's Office of Spectrum Management (OSM) with critical measurement support from ITS for determining policies regarding government radio systems and spectrum utilization. RSMS is a dynamic and flexible system that incorporates automated, semi-automated, and manual techniques for the measurement and analysis of radio emissions. While not defined by any single hardware configuration, the system includes such devices as the latest in spectrum analyzers, digital oscilloscopes, vector signal analyzers, and signal detection devices. Measurements can take place in a laboratory or in the field, or they can be mobile or stationary; therefore the system has been made flexible enough to accommodate each of these situations.

An integral part of the system is the measurement vehicle, which is now in its 4th generation. The vehicle has a highly shielded enclosure (60 dB) with three equipment racks, three 10 meter masts, a 20 kWatt diesel generator, as well as Internet connections, fiberoptic control lines, multiple power outlets, and overhead cable racks. The control and acquisition software is fully developed by ITS so that new and innovative measurement techniques can be easily altered to meet the immediate needs. A major objective in the development of the 4th generation software has been to provide a tool that can easily accommodate new equipment and different hardware configurations, and to expand on existing measurement capabilities.

Contact: J. Randy Hoffman (303) 497-3582
e-mail: rhoffman@its.bldrdoc.gov

Spectrum Compatibility Test and Measurement Sets

The introduction of new radio technologies in close physical and frequency proximity to older ones can result in electromagnetic compatibility (EMC) problems. Although theoretical models and simulations provide much useful information in guiding design decisions, the complexity of modern systems and the existing spectral environment often requires real-world measurements of a proposed system's effects within its proposed operating environment to determine its impact on other users of the radio spectrum. Another problem is the production of a controlled interfering signal with known characteristics in environments where the suspected interferer may be unavailable for use. This includes situations such as laboratory tests using interference from ship or aircraft mounted radars or communications systems. In both situations a system is needed that simulates the spectral emissions of other devices with a wide range of latitude. Examples include determining the thresholds at which types of interference from communication transmitters are manifested as interference effects in radar receivers, and testing the response of a dynamic frequency selection wireless communication device to detect types of radar energy without actually setting up real radars for the test.

To meet these needs, ITS engineers have developed two different types of interference generators. The first system is the Broadband Arbitrary Waveform Transmitter (BAWT) that is used to simulate the spectral output of a wide variety of communication systems. These signals can be coupled directly into a system under test or they can be transmitted into a target system's antenna to more accurately gauge its response to a real interference situation.

In cases where ITS can gain access to the emissions from a particular transmitter, the transmitter's emissions can be digitized using high-speed samplers. The digitized waveforms (in bandwidths up to 30 MHz and at frequencies as high as 26 GHz) are stored. The amplitudes, frequency components, and phase components of the signals are recorded for later playback by arbitrary waveform generators and selected RF signal generators. The advantage of this arrangement is that very complex waveforms may be replicated with complete confidence in the fidelity of the simulated signal to the characteristics of the original signal from which it has been derived.

Contact: Frank H. Sanders (303) 497-7600
e-mail: fsanders@its.bldrdoc.gov

Table Mountain Field Site and Radio Quiet Zone

Established in 1954, the Table Mountain Field Site and Radio Quiet Zone is a unique facility for radio research. Located north of Boulder, the site extends approximately 2.5 miles in a north-south direction by 1.5 miles east-west, and has an area of approximately 1,800 acres. The site is designated as a "Radio Quiet Zone" where the magnitude of strong, external signals is restricted by State law and Federal Regulation in order to minimize radio-frequency interference to sensitive research projects.

Facilities at the site include:

- **Spectrum Research Laboratory** — This is a state-of-the-art facility for research into radio spectrum usage and occupancy. The Table Mountain Radio Quiet restrictions ensure that no signal incident on the mesa overpowers any other, and an antenna farm providing both directional and non-directional antennas spanning a broad range of frequencies makes the entire radio spectrum available for study.

- **Open Field Radio Test Site** — As an elevated, flat-topped butte with uniform 2% slope, Table Mountain is uniquely suited for radio experiments. It is flat with no perimeter obstructions, and the underlying ground is relatively homogeneous. This facilitates studying outdoor radiation patterns from bare antennas or antennas mounted on various structures such as buildings and automobiles. Recent work has included the measurement of digital television signals in a simulated home, studies of measurement methods for evaluating radar signal characteristics, and evaluation of 802.11b wireless network systems.

- **Mobile Test Vehicles** — There are a number of mobile test equipment platforms available at the mesa varying from 4-wheel drive trucks to full-featured mobile laboratories.

- **Large Turntable** — This is a 10.4 meter (34 foot) diameter rotatable steel table mounted flush with the ground. Laboratory space located directly underneath the table provides a location for test instrumentation as well as the control equipment and motors needed to rotate the turntable. This facility is being renovated and is expected to be operational in 2004.

- **Two 18.3 Meter (60 foot) Parabolic Dish Antennas** — These parabolic dish antennas are steerable in both azimuth and elevation and have been used at frequencies ranging from 400 MHz to 6 GHz. Research done using these antennas has included: studies of tropospheric radio scattering, diffraction of radio waves by mountain ranges, bistatic scattering cross sections of thunderstorms, thermal radio emission from thunderstorms, and deep space radio astronomy.

In addition to these facilities, the Table Mountain Research program supports a number of research activities such as studying the effects of radio propagation on the integrity of digital signal transmission and video quality, environmental and man-made noise, verification of antenna propagation models, and the development of measurement methods needed to asses efficient spectrum occupancy and usage (see pp. 10-11).

Partnerships and cooperative research activities are encouraged at the site. Other organizations currently using the facilities include the National Oceanic and Atmospheric Administration (NOAA), the U.S. Geological Survey (USGS), the Deep Space Exploration Society, and Coherent Technologies.

Contact: J. Wayde Allen (303) 497-5871
e-mail: wallen@its.bldrdoc.gov
or
John D. Ewan (303) 497-3059
e-mail: jewan@its.bldrdoc.gov

Telecom Glossary 2000 Web Page

Telecom Glossary 2000 is an American National Standard, ANS T1.523-2001, and is available free to the public on the ATIS/T1 website http://www.atis.org/tg2k

In cooperation with ATIS/T1, ITS maintains a web page that serves as the Development Site for Proposed Revisions to *Telecom Glossary 2000*: http://www.its.bldrdoc.gov/projects/devglossary

This website contains the baseline document, *Telecom Glossary 2000*, as well as features that allow viewers to submit proposed glossary additions and revisions for the revision committee's consideration.

Telecom Glossary 2000 — for which proposed revisions are being solicited — contains approximately 8000 definitions in the disciplines of fiber optics

communications, telephony, National Security/ Emergency Preparedness (NS/EP), National Information Infrastructure (NII), spectrum sharing, radar, radio communications, television (UHF, VHF, cable, high definition television), high-frequency automatic link establishment, radio, facsimile, networks (intelligent networks, next-generation Internet, open network architecture, ISDN, broadband ISDN, and network management), communications security, data processing, premises wiring, grounding and bonding, telegraphy, and video. Recently added disciplines include web terminology, T1 Standards, information assurance/security, and photonics.

The glossary is presented in hypertext with clickable graphics and 69,000 hyperlinks to defined terms. The website contains an ITS-developed search engine with easy-to-follow, menu-driven instructions, to allow a more organized and thorough review of the entire glossary. The advantages of the search engine include tailored, rapid access to the text of all definitions, ranking of results, and hyperlinks to all search engine results.

The Development Site for Glossary Revisions automatically generates e-mail to the glossary's editors whenever anyone submits a proposed revision (addition, deletion, or change of text) by clicking the selected buttons on the Development Site web page. That e-mail is collected automatically in a bin and reviewed for future forwarding to the Revision Committee.

The glossary and the Development-tools web sites are accessible and free to anyone with web access. Typical users include Federal purchasing agents, NS/EP implementors, NII planners, Standards writers and users, R&D workers, O&M workers, technical writers, telecom instructors, and telecom vendors.

Contact: Evelyn M. Gray (303) 497-3307
e-mail: egray@its.bldrdoc.gov

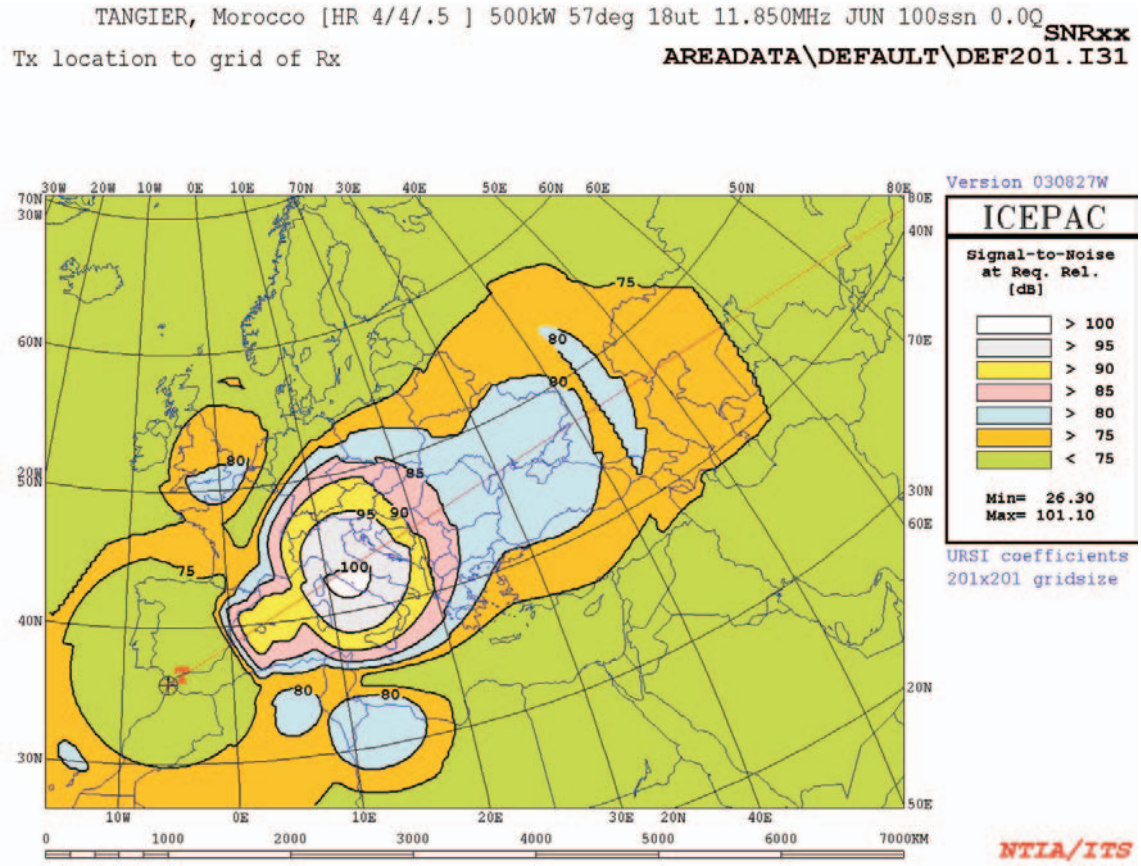
Telecommunications Analysis Services

Telecommunications Analysis Services (TA Services) provides the latest engineering models and research data developed by ITS to industry and other Government agencies via a web-based interface (http://flattop.its.bldrdoc.gov). Designed to be both user-friendly and efficient, it offers a broad range of programs that allow the user to design or analyze the performance of telecommunications systems.

Currently available are: on-line terrain data with 1-arc-second (30 m) for CONUS and 3-arc-second (90 m) resolution for much of the world, and GLOBE (Global Land One-km Base Elevation) data for the entire world; 2000 census data, 1990 census data (also 1997 updated); Federal Communications Commission (FCC) databases; and geographic information systems (GIS) databases (ARCINFO). TA Services has developed models that predict communication system coverage and interference for many broadcast applications. New models in the GIS environment for personal communications services (PCS) and Local Multipoint Distribution Services (LMDS) have been developed (see Telecommunications Analysis Services, pp. 42-43). The TA Services computer has about 210 GB of storage capacity.

The following is a brief description of some programs available through TA Services.

HAAT – Calculates Height Above Average Terrain for an antenna at a specified location.
PCS/LMDS – Allows the user to create or import surfaces which may include terrain, buildings, vegetation, and other obstructions in order to perform line of sight (LOS) and diffraction studies.
FCCFIND, FMFIND, TVFIND, AMFIND, and TOWERFIND – Allows the user to search the FCC database for particular stations or by search radius around a point of interest.
PROFILE – Extracts path profiles according to user-specified input parameters. After the data is extracted, either the individual elevations or an average elevation along the profile can be obtained. A user can also receive plots of the profiles adjusted for various K factors. For microwave links, Fresnel zone clearance can be determined so that poor paths can be eliminated from a planned circuit or network.
SHADOW – Plots the radio LOS regions around a specified location in the United States using digitized topographic data. The program shows areas that are LOS to the base of the antenna, areas that are LOS to the top of the antenna, and areas that are beyond LOS to the antenna.
TERRAIN – Plots terrain elevation contours from any of the terrain databases available (1-arc-second SDTS for CONUS, 3-arc-second USGS, and GLOBE for the whole world).
COVERAGE – Calculates the received signal levels along radials that are spaced at user-defined intervals of bearing around the transmitter. The program lists the contours of signal coverage of the transmitter along each radial and lists distances to



Example of ICEPAC HF area coverage prediction.

user-specified contours for each radial. Either the FCC broadcast rules or the ITS Irregular Terrain Model can be chosen for calculations.

CSPM – Determines the system performance of mobile and broadcast systems in detailed output plots of signal intensity, as shown in the figure above. Plotted outputs can be faxed to the user, plotted on clear plastic for overlaying on geopolitical maps, or downloaded to the user site (in HPGL, GIF, or TARGA format). This program uses the ITS Irregular Terrain Model in a point-to-point mode, or other user-chosen algorithms for path loss calculation.

HDTV – Allows the user to analyze interference scenarios for proposed digital television (DTV) stations. The model contains current FCC and MSTV allotment tables and maintains the catalogs created by all users of the program. The user can create new stations by hand, or by importing station information directly from the FCC database. Analyses may be performed using the existing FCC database and allotment assignments, or the user can replace a station with one created and maintained in the user's catalog.

NWS – A specialized application to assist the National Weather Service in maintaining its catalog of weather radio stations (currently about 750).

PBS – An analysis model similar to the HDTV model, but specialized for Public Broadcasting Stations (PBS). Typical outputs may consist of composite plots showing Grade A and B coverage of several stations or "overlap" plots which show areas covered by more than one station.

ICEPAC/VOACAP/REC533 – High Frequency prediction models which can be downloaded (free) and executed on Windows based platforms.

ITM – Source code available for the Irregular Terrain Model (Longley/Rice).

IF-77 – Source code available for the IF-77 Air/Ground, Air/Air, Ground/Satellite prediction software (.1 to 20 GHz).

Contact: Gregory R. Hand (303) 497-3375
e-mail: ghand@its.bldrdoc.gov

Wireless Networks Research Center (WNRC)

The Wireless Networks Research Center (WNRC) provides a common laboratory area for work in the areas of wireless networks and wireless network access technologies. The WNRC allows the Institute to consolidate efforts in several areas, such as the RF/network interface. This work uses RF link characterization correlated with low-level network management protocols to develop PCS-to-PCS interference models, wireless network propagation models, non-cooperative wireless measurement, and wireless network discovery. RF/network interface measurement devices are used to make detailed measurements of PCS and cellular networks. One device uses a series of PCS/cellular phones to extract low-level protocol messages, network management information, and RF signal quality parameters. Another device has the ability to perform provider-independent PN offset scans and cdma2000 level 3 message logging.

The WNRC contains an experimental IEEE 802.11b wireless local area network (WLAN). ITS has conducted a series of wireless Voice over IP (VoIP) tests utilizing this infrastructure. The WLAN resources include IP packet logging equipment that can be used in network measurements. ITS recently added a code domain analyzer (CDA) measurement capability to the WNRC. The CDA is used to collect both short and long term Walsh channel data for any target IS-95 base station. The CDA operates in both the cellular and PCS frequency bands and can be used in fixed or mobile environments.

The WNRC is used to conduct ITS work in the area of inter-PCS interference, in support of TIA TR-46.2. ITS also has the capability to simulate PCS interference using a series of ITS implemented interference models.

Contact: Christopher J. Behm (303) 497-3640
e-mail: cbehm@its.bldrdoc.gov

Wireless Networks Research Center (photograph by S. Wolf).