Support to Private Sector Telecommunications Activities:

Cooperative Research with Industry

Outputs

- PC software that measures the quality of audio and video signals that have been transmitted through a telecommunications system.
- Tools for measuring the quality of digital video and speech transmission through next generation Internet and Internet 2 technologies.
- Measurements to validate the theoretical capacity of the Bell Labs Layered Space-Time (BLAST) antenna system.

The Federal Technology Transfer Act of 1986 (FTTA), as amended, allows Federal laboratories to enter into cooperative research agreements with private industry, universities, and other interested parties. The law was passed in order to provide laboratories with clear legal authority to enter into these arrangements and thus encourage technology transfer from Federal laboratories to the private sector. Under this Act, a cooperative research and development agreement (CRADA) can be implemented that protects proprietary information, grants patent rights, and provides for user licenses to corporations, while allowing Government expertise and facilities to be applied to interests in the private sector.

ITS participates in technology transfer and commercialization efforts by fostering cooperative telecommunications research with industry where benefits can directly facilitate U.S. competitiveness and market opportunities. For a number of years ITS has participated in CRADAs with private sector organizations to design, develop, test, and evaluate advanced telecommunication concepts. Research has been conducted under agreements with:

- American Automobile Manufacturers Association
- ARINC
- AudioLogic, Inc.
- Bell Atlantic Mobile Systems
- Bell South Enterprises
- Industrial Technology, Inc.
- Integrator Corporation
- Intel Corporation
- Lehman Chambers
- Lucent Digital Radio
- Lucent Technologies
- Motorola Inc.
- East Carolina University's Brody School of Medicine.
- General Electric Company
- GTE Laboratories Inc.
- Hewlett-Packard Company (HP)
- Netrix Corporation
- Telesis Technology Laboratories
- University of Pennsylvania
- US WEST Advanced Technologies
- US WEST New Vector Group

Not only does the private sector partner benefit, but the Institute is able to undertake research in commercially important areas that it would not otherwise be able to do. Recent CRADAs are described below.

- Intel Corporation and ITS have completed cooperative research and development in the area of telecommunications and multimedia. The areas of interest include subjective and objective video quality, subjective and objective audio quality, and wireless communications. PC software that measures the quality of received audio and video signals is available on ITS' web site.
- ITS conducted cooperative research with the University of Pennsylvania to investigate the relationships between application-level performance (e.g., the video quality that is perceived by end-users of a video system) and the next generation Internet (NGI) and Internet 2 (I2) network performance parameters. By determining these Quality of Service (QoS) relationships and disseminating the results to industry, network providers will be able to design better NGI/I2 networks and services. In addition, end-users of NGI/I2 networks and services will benefit since they will have an objective means of measuring QoS from competing network providers. Updated software was completed and delivered this year.
- Lucent Technologies, Bell Laboratories, and ITS completed cooperative research to measure the transmission coefficient matrix associated with two 16-element arrays located above a ground plane. The purpose of this experiment was to validate the theoretical capacity of the

Testing the BLAST antenna system above a ground plane (photograph by P.B. Papazian).

Bell Labs Layered Space-Time (BLAST) antenna system. The BLAST system has the potential to greatly increase the capacity of wireless communications systems.

- East Carolina University's Brody School of Medicine and ITS began cooperative research and development in the area of quality assessment of digital video and audio for telemedicine applications. Traditional techniques for assessing analog video and audio quality are inadequate for accurately quantifying digital audio and video quality due to the adaptive processing of signals by codecs. Therefore, newer digital techniques developed by ITS must be employed for this assessment. A set of video test scenes were processed this year.

Cooperative research with private industry has helped ITS accomplish its mission to support industry's productivity and competitiveness by providing insight into industry needs. This has led to adjustments in the focus and direction of other Institute programs to improve their effectiveness and value.

ITS is interested in assisting private industry in all areas of telecommunications. The pages of this technical progress report reveal many technological capabilities that may be of value to various private sector organizations. Such organizations are encouraged to contact ITS if they believe that ITS may have technology that would be useful to them. Because of the great commercial importance of many new and emerging telecommunication technologies, including third generation wireless (3G), wireless local area networks, digital broadcasting, and intelligent transportation systems, ITS plans to vigorously pursue technology transfer to the private sector through CRADAs and thereby contribute to the rapid commercialization of these new technologies. In addition, ITS plans to commit substantial resources of its own to the development and standardization of these new technologies.

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SUPPORT TO PRIVATE SECTOR TELECOMMUNICATIONS ACTIVITIES:

ITU-T and Related U.S. Standards Development

Outputs

- Leadership of ITU-T and related U.S. telecommunications standards committees.
- Technical contributions presenting U.S. standards proposals and ITS research results.
- Proposed ITU Recommendations and associated U.S. industry standards.

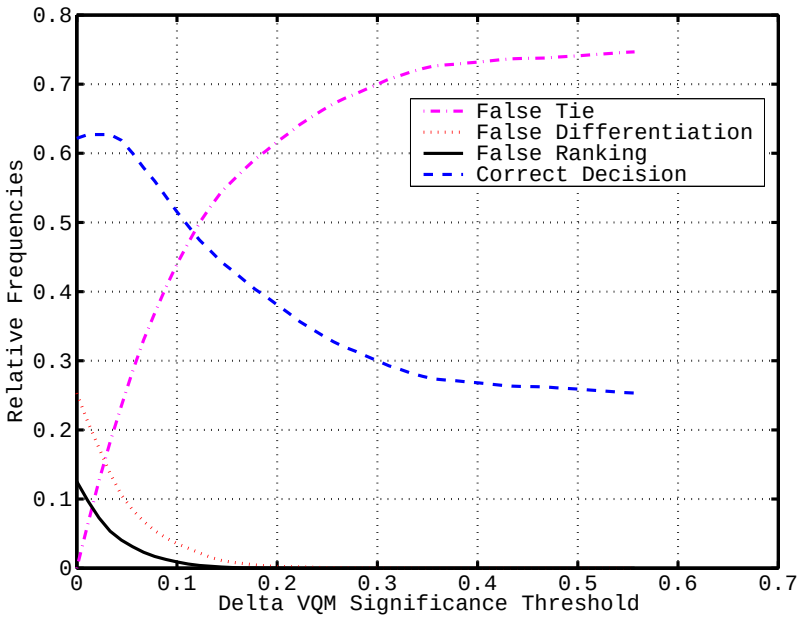
The Institute has a long and distinguished history of leadership, technical contributions, and advocacy of U.S. government and industry proposals in international and related national telecommunication standards committees. These activities have been focused in the International Telecommunication Union (ITU) — the United Nations-affiliated standards organization responsible for the cooperative planning and interoperation of public telecommunication systems and services worldwide. The ITU's technical work is centered in two permanent organs: the Telecommunication Standardization Sector (ITU-T), and the Radiocommunication Sector (ITU-R). The ITU-T develops international standards (Recommendations) addressing technical, operating, and tariff questions relating to all aspects of wireline telecommunications. The technical work of ITU-T is conducted in thirteen Study Groups whose responsibilities are distinguished on the basis of particular technical specialties and standards development needs. ITU-T Recommendations have a strong impact on both the evolution of U.S. telecommunications infrastructures and the competitiveness of U.S. telecommunications equipment and services in international trade.

ITS has played a strong role in ITU-T standardization work for many years. The Institute's technical goal there — and in related national standards work — has been to motivate the development and standardization of user-oriented, technology-independent measures of telecommunication service quality. Such measures promote competition and technology innovation among equipment and service providers; facilitate interworking among independently operated networks and dissimilar technologies in the provision of end-to-end services; and give users a quantitative, practical means of defining their specific telecommunication requirements and selecting products that effectively meet them. In prior work, ITS participants have led ITU-T and related U.S. standards committees in defining the basic principles and framework that underpin a user-oriented approach to telecommunications quality assessment; developed a set of generic, user-oriented quality measures for data transfer and call processing functions; and applied those generic measures in deriving specific performance parameters and measurement methods for X.25-based packet switching, frame relay, narrowband and broadband integrated services digital network (ISDN), and asynchronous transfer mode (ATM) technologies. This work has produced over a dozen ITU-T Recommendations and related U.S. industry standards and has strongly influenced both the theory and practice of digital network performance description. In recent years, ITS participants have been working to extend the performance description principles and framework to integrated IP and telephony networks, and to develop objective, perception-based quality metrics for voice, video, and multimedia services.

In FY 2002, the Institute's ITU-T leadership was focused in two groups: Study Group 13 Working Party 4 (Network Performance and Resource Management) and Study Group 9's Working Group on Quality Assessment. SG 13/WP 4 develops performance Recommendations for high-speed synchronous digital hierarchy (SDH), ATM, wave division multiplexing (WDM), and IP-based network technologies. SG 9's Working Group on Quality Assessment defines quality objectives for integrated broadband cable networks and television and sound transmission. During 2002, ITS also provided leadership and technical contributions to the ITU affiliated Video Quality Experts Group (VQEG) and the American National Standards Institute (ANSI) accredited T1 (Telecommunications) Committee's Technical Subcommittee T1A1 (Performance, Reliability, and Signal Processing). VQEG works in conjunction with ITU-T SG 9 and ITU-R WP6Q (Broadcasting Services – Performance Assessment and Quality Control) to develop objective, computer

implementable, perception-based video quality metrics (VQMs) that emulate the human visual system. T1A1 contributes strongly to ITU-T in all of these technology areas.

During FY 2002, ITS led negotiations resulting in final ITU-T approval of two new Recommendations (Y.1541, Y.1221) that specify standard Quality of Service (QoS) Classes and Traffic Contracts for IP-based networks that offer assured-quality services. Y.1541 is the first ITU-T Recommendation to specifically define performance objectives for IP-based networks. Y.1221 complements Y.1541 by defining standard parameters for characterizing and limiting offered traffic. These related Recommendations will be important in defining service level agreements (SLAs) among independent network operators that wish to cooperate in providing assured-quality IP packet flows. In related work, ITS motivated T1 and ITU-T efforts to define IP network QoS signaling standards that will facilitate such cooperation. In pursuing that goal, ITS instigated and participated in a highly successful Committee T1 "Summit" on Signaling for Voice over IP (VoIP) and contributed to several ITU-T documents that specify generic IP network QoS signaling requirements.



ITS-developed framework can be used to evaluate the power and limitations of proposed objective video quality metrics.

In the video quality area, ITS spearheaded T1A1 activities leading to Committee T1 approval of five new Technical Reports defining objective video quality metrics (VQMs). The first (TR 72) specifies a set of "meta-metrics" that can be used to evaluate the resolving power and accuracy of proposed objective VQMs. ITS presented TR 72 to ITU-T SG 9 in 2002, and that group expects to approve a new ITU-T Recommendation based on TR 72 in 2003. The new Recommendation will assist SG 9 and the VQEG in assessing objective VQMs proposed for standardization, possibly enabling ITU-T to recommend a single, optimized VQM for a wide range of quality assessment needs.

The figure illustrates an ITS-developed framework, defined in TR 72 and its counterpart draft ITU Recommendation, for evaluating the power and limitations of particular VQMs in replicating the subjective video quality assessments of human viewer panels. The figure plots the relative frequencies of various outcomes that can occur when the VQM ranking of a pair of video signals (A,B) is compared with the subjective viewer panel ranking for the same two signals (the latter ranking assumed to be "true" by definition). Four possible outcomes of such a comparison are distinguished: false ranking (the VQM ranks A better than B, while the viewers rank B better than A); false tie (the VQM fails to recognize a difference the human viewers see); false differentiation (the VQM reports a difference human viewers do not see); and the desired outcome, correct decision (the VQM ranking agrees with the subjective ranking). The abscissa in all cases is the Delta VQM Significance Threshold, i.e., the smallest difference between VQM values that the VQM algorithm declares to be valid. This framework is useful in comparing the performance of alternative VQMs, and can be used to optimize a particular VQM by choosing the Significance Threshold that minimizes a user-specified cost function.

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Support to Private Sector Telecommunications Activities:

ITU-R Standards Activities

Outputs

- Approval by Working Party 8B of NTIA methodology for radar spurious emission measurements in WP 8B as ITU-R Draft New Recommendation.
- Conference at ITS Boulder laboratory for WP 8B International Radar Correspondence Group to consider radar spurious emission measurements.
- Contribution for WP 8B describing how dynamic frequency sharing (DFS) techniques can allow use of radar spectrum bands by wireless communication systems.
- Contributions for WP 8B describing results of signal interference tests in maritime, air traffic control, and weather surveillance radars.

In Study Group 8 (SG 8) of the International Telecommunication Union — Radiocommunication Sector (ITU-R), a number of proposals have been made by non-U.S. Administrations to introduce communication systems into bands that have heretofore been allocated to radiolocation ("radar") use on a primary basis. The U.S. Administration has made an enormous investment in the development and deployment of radars in these bands, including thousands of military and civil systems that play critical roles in national defense, transportation, and atmospheric and space science. Therefore, it is essential to the U.S. Administration that new systems proposed for spectrum sharing with radars be shown to be electromagnetically compatible with existing and future radar operations. To this end, ITS engineers have actively and critically supported the U.S. Administration in ITU-R SG 8, particularly in Working Party 8B (WP 8B).

The RSMS transmits radar signals during demonstration of U.S. spectrum measurement techniques for the ITU-R Radar Correspondence Group in Boulder (photograph by F.H. Sanders).

Meeting of ITU-R Working Party 8B in Geneva, Switzerland (photograph by F.H. Sanders).

In FY 2002, ITS engineers addressed the problem of dynamic frequency selection (DFS) and wrote a Contribution for WP 8B on the topic. DFS is a proposed methodology in which wireless communication systems share spectrum with radars by detecting radar signals and then avoiding those frequencies for data transmission. This approach has never been implemented and presents a number of difficult, unsolved problems. These include developing a methodology for identifying radar signals and determination of the amount of time that must be allocated for detection of radar signals. The Contribution written by ITS engineers and co-authored by NTIA Office of Spectrum Management (OSM) engineers was the first and so far the only attempt made by any Administration to develop a practical DFS approach that solves these problems. The Contribution represents both a workable solution and a challenge to other Administrations to develop a better approach, if such exists.

ITS engineers have played a key role in WP 8B development of techniques for measuring radar emission spectra, and have developed world-recognized expertise in this difficult field. In August 2002, ITS hosted a meeting of the WP 8B Radar Correspondence Group (RCG) in Boulder for the purpose of discussing an ITS WP 8B Contribution that describes such techniques. At the meeting, ITS engineers demonstrated the use of these techniques for measuring radar emissions. The U.S. Contribution was subsequently approved as a Draft New Recommendation by WP 8B.

ITS and OSM performed a complicated series of radar interference measurements in 2002 to determine levels at which interference caused observable degradation in radar receiver performance. Utilizing these measurements, ITS authors jointly authored several WP 8B Contributions with OSM engineers. These papers challenged the thresholds at which existing documentation indicated that such interference effects should be observable in a variety of radar types. Radars that were tested included maritime surface search radars, air traffic control radars, and a weather surveillance radar. ITS engineers also supported the U.S. Administration with critiques of Contributions from other Administrations in Working Parties 8B, 8D, and 8F.

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