ITS Tools and Facilities

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 efficient and robust 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 the highest quality microphones and cameras. Recording and playback devices include studio-quality analog and digital video tape recorders with two to eight audio channels, digital audio recorders, digital audio tape machines, and CD players. These systems are augmented with several digital audio and video workstations and numerous top 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 switchers 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.

Three separate rooms with controlled visual and/or acoustic environments are available for the subjective testing of audio and video signals. The controlled environments are specified in 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.

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. Four systems offer the ability to record and play back uncompressed digital audio bit-streams together with synchronized uncompressed SD and HD video bit-streams that conform to ITU-R and SMPTE Recommendations (e.g., SMPTE 259M/272M, 292M). Much audio and video processing is performed on high-performance workstations, supported by high capacity RAID arrays for storage of the uncompressed audio and video streams.

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 wired and wireless 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++ and MATLAB, processes video signals in accordance with ANSI T1.801.03-2003, ITU-T Recommendation J.144, and ITU-R Recommendation BT.1683, 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.

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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 channel. Consisting of a transmitter, receiver, and data acquisition system, the DSCP is used to make complex impulse-response measurements. The DSCP can transmit variable rate psudo noise codes at the same RF frequency for multiple-input multiple-output (MIMO) studies or multiple RF frequencies as desired. The DSCP receiver down-converts and digitizes the pseudo-noise signal at an intermediate frequency (IF), and then post-processes the

data to calculate the channel impulse response. The system can collect data on multiple channels every 600-800 μs, allowing characterization of the Doppler spectrum and time variability of the mobile channel for HF systems (up to 5.8 GHz). Historically, the DSCP was employed extensively for channel characterization of cellular and personal communications services. ITS expanded the probe to eight channels capable of mobile phased array or MIMO measurements. Also available is a wide-bandwidth, high-frquency probe, particularly suited for high-resolution requirements such as wireless local area network (LAN) applications up to 30 GHz. Most recently, the probe's measurement range has been expanded down to the UHF TV bands, and has been used for short-range mobile-to-mobile propagation channel characterization. In this mode of operation, a variable bit rate code generator is used to allow simultaneous recordings at different bandwidths and frequencies.

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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 provides access to the ITS local area network (LAN) while the 802.11 link connects this field site to ITS' Wireless Networks Research Center (see p. 73). The site can provide six independent duplex fiber channels to the ITS lab. This allows research to be conducted over an isolated one-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 sites. These links provide 802.11b services and are also used for network performance testing. The site's unique 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.

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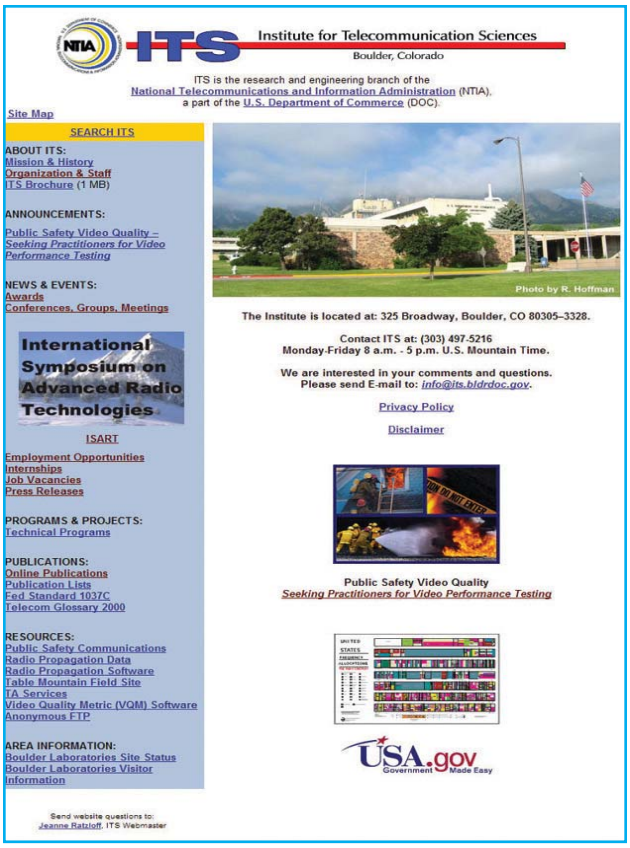

ITS home page: http://www.its.bldrdoc.gov

ITS Internet Services

ITS provides public Internet access to NTIA/ITS publications, program information, meeting information, and on-line resources such as Telecommunications Analysis Services, which are 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 standards committees. Highlights of ITS Internet Services include:

- Information about ITS programs and projects. Available at http://www.its.bldrdoc.gov/programs/.
- An ITS organization chart and listing of ITS staff with contact information. Available at http://www.its.bldrdoc.gov/organization.php.
- Recent ITS publications including NTIA Reports, special publications, and journal articles. Available at http://www.its.bldrdoc.gov/pub/pubs.php.
- Radio propagation data. Available at http://www.its.bldrdoc.gov/data/radio_propagation_data/.

- Radio propagation software. Available at http://www.its.bldrdoc.gov/software/.
- Information about the Table Mountain Field Site. Available at http://www.its.bldrdoc.gov/table_mountain/.
- Telecommunications Analysis Services. Available at http://tas.its.bldrdoc.gov/.
- Video Quality Metric software. Available at http://www.its.bldrdoc.gov/n3/video/vqmsoftware.htm.
- Information about ITS-sponsored events such as ISART. Available at http://www.its.bldrdoc.gov/meetings/.
- The ITS brochure. Available at http://www.its.bldrdoc.gov/ITS_brochure/ITS_brochure.pdf.

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ITS Local Area Network

ITS maintains a highly flexible local area network to support local networking services and laboratory interconnections. A structured cabling system interconnects all offices and laboratories with optical fiber, category 5, and category 6 twisted-pair cabling to support high-bandwidth communications on demand. Over 200 devices are supported on 10Base-T, 100Base-T, and gigabit segments. This provides ITS with great flexibility and rapid reconfiguration capability for new programmatic needs. A firewall-based VPN capability securely extends the network to authorized personnel anywhere in the world.

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Mobile Radio Propagation Measurement Facilities

ITS maintains and continually develops a pair of measurement vehicles comprising a transmitter-receiver system that characterizes the properties of radio channels over a wide frequency range, from VHF to 30 GHz. The transmitter vehicle has an on-board generator, a pair of telescoping masts, and a set of radio modulators and transmitters. The receiver van is equipped with on-board power, a telescoping mast, azimuth and elevation controllers, and global positioning system (GPS) devices with a dead-reckoning backup. A suite of measurement equipment, much of it designed and hand-built by ITS engineers, is used in the vehicle. These include wideband systems for measuring radio channel impulse responses; impulse response measurement capability at 30 GHz with 2-ns resolution is enhanced with a digital wideband recording system. To support mobile-to-mobile short-range propagation model development, an 8-channel receiver and an 8-channel, 14-bit data acquisition system have been developed. Multi-channel synchronous acquisition can be used for antenna array measurements and multi-frequency broadband measurements. Mobile measurement capability allows space division multiple access (SDMA) algorithms to be implemented using data collected in a wide variety of environments (e.g., urban, rural, and suburban). This data can in turn be used to model and simulate the performance of radio systems in such environments. A suite of analysis software is continuously developed and maintained for calculating mobile propagation metrics from impulse response data. Typical metrics are power delay profiles, delay spread, received power versus bandwidth, Doppler spectrum, and coherence bandwidth.

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Public Safety Audio & Video Laboratories

One of the most challenging aspects of public safety communication is the harsh noise environment in which public safety practitioners must effectively establish and conduct voice communications. The Public Safety Audio Laboratory (PSAL) and Public Safety Video Laboratory (PSVL) are facilities for investigating the voice and video quality of public safety communication systems in harsh environments. The PSAL consists of digital systems for mixing, storage, and distribution of audio; sound attenuated chambers for effective isolation; and International Telecommunication Union (ITU)-compliant head and torso simulators (HATS) for acoustic coupling to radio interfaces. The PSVL consists of cameras, video capture systems, video coding and decoding systems, network simulators, video editing stations, and props.

The PSAL is built on a foundation of digital audio mixing and distribution. All audio mixing, distribution, storage, and filtering are conducted in the digital realm with 48 kHz-sampled audio. This provides a high-quality, distortion-free distribution system that is not impacted by other equipment in the laboratory. The digital capabilities include: digital mixing, 24-track digital recording, 8-channel digital input and output to Windows-based computers, digital audio tape (DAT), and 1/3 octave digital filters. Usage of analog audio signals is kept to a minimum by 1) digitizing analog inputs at the input and keeping them digital throughout any processing, and 2) only performing digital-to-analog conversion on signals that are to be converted to acoustic signals.

The more specialized equipment in the PSAL includes the two HATS systems. The HATS systems are defined by the ITU in Recommendations P.58 (Head and torso simulator for telephonometry), P.57 (Artificial ears), and P.51 (Artificial mouth). These recommendations specify the physical characteristics and acoustical/electrical interface characteristics that enable a consistent simulation of the speaking and hearing frequency responses of the "average" human. The HATS enable consistent acoustic input to communications equipment under test and provide a "willing subject" that will not be subject to hearing loss when exposed to harsh noise environments for extended periods.

The PSAL system provides a reproducible acoustic path that enables emulation of the harsh noise environments encountered by public safety practitioners. The recorded output from the system can be used in a number of ways. For example, the recordings might be analyzed by an objective measurement technique such as that defined in ITU Recommendation P.862 (Perceptual evaluation of speech quality (PESQ): an objective method for end-to-end speech quality assessment for narrow-band telephone networks and speech codecs). Alternatively, the recordings might be incorporated into a subjective test experiment where listeners will rate the quality of the audio.

The primary role of the PSVL is to support the PSVQ project (see pp. 38-39). In accomplishing this mission, scenes that contain selected vital elements of public safety responder uses are created and filmed on high-definition cameras. These scenes include simulations of surveillance cameras (indoor and outdoor), in-car police cameras, and search and rescue robot cameras, among others. The video is then captured and edited on the PSVL workstations. Selected scenes are processed through controlled versions of the communication systems that might be typical of what a jurisdiction may consider purchasing. The communication systems processing includes compression schemes and simulated wired and wireless networks.

To determine if a system is adequate for use in specified applications, first responders view the video and attempt to perform certain tasks such as identifying an object or reading a license plate. The results of these tests provide data for developing recommendations.

Together, the PSAL and PSVL provide valuable insight into the requirements for public safety audio and video communications.

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Public Safety RF Laboratory

ITS' management of the Public Safety RF Laboratory (PSRF Lab) supports sponsor efforts to test Land Mobile Radio (LMR) systems and components according to Telecommunications Industry Association (TIA) Project 25 (P25) testing standards for LMR (the TIA-102 suite of standards). ITS' PSRF Lab staff contributes to the development and maturation of all three facets of the P25 testing standards: performance, conformance, and interoperability. The PSRF Lab implements these test standards in the lab in support of internal research, outside agency (OA) interagency agreements (IAAs), and cooperative research and development agreements (CRADAs) with other non-Federal government entities.

In 2007, the PSRF Lab completed installation of an RF screen room and developed automated test software to assess the RF performance characteristics of P25 equipment. In 2008, PSRF Lab staff installed a functional working two-site, three-channel VHF trunking system and a single-site, four-channel UHF trunking system, using commercial P25 equipment. These trunking systems are facilitating the PSRF Lab mission to contribute to the development of the Inter-RF Subsystem Interface (ISSI) as defined by TIA.

An ongoing external program of great interest to the PSRF Lab is the Department of Homeland Security (DHS) P25 Compliance Assessment

Program (P25 CAP), a voluntary program that allows P25 equipment suppliers to formally demonstrate their products' compliance with a select group of requirements within the TIA-102 suite of P25 standards. The purpose of the program is to provide emergency response agencies with evidence that the communications equipment they are purchasing meets P25 standards for performance, conformance, and interoperability, and to ensure that testing entities are implementing P25 test procedures correctly. The PSRF Lab is now undertaking the task of implementing the practices developed by the DHS P25CAP Governing Board, in order to allow the PSRF Lab to be as capable of performing the performance, conformance, and interoperability tests that P25CAP-recognized laboratories perform.

While the primary use for ITS' PSRF Lab test and measurement capability is the testing of P25 LMR systems and components, the underlying infrastructure and analysis facilities of ITS' PSRF lab can support a much broader range of tests and radio equipment. This capability is available on a first-come, first-served basis to both NTIA and other agencies.

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Pulsed Radar Target Generator

The Pulsed Radar Target Generator is an electronic tool 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. Some radar models transmit modulated pulses. The generator can produce modulated pulses such as chirped and phase coded modulations (including the popular Barker code set). Several parameters of the signals can be adjusted over a wide range to be compatible with several different radar models. 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 targets can be set to occur at a fixed time interval after a timing pulse (for example, beginning of scan) supplied by the radar. The generator can be used to verify operation or troubleshoot the radar under test. ITS has used 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.

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Radio Spectrum Measurement Science (RSMS) System Tools

The Radio Spectrum Measurement Science (RSMS) system is a state-of-the-art measurement system designed for gathering information on 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. The RSMS system 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 intercept and collection systems. Measurements can take place in a laboratory or in the field, and 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, and a 20-kW 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 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.

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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 with a variety of software capabilities to support propagation planning and modeling, as well as emerging technologies research. The secure facilities 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 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.

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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 useful information in guiding design decisions, the complexity of modern systems and the existing spectral environment often require real-world measurements of a proposed system's effects within its actual or proposed operating environment to determine its impact on other users of the radio spectrum. Another problem is to adequately produce controlled interfering signals with known characteristics in environments where suspected interferers may be unavailable for tests and measurements. This includes situations such as laboratory investigations of possible interference from ship or aircraft-mounted radars or communication systems. In these sorts of situations a system is needed that simulates the spectral emissions of other devices with a wide range of latitude and fidelity. An example of these needs is the requirement to determine the thresholds at which various types of interference from communication transmitters are manifested as observable interference effects in a variety of radar receivers. Another example would be to determine the source(s) of interference from terrestrial services to space-based communication links.

To meet these needs, ITS engineers have developed two different approaches to generating interference signals. One approach is to build custom hardware and software combinations of discrete-component equipment, including programmable arbitrary waveform generators, mixers, RF signal generators, and amplifiers. ITS has used a number of these configurations 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 through space into a target system's receiver to more accurately gauge its response to a real interference situation.

The second approach that ITS uses for generating interference is to utilize high-speed digitizers, called vector signal analyzers (VSAs), to record interference waveforms in bandwidths up to 36 MHz, and to then either radiate or hardline-couple those waveforms into victim receivers using vector signal generators (VSGs) that operate somewhat as inverses to VSAs. Alternatively, VSGs may be preprogrammed with the requisite mathematical information to create particular waveform modulations, such as quadrature phase shift keyed (QPSK) signals.

The ITS VSGs can be used in conjunction with high-power amplifiers to generate interference signals at high power at frequencies as high as 26 GHz. The advantages of using VSGs to generate interference include simplicity of operation and use, plus the ability to replicate very complex interference waveforms with complete confidence in the fidelity of the simulated signal to the characteristics of the original signal from which it was derived.

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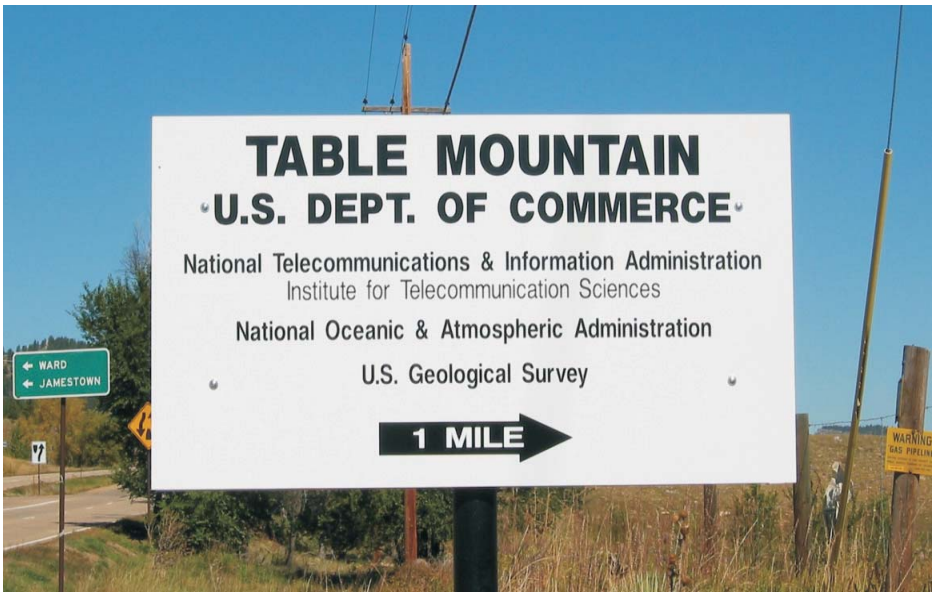

Sign at the west entrance to the Table Mountain field site (photograph by J.D. Ewan).

Table Mountain Field Site and Radio Quiet Zone

Established in 1954, the Table Mountain Field Site and Radio Quiet Zone is a unique radio research facility. Located north of Boulder, the site extends approximately 2.5 miles north-south 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 to minimize radio-frequency interference to sensitive research projects. Facilities at the site include:

- **Spectrum Research Laboratory** — A state-of-the-art facility for research into radio spectrum usage and occupancy. Radio Quiet restrictions ensure that no signal incident on the mesa overpowers any other.
- **Open Field Radio Test Site** — A flat-topped butte with uniform 2% slope, Table Mountain is uniquely suited for radio experiments. It has no perimeter obstructions and the ground is relatively homogeneous. This facilitates studying outdoor radiation patterns from bare antennas or antennas mounted on structures.
- **Mobile Test Vehicles** — There are several mobile test equipment platforms available at the mesa, ranging from 4-wheel drive trucks to full-featured mobile laboratories.
- **Large Turntable** — A 10.4-meter (34-foot) diameter rotatable steel table mounted flush with the ground. Laboratory space underneath houses test instrumentation as well as the control equipment and motors to rotate the turntable. This facility can be operated remotely by computer.
- **18.3 Meter (60 Foot) Parabolic Dish Antennas** — These two antennas are steerable in both azimuth and elevation and have been used at frequencies from 400 MHz to 6 GHz.
- **Radar Test Range** — A large space just south of the Spectrum Research Laboratory is available for testing radar systems.

The Table Mountain Research program supports a number of research activities, e.g., studying the effects of radio propagation on digital signal transmission, environmental and man-made noise, verification of antenna propagation models, and the development of measurement methods needed to assess efficient spectrum occupancy and usage (see pp. 10-11). Partnerships and cooperative research activities are encouraged at the site. Other agencies currently using the facilities include the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Geological Survey (USGS).

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Telecommunications Analysis Services

The Telecommunications Analysis (TA) Services program provides the latest ITS-developed engineering models and research data to industry and other Government Agencies via a web-based interface (http://tas.its.bldrdoc.gov/). 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) resolution 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; the U.S. Census data for 2000, 1997 update, and 1990; FCC databases; and 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 have been developed (see pp. 40-41). The following is a brief description of 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 user-specified contours for each radial. Either the FCC broadcast rules or the ITS Irregular Terrain Model (ITM) can be chosen for calculations.
CSPM – Determines the system performance of mobile and broadcast systems in detailed output plots of signal intensity. 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 ITM 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 program users. The user can create new stations by hand, or by importing station information directly from the FCC database. Analyses may be performed using existing FCC database and allotment assignments, or the user can replace a station with one created and maintained in his/her catalog.
NWS – A specialized application to assist the National Weather Service in maintaining its catalog of weather radio stations (currently about 920).
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 ITS 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).

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Wireless Networks Research Center (WNRC)

The Wireless Networks Research Center (WNRC) provides a common laboratory area for research in 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. A code domain analyzer (CDA) measurement capability, used to collect both short and long term Walsh channel data for any target IS-95 base station, has been added to the WNRC. 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 the Alliance for Telecommunications Industry Solutions (ATIS) subcommittee WTSC-RAN. ITS also has the capability to simulate PCS interference using a series of ITS implemented interference models.

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American Kestrels at the Table Mountain Field Site (photograph by J.W. Allen).