ITS Outputs in FY 2003

NTIA Publications

J.W. Allen and T.X Brown, Eds., "Proceedings of the International Symposium on Advanced Radio Technologies: March 4-7, 2003," NTIA Special Publication SP-03-401, Mar. 2003.

No abstract available.

J.W. Allen and T. Mullen, "Digital television (DTV) field strength and video quality study," NTIA Technical Memorandum TM-03-405, Aug. 2003.

A particular concern about digital television (DTV) broadcasts is whether such broadcasts have sufficient power to be received using inexpensive indoor antennas located inside a typical home. To test this, the Institute for Telecommunication Sciences (ITS) constructed a "simulated home" mounted on a flatbed trailer. This allowed ITS to move the test home to a number of locations in the vicinity of an operating commercial DTV transmitter. By equipping this test home with commercially available DTV receivers and an indoor antenna located at the center of the home, ITS could then observe and record the DTV reception at a number of test locations. This information was further correlated with the incident field strengths by measuring the signal power outside the structure at a height of 10 meters above ground and at a location inside the structure at a height of roughly 1.5 meters above ground. This report summarizes the results of this study.

J.R. Hoffman, E.J. Haakinson, and Y. Lo, "Measurements to determine potential interference to public safety radio receivers from ultrawideband transmission systems," NTIA Report TR-03-402, Jun. 2003.

This report describes laboratory measurements to determine the extent and nature of interference to Public Safety radio receivers by ultrawideband (UWB) signals. Two Public Safety radio receivers from different manufacturers were tested in the 138-MHz band, both configured for Project 25 digital radio mode and one additionally configured and tested in analog mode. The laboratory measurements were performed by inserting increasing levels of UWB interference and measuring either bit-error rate (BER) for digital radios or signal-plus-noise-plus-distortion to noise-plus-distortion ratio (SINAD) for one of the same radios placed in analog mode. By varying pulse repetition frequency (PRF), pulse spacing schemes, and gating, a variety of UWB signals were simulated, which were either Gaussian noise-like, sinusoidal, or a hybrid of the two when passed through the receiver passband. Results showed that, when reported in terms of average UWB power in the receiver bandwidth, there is little difference in interference to Public Safety radios when comparing each of the generated UWB signal types. When expressed in terms of signal-to-interference power ratio, where interference power is defined as the power passed through the receiver passband, reference sensitivity (5% BER for digital radios and 12 dB SINAD for analog radios) occurs at approximately 10 dB, with a variation of 2 to 5 dB on either side, depending upon the receiver and signal type. When the interference power is expressed in terms of anything other than the mean power in the receiver bandwidth (e.g., wider bandwidths or peak power), the receiver response can vary greatly depending upon the nature of the interfering signal.

P.B. Papazian, Y. Lo, J.J. Lemmon, and M.J. Gans, "Measurements of channel transfer functions and capacity calculations for a 16x16 BLAST array over a ground plane," NTIA Report TR-03-403, Jun. 2003.

Wideband channel transfer function measurements were made for a 16-element transmit and 16-element receive, multiple input, multiple output (MIMO) antenna array. The measurements were conducted using the National Institute of Standards and Technology (NIST) open area test site (OATS), allowing analytic calculations of the channel transfer functions. The H matrix for the BLAST array was then determined from measured data and the link capacity was calculated using information theory. The theoretical link capacity was then calculated and found to be 22.16 Bits/Hz/s for horizontally polarized antennas and 22.19 Bits/Hz/s for vertically

polarized antennas. It was then found that the measured results agreed with the theoretical calculations with 5% error using horizontally polarized antennas and with <0.3% error for the vertically polarized case. The objective of this work was to verify that wideband measurements could be used to accurately measure H and predict the capacity of a MIMO channel.

M.H. Pinson and S. Wolf, "Video quality metric software, version 2: Volume 1, SGI 64-bit code; Volume 2, SGI 32-bit code; Volume 3, Sun code; Volume 4, HP code," NTIA Software/Data Product SD-03-396, Oct. 2002.

No abstract available.

S.D. Voran, "An iterated nested least-squares algorithm for fitting multiple data sets," NTIA Technical Memorandum TM-03-397, Oct. 2002.

A multiple data set fitting problem often arises in conjunction with the development of objective estimators of perceived audio or video quality. In such development work, we often seek the best linear relationship between a set of objective audio or video quality estimation parameters and a set of subjective audio or video quality scores. In order to find the most robust and reliable relationship, we prefer to perform a least-squares fit using as many audio or video data points as possible. This motivates us to combine scores from different subjective tests. Unfortunately, scores from different subjective tests or data sets can differ in significant ways due to differing test procedures, environments, languages, and other sources. We develop a solution to this multiple data set fitting problem: the iterated nested least-squares (INLS) algorithm. This algorithm iterates between two least-squares steps. One step attempts to homogenize heterogeneous data sets through the use of a single first-order correction for all of the data points in each data set. The other least-squares step solves for the appropriate linear combination of the parameters, across all data sets. We also offer example INLS algorithm results using simulation data and data from telephone-bandwidth speech quality tests. For convenience we have written this memorandum in the language of objective estimation of perceived audio and video quality but the results are completely general and can be used to fit other types of data sets as well.

S.D. Voran, "Compensating for system gain: Motivations, derivations, and relations for three common solutions," NTIA Technical Memorandum TM-03-398, Oct. 2002.

It is often desirable to compensate for system gain, especially before objectively estimating perceived audio or video quality from system inputs and outputs. A common approach is to scale the system output to compensate for system gain. One can take three views of the system, and this leads to three different gain compensation solutions: one that minimizes distortion, one that matches input-output power, and one that maximizes signal-to-distortion ratio. We derive these three solutions, describe the algebraic and geometric relationships between them, and provide a generalized result that subsumes all three. We provide audio and video examples and show that these three solutions can differ significantly. We also report some of the gain compensation choices found in the objective audio and video quality estimation literature.

Outside Publications

Articles in Conference Proceedings

N. DeMinco and P.M. McKenna, "Evaluation and comparative analysis of radio-wave propagation model predictions and measurements," in *Applied Computational Electromagnetics Society Symposium Digest*, vol. X, Mar. 2003.

This paper describes recent analyses performed on propagation model predictions and comparisons of those predictions with measured data. The specific radio-wave propagation prediction model is the Irregular Terrain Model (ITM) developed by the Institute for Telecommunication Sciences. The model is valid at frequencies from 20 to 20,000 MHz. Descriptions of specific problems encountered with analyses and comparisons of predicted versus measured data are discussed. The major results of this study are:

1. Model predictions are extremely sensitive to the magnitude of the effective antenna height, and an alternative effective antenna height algorithm is necessary to improve prediction accuracy.

2. A terrain database that does not accurately represent the propagation path will severely impact the model loss predictions.

3. When the measured data samples are correlated (i.e., not independent), a multivariate statistical analysis of the available measured data must be used to properly assess stochastic behavior.

R.J. Matheson, "The electrospace model as a frequency management tool," in "Proceedings of the International Symposium on Advanced Radio Technologies: March 4-7, 2003," J.W. Allen and T.X Brown, Eds., NTIA Special Publication SP-03-401, Mar. 2003.

In this tutorial paper, the electrospace is described as a theoretical hyperspace occupied by radio signals, which has dimensions of location, angle-of-arrival, frequency, time, and possibly others. Because these dimensions are independent, a given radio signal has a unique descriptor in the electrospace. Signals having different electrospace descriptors can theoretically be separated by a suitable receiver. The electrospace model provides a good framework to define spectrum user rights that divide licensed spectrum into parcels that can be flexibly used in an independent and non-interfering manner, while allowing complete freedom to divide and aggregate spectrum parcels via a secondary market. Disadvantages of the electrospace model are that it assumes ideal receivers and it allows the specification of spectrum parcels that cannot practically be used in the real world. Additional rules can be added to account for non-ideal receivers.

C. McKay and F. Masuda, "Empirical study of 802.11b wireless networks in the presence of Bluetooth interference," in "Proceedings of the International Symposium on Advanced Radio Technologies: March 4-7, 2003," J.W. Allen and T.X Brown, Eds., NTIA Special Publication SP-03-401, Mar. 2003.

Two complementary wireless networking standards, Bluetooth and 802.11b, operate in the 2.4 GHz Industrial, Scientific, and Medical (ISM) band. Although they use different methods to modulate and transmit data, significant interference can occur. Under certain conditions, a Bluetooth-enabled device can render an 802.11b connection almost useless. This paper presents

measurement results from a study on the throughput of an 802.11b link when one end of the link is subjected to interference from Bluetooth devices.

C. McKay and F. Masuda, "Empirical studies of wireless VoIP speech quality in the presence of Bluetooth interference," in *Proc. IEEE International Symposium on Electromagnetic Compatibility 2003*, Boston, MA, Aug. 2003.

Both Bluetooth and 802.11b wireless devices operate in the same frequency range. Increasingly, Voice-over-IP (VoIP) traffic is being routed over wireless network segments where packet loss can be an issue. This paper presents the results of a study of the effects of Bluetooth devices on the quality of VoIP calls over 802.11b networks.

A. Paul, P. McKenna, and F. Najmy, "Evaluation of two site-specific radio propagation models," in "Proceedings of the International Symposium on Advanced Radio Technologies: March 4-7, 2003," J.W. Allen and T.X Brown, Eds., NTIA Special Publication SP-03-401, Mar. 2003.

This paper discusses evaluation of site-specific propagation models used in the VHF and UHF range of frequencies which are needed for prediction of coverage and interference, especially for wireless communication applications. It describes two ongoing tasks, one at the National Telecommunications and Information Administration (NTIA) and the other at the International Telecommunication Union (ITU). In the United States, two major deterministic site-specific propagation models have been used for a long time: the Terrain Integrated Rough Earth Model (TIREM) developed for the Joint Spectrum Center (JSC) of the Department of Defense, and the Irregular Terrain Model (ITM) developed by the Institute for Telecommunication Sciences (ITS) of NTIA. About two years ago, the Office of Spectrum Management (OSM) of NTIA started a task for comparison and harmonization of the two models (TIREM and ITM). Both ITS and OSM are working on this task in cooperation with JSC. Predicted propagation losses from both models have been compared with large numbers of measured data. The first order statistical results, such as mean prediction error and its standard deviation, are similar for the two models. However, errors for individual

paths between the two models sometimes differ by 20 dB or more. Some of the results of the comparison task and possible explanations for the discrepancies are presented. At the ITU Radiocommunication Study Group 3 (ITU-R SG 3) on propagation, Working Party 3K decided to proceed with a Preliminary Draft New Recommendation (PDNR) on a method for path-specific propagation prediction. An outline for this document, developed in 2002, is also discussed.

M. H. Pinson and S. Wolf, "Comparing subjective video quality testing methodologies," in *Proc. SPIE Video Communications and Image Processing Conference*, Lugano, Switzerland, Jul. 2003.

International recommendations for subjective video quality assessment (e.g., ITU-R BT.500-11) include specifications for how to perform many different types of subjective tests. Some of these test methods are double stimulus where viewers rate the quality or change in quality between two video streams (reference and impaired). Others are single stimulus where viewers rate the quality of just one video stream (the impaired). Two examples of the former are the double stimulus continuous quality scale (DSCQS) and double stimulus comparison scale (DSCS). An example of the latter is single stimulus continuous quality evaluation (SSCQE). Each subjective test methodology has claimed advantages. For instance, the DSCQS method is claimed to be less sensitive to context (i.e., subjective ratings are less influenced by the severity and ordering of the impairments within the test session). The SSCQE method is claimed to yield more representative quality estimates for quality monitoring applications. This paper considers daa from six different subjective video quality experiments, originally performed with SSCQE, DSCQS and DSCS methodologies. A subset of video clips from each of these six experiments were combined and rated in a secondary SSCQE subjective video quality test. We give a method for post-processing the secondary SSCQE data to produce quality scores that are highly correlated to the original DSCQS and DSCS data. We also provide evidence that human memory effects for time-varying quality estimation seem to be limited to about 15 seconds.

M. H. Pinson and S. Wolf, "An objective method for combining multiple subjective data sets," in *Proc. SPIE Video Communications and Image Processing Conference*, Lugano, Switzerland, Jul. 2003.

International recommendations for subjective video quality assessment (e.g., ITU-R BT.500-11) include specifications for how to perform many different types of subjective tests. In addition to displaying the video sequences in different ways, subjective tests also have different rating scales, different words associated with these scales, and many other test variables that change from one laboratory to another (e.g., viewer expertise and criticality, cultural differences, physical test environments). Thus, it is very difficult to directly compare or combine results from two or more subjective experiments. The ability to compare and combine results from multiple subjective experiments would greatly benefit developers and users of video technology since standardized subjective data bases could be expanded upon to include new source material and past measurement results could be related to newer measurement results. This paper presents a subjective method and an objective method for combining multiple subjective data sets. The subjective method utilizes a large meta-test with selected video clips from each subjective data set. The objective method utilizes the functional relationships between objective video quality metrics (extracted from the video sequences) and corresponding subjective mean opinion scores (MOSs). The objective mapping algorithm, called the iterated nested least-squares algorithm (INLSA), relates two or more independent data sets that are themselves correlated with some common intermediate variables (i.e., the objective video quality metrics). We demonstrate that the objective method can be used as an effective substitute for the expensive and time consuming subjective meta-test.

F. Sanders, "Dependence of radar emission spectra on measurement bandwidth and implications for compliance with emission mask criteria," in "Proceedings of the International Symposium on Advanced Radio Technologies: March 4-7, 2003," J.W. Allen and T.X Brown, Eds., NTIA Special Publication SP-03-401, Mar. 2003., pp. 73-79.

Radar transmitter emission criteria normally include the specification of frequency-dependent emission masks. These masks specify the amount by which unwanted radar emissions (both out-of-band and spurious) must be suppressed relative to the power levels emitted at the radars' fundamental frequencies. Compliance with emission masks is determined through measurements of emission spectra. The measured levels of radar unwanted emissions and fundamental-frequency emissions both vary as a function of measurement system bandwidth, Bm. But the variation with Bm differs between the unwanted emissions and the fundamental-frequency emissions. Moreover, the variation of unwanted emission levels varies as a function of frequency as well as Bm. This creates a problem for radar emission mask-compliance measurements.

The National Telecommunications and Information Administration (NTIA) Institute for Telecommunication Sciences (ITS) has explored this problem by performing emission spectrum measurements on a maritime surface search (navigation) radar. In the spectrum data that are presented, the radar unwanted emission levels are found to vary between $12 \log(Bm)$ and $20 \log(Bm)$, depending upon frequency. But the measured power of the radar fundamental frequency is found to vary as $20 \log(Bm)$ for all bandwidths that are less than or equal to 1/(radar pulse width). The result is that the level offset between the unwanted emissions and the fundamental-frequency emission level depends upon the measurement bandwidth and the frequency of the unwanted emissions. This result implies, at a minimum, that measurement personnel must take the effect of Bm into account when performing radar emission spectrum measurements for the purpose of determining emission mask compliance. Based upon the results of these maritime radar spectrum data, some technical strategies for measuring radar emission spectra for emission mask compliance are proposed. Possible technical implications for future development of radar emission masks are also discussed.

R. Stafford, C. Behm, and C. Redding, "Over-the-air techniques to determine IS-95 base station resource allocation," in *Proc. MILCOM 2002*, Anaheim, CA, Oct. 2002.

Federal communications users are increasingly dependent on commercial wireless systems. In the aftermath of both man-made and natural disasters, commercial wireless systems will be in high demand. Federal and commercial users must compete for scarce resources during high demand situations. Since most network performance data is not publicly available, it is crucial that federal wireless network users have the same level of information as the service providers. Wireless network performance data could provide federal users with the ability to avoid congested (high call-blocking) areas, view the effectiveness of wireless priority services, and assess infrastructure vulnerabilities. Walsh channel power occupancy can be used as an indicator of IS-95 network congestion. This paper describes methods and techniques used to conduct over-the-air measurements of IS-95 Walsh channel power occupancy. This data is then used to examine short and long term traffic channel statistics for several IS-95 carriers in the Denver metropolitan area.

S.D. Voran, "Channel-optimized multiple-description scalar quantizers for audio coding," in *Proc. IEEE 10th Digital Signal Processing Workshop*, Pine Mountain, GA, Oct. 2002.

Multiple-description coding is one way to gain robustness against lossy channels. We extend the multiple-description scalar quantizer (MDSQ) to a channel-optimized MDSQ (COMDSQ) that minimizes mean-squared error for a given channel environment. We discuss necessary and sufficient conditions for the optimality of M-channel COMDSQ's and provide a procedure for the design of 2-channel COMDSQ's. We provide example results including audio files from waveform and transform coders that employ COMDSQ's.

S.D. Voran, "Perception of temporal discontinuity impairments in coded speech – A proposal for objective estimators and some subjective test results," in *Proc. MESAQIN (Measurement of Speech and Audio Quality in Networks) Conference*, Prague, Czech Republic, May 2003.

Temporal discontinuities in received speech are a reality of Internet Telephony or Voice over Internet Protocol (VoIP) systems. These relatively new impairments pose unique challenges to objective estimators of perceived speech quality. We suggest that objective estimators may benefit from the addition of a temporal discontinuity impairment processor and we provide subjective test results that may help with the design of such processors.

We added the loss, pause, and jump impairments (nine different levels of each) to random locations in active segments of G.723.1 coded speech. We then measured the resulting perceived speech quality via a formal absolute category rating subjective experiment using the mean opinion score (MOS) scale.

The results show that these three different impairments have similar influences on perceived speech quality, even though the pause and jump impairments are exact opposites (temporal dilation vs. temporal contraction). The results also demonstrate that at a fixed impairment rate, dispersion of these impairments is less detrimental to perceived speech quality than clustering of these impairments. We offer a simple mathematical model that relates impairment parameters to experimental MOS values. It is expected that these results will be of value to those who develop objective estimators of packetized speech quality as well as those who design jitter buffers and jitter buffer management (or playout) algorithms.

Journal Articles

N. Seitz, "ITU-T QoS standards for IP-based networks," *IEEE Communications Magazine*, Volume 41, No. 6, pp. 82-89, June 2003.

To support IP/PSTN convergence, future IP networks will need to provide reliable, differentiated QoS to a diverse set of user applications, including telephony. To achieve end-to-end QoS solutions, IP network providers will need to agree on a common set of IP packet transfer performance parameters and QoS objectives. This paper describes two new ITU-T Recommendations, Y.1540 and Y.1541, that document such an agreement.

Other Publications

P. Papazian and R. Dalke, "Local multipoint distribution services (LMDS)," in *Wiley Encyclopedia of Telecommunications*, J.G. Proakis, Ed., New York: Wiley-Interscience, 2002, vol. 3, pp. 1268-1279.

No abstract available.

Unpublished Presentations

R. Matheson, "Measurement technology and issues," invited talk at the FCC Technological Advisory Council on Noise and Interference, July 7, 2003.

S. Voran, "Procedure for evaluation of candidate vocoders," invited presentation to TIA/EIA TR-8.4, June 2003. The talk addressed specific issues associated with subjective and objective estimation of speech quality as they related to current discussions and objectives of that group.

Conferences Sponsored by ITS

International Symposium on Advanced Radio Technologies (ISART 2003)

The International Symposium on Advanced Radio Technologies (ISART 2003) was held March 4-7, 2003. This symposium explores the current state of the radio art with an eye towards forecasting the use of wireless technology in the future. In order to accomplish this goal, ISART brings together a diverse collection of people from academia, business, and government agencies to discuss the interplay between technological "how-to," the possibilities and restrictions created by regulation and policy, and the economic motivation of the business world.

One notable addition to this year's conference was the publication of the "Proceedings of the International Symposium on Advanced Radio Technologies," NTIA Special Publication SP-03-401, Mar. 2003. For more information about this conference see: http://www.its.bldrdoc.gov/meetings/art/.

Standards Leadership Roles

David J. Atkinson, Technical Coordinator for the development of a Justice and Public Safety XML Data Element Dictionary, through the XML sub-committee of the Global Justice Information Network's Infrastructure/Standards Working Group.

Paul M. McKenna, National Chair of the U.S. contingent of ITU-R Study Group 3 (Radiowave Propagation); Chair of ITU-R Task Group 3/2 on Broadcast and Land Mobile Point-to-Area Propagation Predictions; Chair of Drafting Groups 3J6 and 3M-3B.

William J. Pomper, Chair of APCO/NASTD/FED Project 25 Encryption Task Group; Member of TIA/TR-8 - Mobile and Personal Private Radio Standards Committee; Technical Advisor to NCS Federal Telecommunications Standards Committee.

Timothy J. Riley, Editor for the proposed American National Standard: "Third Generation Systems and Licensed Band PCS Interference," as a member of TIA committee TR46.2 (Mobile & Personal Communications 1800 — Network Interfaces).

Neal B. Seitz, Chair of ITU-T Study Group 13 Working Party 4 (Network Performance and Resource Management); Vice Chair of ANSI-accredited Technical Subcommittee T1A1 (Performance and Signal Processing).

Arthur Webster, Co-chair of Video Quality Experts Group (VQEG); Rapporteur for Question 21/9 (Objective and subjective methods for evaluating conversational audiovisual quality in multimedia services) in ITU-T Study Group 9 (Integrated broadband cable networks and television and sound transmission).

Representative Technical Contributions

Contributions listed below are a brief example of the extensive standards work that ITS does each year.

High-power Radars (authors include F. Sanders, B. Bedford, R. Sole, R. Hinkle)

- "Test results illustrating the susceptibility of maritime radionavigation radars to emissions from digital communication and pulsed systems in the bands 2 900-3 100 and 9 200-9 500 MHz," Draft New Report, ITU-R Working Party 8B.

- "Unwanted emissions of primary radar systems," Proposed revision of Question ITU-R 202-2/8.

Network Survivability (authors/editors include A. Webster)

- T1.TR.79-2003 "Overview of Standards in Support of Emergency Telecommunications Service (ETS)."

- T1.TR.xx-2003 Draft Technical Report "Traffic Priorities in Emergency Telecommunications Service."

- Draft New Recommendation J.TDR, "Requirements and Specifications for Telecommunications for Disaster Relief over IPCablecom Networks," ITU-T Study Group 9.

TIA TR-8 (Private Land Mobile Radio) and APCO Project 25 (authors/editors include R.S. Bloomfield).

- "Proposal Concerning Development of a Documentation Plan for ISSI Interoperability Test Methods" (IPP Task Group; Jun. 10, 2003).

- "ITS Comments on *RTP Common VoIP RTP Payload May2003.doc*" (RTP Ad Hoc Group; Jul. 8, 2003).

- "ITS Comments on *System TG RFSS Ad Hoc Group June 12, 2003*" (RFSS Ad Hoc Group; Jul. 18, 2003).

- "ITS Comments on *APCO P25 Inter-RF System Interface (ISSI) Overview (Draft TSB-102.BACC-A, June 11, 2003)*" (TR-8.19 Wireline Interface Subcommittee; Jul. 24, 2003).

- "Draft of Issue C of Planned New TSB: Project 25 ISSI Performance Specifications for Voice Services" (ISSI Task Group; Aug. 7, 2003).

- "Issue D of Planned New TSB: Project 25 ISSI Measurement Methods for Voice Services" (ISSI Task Group; Aug. 7, 2003).

Video Quality (authors include S. Wolf and M. Pinson)

- ANSI T1.801.03-2003, "Digital Transport of One-Way Video Signals - Parameters for Objective Performance Assessment."