
SUPPORT TO PRIVATE SECTOR TELECOMMUNICATIONS ACTIVITIES:

Cooperative Research with Industry

Outputs

- PC software (VQM) that objectively measures video quality made available on the Internet for evaluation.
- Mobile, broadband measurements of propagation in urban and suburban environments made available to Lucent Bell Labs for research into the performance of Multiple Input Multiple Output (MIMO) antenna systems.

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. ITS has participated for a number of years in CRADAs with private sector organizations to design, develop, test, and evaluate advanced telecommunication concepts. Research has been conducted under agreements with:

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| • American Automobile Manufacturers Association | • East Carolina University's Brody School of Medicine. |
| • ARINC | • General Electric Company |
| • AudioLogic, Inc. | • GTE Laboratories Inc. |
| • Bell South Enterprises | • Hewlett-Packard Company (HP) |
| • Bell Atlantic Mobile Systems | |

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| • Industrial Technology, Inc. | • Netrix Corporation |
| • Integrator Corporation | • Telesis Technology Laboratories |
| • Intel Corporation | • University of Pennsylvania |
| • Lehman Chambers | • US WEST Advanced Technologies |
| • Lucent Digital Radio | • US WEST New Vector Group |
| • Lucent Technologies | |
| • Motorola Inc. | |

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 video signals is available on ITS' web site.
- Lucent Technologies, Bell Laboratories, and ITS initiated cooperative research to evaluate the performance of multiple input multiple output (MIMO) antenna systems for mobile wireless communications. MIMO technology promises to greatly increase spectrum capacity for wireless services including high data rate mobile services.
- ITS entered into 173 new CRADAs, in FY 2003, with parties interested in evaluating ITS' Video Quality Metric (VQM) software (see figure on next page). This software objectively measures video quality as it would be perceived by end-users of a video system. ITS's VQM has been made a national standard by ANSI. VQM is also in the process of being accepted as an international standard by the International Telecommunication Union. The software is covered by ITS patents that are available for licensing under fair and equitable terms.



First page of the online CRADA for Video Quality Metric (VQM) Software, available on the ITS website at http://its.bldrdoc.gov/n3/video/vqmdownload_US.htm

- ITS entered into five new CRADAs with the private sector for the application and evaluation of ITS' Telecommunications Analysis Services (TA Services). TA Services consists of a number of wireless databases and propagation models that can be used on a reimbursable basis.

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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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 are 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 Telecommunication Standardization Sector (ITU-T) develops international standards (Recommendations) addressing technical, operating, and tariff questions relating to all aspects of wireline telecommunications. ITU-T Recommendations have a strong impact on both the evolution of U.S. telecommunications infrastructures and the competitiveness of U.S. telecommunications products in international trade.

ITS has played a strong role in ITU-T standardization work for many years. The Institute's 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 telecommunication requirements and selecting products that effectively meet them.

In FY 2003, the Institute provided leadership in two key ITU-T groups: Study Group 13 Working Party 4

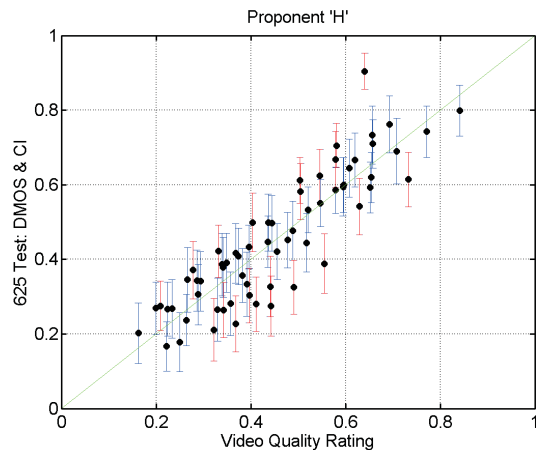
(Network Performance and Resource Management) and Study Group 9's Working Group on Quality Assessment. SG 13/WP 4 develops performance Recommendations for high-speed synchronous digital hierarchy (SDH), asynchronous transfer mode (ATM), dense wave division multiplexing (DWDM), and Internet Protocol (IP) based network technologies. SG 9's Working Group on Quality Assessment defines quality objectives for integrated broadband cable networks and television and sound transmission. 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 2003, the Institute's SG 13 leadership participated in managing over a dozen standards development projects, contributing to new or revised draft Recommendations in technology areas including IP network Quality of Service (QoS), optical network performance, multi-protocol label switching (MPLS) performance, and IP and ATM network resource management. ITS led SG 13/WP 4 participation in special activities including the conduct of a SG 13 "Futures Session" to plan advanced network standardization, formation of an ITU-T Joint Rapporteur Group on Next Generation Networks (JRG-NGN), and publication of an *IEEE Communications Magazine* Feature Topic on IP Network QoS. The lead article in this issue is referenced below. ITS spearheaded industry standards planning on several issues of interest to U.S. industry and government, e.g., QoS signaling for IP-based networks. The ability to control QoS in multi-service, multi-provider IP networks is expected to be important to user acceptance of voice over IP (VoIP) — and to IP-based telephony deployment, service innovation, and revenue growth.

ITS has co-chaired the ITU Video Quality Experts Group since its formation in 1997. VQEG enables video experts from many countries to collaborate in developing and evaluating video quality metrics, and its results strongly impact the standardization of VQMs in both ITU-T and ITU-R. The group works primarily via an e-mail reflector, publicly accessible at <http://www.VQEG.org>. Over 300 participants are currently subscribed to this reflector.

During FY 2003, VQEG completed a 3-year evaluation of proposed “full reference” VQMs for assessing the video quality of standard definition television. Eight proponent laboratories from six countries submitted candidate VQMs for evaluation. Seven research organizations from three countries formed an independent laboratory group that conducted the evaluation. The laboratory group developed a comprehensive test plan, coordinated it among the participants (and interested standards bodies), selected test material (unknown to the proponents) comprising a representative sample of distribution quality television content, processed the selected video “clips” through widely used video compression systems, and obtained subjective ratings of the source and degraded video quality using human viewer panels. The proponents independently evaluated the same source and degraded video clips using their candidate objective VQMs. The laboratory group performed a comprehensive analysis of the resulting data to confirm the validity of the subjective test results and to compare the subjective and objective ratings. VQEG presented the results in a final report to ITU-T SG 9 (see below).

The figure (above right) illustrates the correlation between subjective and objective ratings for the proponent VQM that provided the best overall correlation with the subjective results (VQM “H” in the referenced report). The y-axis represents the subjective video quality rating produced by the human viewer panels — specifically, the normalized difference between the mean opinion score (MOS) of the unimpaired source video and that of the degraded output video. The x-axis represents the corresponding normalized video quality rating predicted by the candidate objective VQM. An “ideal” objective VQM would produce exactly the same rating as the subjective viewer panels for each source and degraded video clip, and all of the plotted points would lie exactly on the diagonal. The correlation illustrated is for the 625-line television system used in much of Europe; it is numerically 0.89. For the 525-line television system used in North America, the same VQM produced an even better overall correlation (about 0.94). VQM H was the only VQM rated in the top-performing group for both the 525- and 625-line systems.



Difference mean opinion score (DMOS) and confidence interval (CI) versus video quality rating for proponent ‘H.’

On the strength of these results, several cooperating standards organizations took action to standardize the VQM H objective video quality assessment algorithm during FY 2003. Committee T1 standardized the new algorithm in American National Standard T1.801.03-2003. ITU-R SG 6 submitted a new Recommendation documenting the new algorithm for ITU-R approval, and ITU-T SG 9 plans to submit a compatible Recommendation for ITU-T approval early in 2004. Details regarding the Institute’s video quality contributions to ITU-R are provided in the ITU-R Standards Activities section of this report (pp. 66-67). Details regarding VQM H (which was developed at ITS) are provided in the Video Quality Research section of this report (pp. 60-61).

Recent Publications

N. Seitz, “ITU-T QoS standards for IP-based networks,” *IEEE Communications Magazine*, Vol. 41, No. 6, pp. 82-89, Jun. 2003.

A. Webster, “Final Report from the Video Quality Experts Group on the Validation of Objective Models of Video Quality Assessment, Phase II (FR-TV2),” ITU-T Study Group 9 Contribution 60, Sep. 2003.

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ITU-R Standards Activities

Outputs

- Measurements performed to determine how measured levels of radar unwanted emissions vary as a function of receiver bandwidth.
- Presentations at meeting in London, UK of WP 8B International Radar Correspondence Group to consider new limits and measurement techniques for assessment of radar spurious emissions.
- Comparative measurements of radar spurious emissions performed by ITS at a laboratory in the UK for validation of the technique given in a Study Group 8 Draft New Recommendation.
- Ongoing technical support to the U.S. Administration in its investigation of advanced technologies for sharing radio spectrum between radars and short-range wireless communication devices at microwave frequencies.
- ITS-developed measurement method for broadcast television video quality, included in a Preliminary Draft New ITU-R Recommendation as a normative technique to be used internationally.

Success in worldwide telecommunications markets, as well as successful and compatible use of telecommunications technologies both domestically and abroad, is critical to the long-term success of the United States in many spheres. To achieve these goals, the U.S. Administration participates in a worldwide telecommunications standards and regulatory body, the International Telecommunication Union — Radiocommunication Sector (ITU-R), to further its objectives with regard to all forms of wireless communications on a worldwide basis. ITS in turn provides important, ongoing technical support for the U.S. Administration in several ITU-R Study Groups and Working Parties. Current areas of interest include (but are not limited to): improved methods for assessing spectrum impacts of high-power radars; advanced spectrum sharing technologies between wireless communication devices and radars; and video and audio quality-assessment technologies.

To support improved spectrum efficiency for both the private sector and governments, ITS engineers have performed ongoing technical work to assess and improve spectrum emissions from high-power radars and to pass their work to the international community in ITU-R Working Party 8B (WP 8B). In FY 2003, this work involved a series of measurements on emissions from a high-power radar at the ITS Table Mountain research facility. The spectrum measurements were used first of all to determine how the measured levels of unwanted emissions depended upon the selection of measurement bandwidth, an important consideration in the development of radar emission level masks both domestically and abroad. The results showed that measured unwanted emission levels varied at the rate of about $16\log(\text{bandwidth})$, as contrasted with the well-known $20\log$ variation measured at the radar fundamental frequency. Secondly, the measurements demonstrated that spectrum measurements performed at half the far-field distance of the radar antenna were nearly identical to results obtained in the far field of the same antenna. All these results were presented at a meeting of the WP-8B Radar Correspondence Group (RCG) in London, UK in June. They are available on-line at <http://www.its.bldrdoc.gov/meetings/rcg/contributions.html>. Following that meeting, engineers from ITS and NTIA's Office of Spectrum Management (OSM) engineers performed system development measurements at a facility near Portsmouth, UK.

Finally, a number of proposals have been made by non-U.S. Administrations in ITU-R to introduce communication systems into bands that have heretofore been allocated for radars on a primary basis. Since the U.S. Administration has made an enormous investment in the development and deployment of both military and civilian radars, it is essential that new systems proposed for spectrum sharing with radars be shown to be electromagnetically compatible with existing and future radars. To this end, ITS engineers in FY 2003 prepared to test the new technology, called dynamic frequency selection (DFS) for the U.S. Administration.

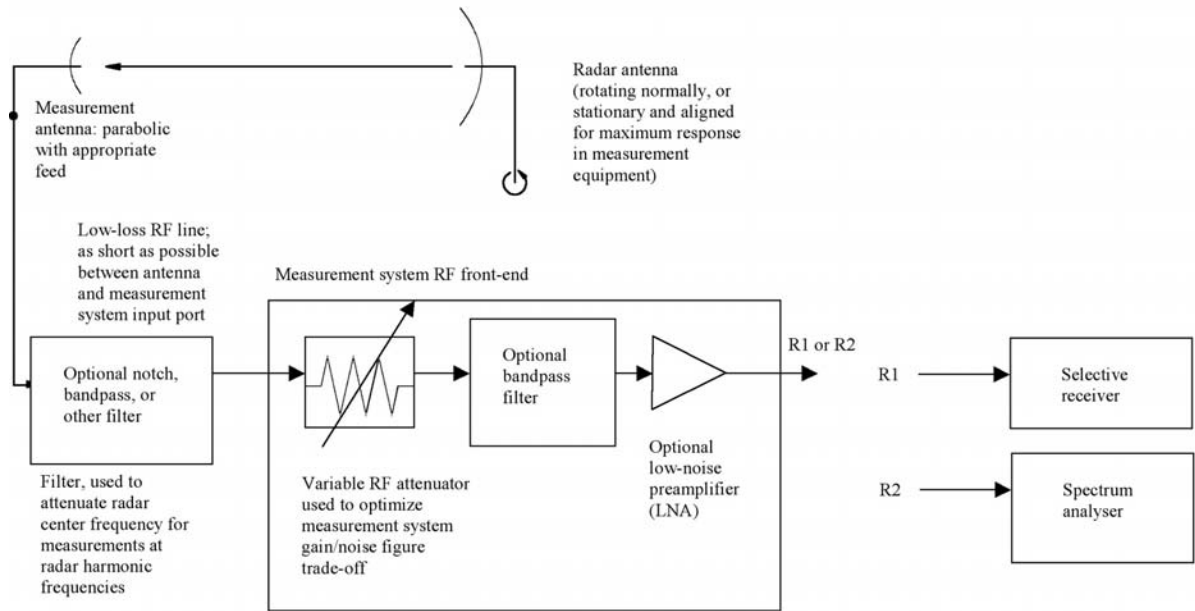


Diagram from ITU-R Study Group 8 Draft New Recommendation M.1177-2, showing ITS-designed radar spectrum measurement system that has been adopted internationally for radar emission measurements.

DFS has never been implemented operationally and presents a number of difficult, unsolved technical problems. In FY 2003, ITS and OSM engineers developed a test procedure to assess the performance of prototype DFS devices operating near 5 GHz. Initial tests will be performed early in FY 2004, and results quantifying DFS effectiveness are expected to be provided in a number of forums including the ITU-R later in FY 2004.

In FY 2003, a video quality measurement system developed by ITS engineers was made a normative worldwide measurement method in a new ITU-R WP 6Q Preliminary Draft New Recommendation (PDNR). In ITU-R Working Party 6Q (WP 6Q), this technique was included in the PDNR along with other U.S. contributions defining the scope, purpose, and application of the PDNR. Further information about this work can be found in the ITU-T section of this technical progress report (pp. 64-65).

Recent Publications

ITU-R WP-8B Radar Correspondence Group (RCG) document RCG-14, "Variation in measured levels of OOB and spurious emissions with measurement bandwidth."

ITU-R WP-8B RCG document RCG-15, "Near-field and far-field spectrum measurements on a maritime radar."

(Both WP-8B documents are available at <http://www.its.bldrdoc.gov/meetings/rcg/contributions.html>)

ITU-R SG-8 Draft New Recommendation M.1177-2, "Techniques for measurement of unwanted emissions from radar systems."

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