Telecommunications and Information Technology Planning

The telecommunications and information technology planning function represents the highest-level system or network perspective of the Institute. This work includes planning and analyzing existing, new, and proposed telecommunications and information technology systems, especially networks, to improve efficiency and enhance performance and reliability. ITS performs this work for both wireline and wireless applications. This encompasses work frequently referred to in industry as "systems engineering."

All phases of strategic and tactical planning are conducted under this work area, as well as problem solving and actual implementation engineering. ITS engineers identify users' functional requirements and translate them into technical specifications. Telecommunication system designs, network services, and access technologies are analyzed, as well as information technologies (including Internet and Internet-related schemes).

In November 2006, several members of the division were awarded the Department of Commerce Gold Medal, the highest honor given by the Department (see p. 86 for more information). The group was recognized for leading an effort to develop a national strategy to enhance public safety communications and assisting the development of technical standards to enable rapid deployment of a new generation of digital land mobile radio systems. This work supports the Commerce Department's goal of improving public safety communications to better serve Americans and protect American security.

Following is a summary of significant activities that occurred in the area of telecommunications and IT planning during FY 2007. Telecommunications interoperability relating to Public Safety communications remains the largest program area.

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Areas of Emphasis

Interoperability Efforts for Public Safety Communications The Institute conducts a broad-based technical program aimed at facilitating communications interoperability and information-sharing among wireless and IT systems within the public safety/homeland security community. These activities are sponsored by the NIST Office of Law Enforcement Standards Program and the Department of Homeland Security. These efforts are planned and performed with coordination among local, State, tribal, and Federal practitioners. Technical thrusts within the program, described in separate sections on the following pages, include:

Public Safety Broadband Communications

Standards Development for Public Safety Interoperability

Project 25 Compliance Assessment Program

Department of Commerce ISSI Evaluation and Test System (DIETS)

Emergency Telecommunications Service (ETS) Standards Development The Institute develops and verifies ETS Recommendations for ITU-T Study Group 9. The project is funded by the Department of Homeland Security's National Communications System.

Multimedia Quality Research The Institute characterizes and analyzes the fundamental aspects of multimedia quality assessment and network interoperability. A primary goal of this research is to develop an algorithmic system to objectively assess multimedia quality by combining audio quality, video quality, and audiovisual synchronization information. The project is funded by NTIA.

Wireless Network Measurement Methods The Institute studies the performance characteristics of wireless networks and attempts to standardize measurement methods in order to better understand the applicability of different types of wireless networks to specific user requirements. The project is funded by NTIA.

Public Safety Broadband Communications

Outputs

- DHS pilot project bridging land mobile radio and broadband.
- Public Safety 700-MHz Broadband Statement of Requirements.
- Protocol selection for the 4.9-GHz public safety band.

Broadband communications for the public safety community is currently in overdrive. The National Capital Region has deployed a broadband network at 700 MHz, the Department of IT in New York City has deployed a broadband network at 2.5 GHz, and a number of other public safety agencies have been deploying 4.9-GHz broadband systems. Couple this with all of the pilots, standards, and requirements work occurring at the national level, and it is easy to see there is a great deal of effort being put into this advancement in public safety communications.

On behalf of the NIST Office of Law Enforcement Standards (NIST/OLES) and the U.S. Department of Homeland Security's Office for Interoperability and Compatibility (DHS/OIC), ITS has launched and is managing a pilot project in the District of Columbia that will field-test the integration of new broadband technologies with existing emergency responder two-way radio systems. The project, known as Radio Over Wireless Broadband (ROW-B), will enable emergency responders to communicate across traditional radio and advanced wireless broadband communication systems. ROW-B will also integrate this communication with geographic information systems data, thereby providing real-time access to the locations of resources in an emergency responder's area.

ROW-B is a partnership with OIC, the District of Columbia's Office of the Chief Technology Officer (OCTO), and Clarity Communication Systems Inc. The project will facilitate interoperability with OCTO's existing communication network and their citywide broadband network pilot program known as the Wireless Advanced Responder Network.

ROW-B will use a new standard called the Inter-RF Subsystem Interface (ISSI). ISSI is part of the Association of Public-Safety Communications Officials (APCO) Project 25, which is an effort to create standards that allow emergency responder radios to communicate and interoperate. In this project, the interface will provide a common connection point between the disparate two-way radio systems and wireless broadband networks (at 700 MHz).

In addition to the 700-MHz DHS pilot project, ITS is working on public safety's current 700-MHz broadband effort, where the 700-MHz broadband spectrum is shown in Figure 1. On August 10, 2007, the Federal Communications Commission (FCC) released the Second Report and Order as a revision to the 700 MHz Rules to Advance Interoperable Public Safety Communications and Promote Wireless Broadband Deployment. The Second Report and Order created, for the first time, a public/private partnership whereby public safety spectrum will be joined with commercial spectrum.

The combined spectrum will be managed by the Public Safety Broadband Licensee (made up of public safety organizations such as the International Association of Fire Chiefs and the International Association of Chiefs of Police) and a network built out by the winner of the spectrum auction currently scheduled for January 23, 2008.

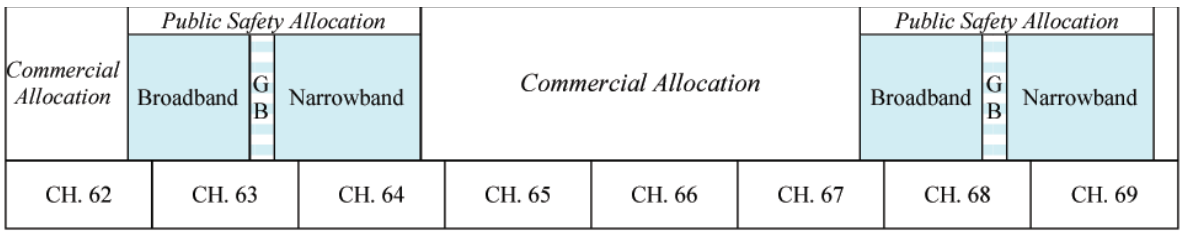

Figure 1. Depiction of public safety's revised spectrum allocation for the public/private partnership created by the FCC in 700 MHz.

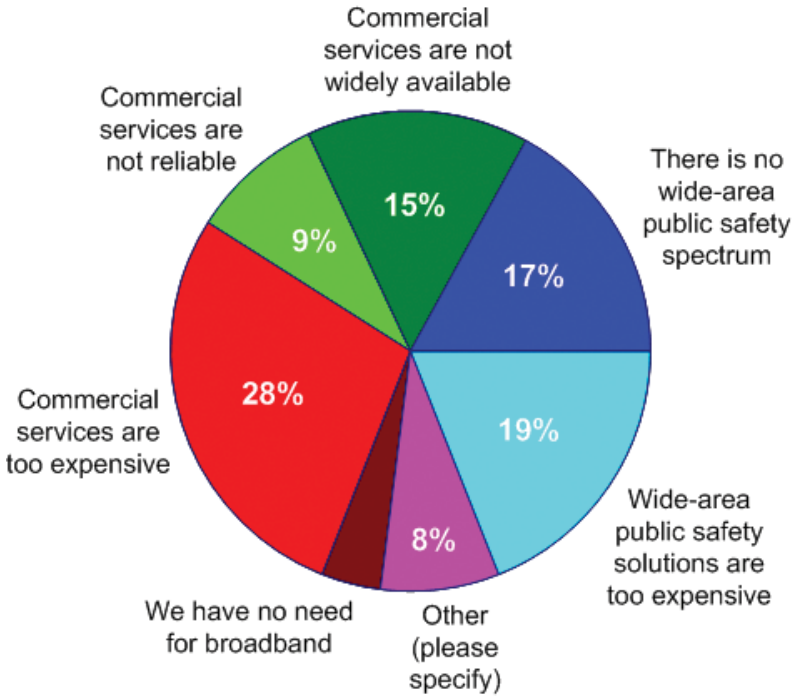

Figure 2. Barriers to public safety broadband communications.

To facilitate a comprehensive understanding between public safety and the winner of the auction, a Public Safety 700-MHz Broadband Statement of Requirements will be created. ITS is co-chairing the National Public Safety Telecommunications Council's Broadband Working Group, where the 700-MHz Statement of Requirements is being written. As part of this effort, information was gathered pertaining to current barriers faced by public safety in building out broadband systems on their own. The results of this information gathering are shown in Figure 2. Additionally, ITS is leading the authoring/editing of the document.

Once the auction is complete, ITS will continue to participate in the 700-MHz broadband effort on behalf of public safety through test and evaluation of the technology that will be deployed to meet the practitioner requirements. Where gaps are identified between the technology deployed and the requirements from the Public Safety 700-MHz Broadband Statement of Requirements, ITS, on behalf of NIST/OLES and DHS/OIC, will lead the effort in the technology's originating Standards Development Organization to reflect public safety needs.

In addition to the 700-MHz broadband effort, ITS is also heavily involved in public safety's 4.9-GHz broadband effort. For the last two years, ITS has chaired the APCO Project 25 Interface Committee's Broadband Task Group, where an effort is currently underway to select an air interface protocol for use as public safety's standard in the 4.9-GHz band.

In addition to chairing the group leading the standardization process, ITS also directly supports the Project 34 User Needs Committee on behalf of NIST/OLES through the creation of a public safety user selection process, where formal decision analysis will be used to lead the practitioners to a decision between the two proposed protocols (IEEE 802.11-2007 and 802.16e) based on their requirements and priorities.

Lastly, ITS is also leading the simulation effort related to the project. In this effort, the four scenarios from the main body of the SAFECOM Public Safety Statement of Requirements have been simulated to compare and contrast the two proposed protocols' performance, based on the Project 34 Incident Area Networking Statement of Requirements.

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Standards Development for Public Safety Interoperability

Outputs

- Functional and performance specifications for Project 25/TIA digital radio & system standards.
- Standardized measurement methods for testing Project 25 radios and systems.
- Technical contributions to TIA-TR8 and APIC working groups.

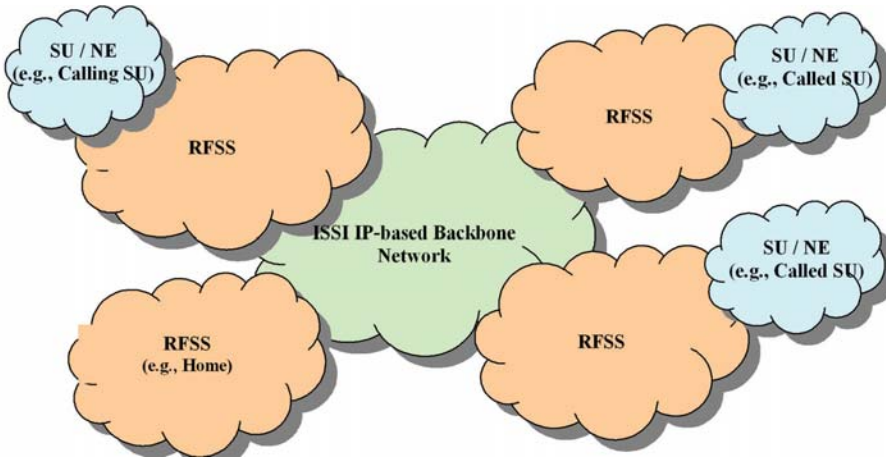
Too often, public safety practitioners' communications systems do not meet their needs for operability (security, service area, performance, and survivability for intra-agency communications) and interoperability (inter-discipline and inter-jurisdiction communications where and when communications are needed). ITS, in cooperation with other agencies, is committed to addressing these operability and interoperability problems. A key step in achieving interoperability for public safety communications equipment is the standardization of the technical interfaces, protocols, measurement methods, and performance requirements for public safety communications equipment.

Standards development activities for the public safety community's new generation digital land mobile radio systems are being performed under a joint effort of public safety users and equipment manufacturers. The users are represented by local, State, and Federal government organizations and manufacturers are represented by industry members of the Telecommunications Industry Association (TIA). This standards development process is known as Project 25 (P25). P25 members establish user requirements and draft specifications based on the users' perspective, and TIA (and its TR-8 Committee) uses processes accredited by the American National Standards Institute (ANSI) to develop formal, nationally recognized standards that can be used to design and manufacture equipment and evaluate its performance and interoperability. ITS represents users on technical contributions and issues and provides guidance when technical decisions are to be made. ITS holds leadership positions within several P25 Working Groups: Vice Chair of the Inter-Radio Frequency Subsystem Interface (ISSI) Task Group, Vice Chair of the P25 Systems Architecture Working Group (PSAWG), Vice Chair of the Vocoder Task Group (VTG), Vice Chair of the Compliance Assessment Process and Procedures Task Group (CAPPTG), and Chairman of the BroadBand Task Group (BBTG).

With Congress providing grants to state and local governments for telecom equipment and the funding for Federal public safety communications systems, Congressional bills have defined the importance of having P25 standards in place. As a result, the P25 Steering Committee and technical committees have set aggressive timeframes for completion of the documents that make up the standards associated with each P25 interface.

On behalf of the public safety community, ITS facilitated development of P25/TIA Standards for radio system interfaces critically needed by users. Through direct and extensive involvement with government and industry representatives and technical contributions across many fronts, ITS was responsible for advancing progress in the TIA TR-8 technical committees and associated Project 25 APIC working groups. In FY 2007, critical specifications, including those recognized as essential by the U.S. Congress, were standardized by TIA and ITS was instrumental in their development, including the ISSI and other critical P25 wireline interfaces. Significantly, these new standards will enable essential advanced P25 services to be provided using the ISSI. For example, P25 supplementary data services have been standardized that will enable such key features as emergency alert signaling to be implemented on a multivendor, interoperable basis. In FY 2007, ITS continued to progress work on the ISSI suite of standards. ITS was and is a major contributor in these key P25 areas:

- ISSI Measurement Methods: TIA-102.CACA (approved in April 2007)
- ISSI Performance Recommendations: TIA-102. CACB (approved in April 2007)
- P25 Statement of Requirements (updated version approved in August 2007)
- ISSI Conformance Test Procedures for Voice Services (expected to be approved in February 2008)



Principal functional entities supporting P25 wide area voice services involving the ISSI.

As a result of technical research and standards contributions to the CAPPTG and ISSI Task Group, agreement was reached in October 2007 to undertake the development of a critical new standard that will define ISSI interoperability test procedures. ITS will, as a focus area in FY 2008, be providing support for the development of this unprecedented, and complex standard. Completion of such standards is required to enable successful conduct of the P25 Compliance Assessment Program (described on pp. 18-19).

The figure above identifies the principal functional entities involved in providing and using P25 voice services involving the ISSI. These functional entities are the Radio Frequency Subsystems (RFSSs), the ISSI, Subscriber Units (SUs), and Network Equipment (NE). Multiple SUs and supporting NE are interconnected via RFSSs to enable P25-standardized wide area voice services. The ISSI IP-based backbone network, a "network of networks," establishes connectivity among RFSSs that implement ISSI functional services and protocols.

In addition to ISSI-related standardization, important work in public safety communications security is ongoing in P25 and TIA TR-8 as well. Currently the key areas in security where ITS is making significant contributions include the P25 Security Services Architecture Overview, the P25 Digital Land Mobile Radio Link Layer Encryption, the Key Management Facility (KMF) Interface Standard, security requirements and profiles for the ISSI, and an update of the Over The Air Rekeying (OTAR) specification.

ITS is working on standardization in other standards development organizations (SDOs) as well. In Project MESA, a joint effort of the European Telecommunications Standards Institute (ETSI) and TIA, efforts have concentrated on defining the public safety requirements for broadband mobile applications worldwide. ITS has provided user operational requirements that represent the views of U.S. public safety users. In the Institute of Electrical and Electronics Engineers (IEEE), ITS engineers are investigating 802.11x and 802.16x to determine their suitability for Public Safety telecommunications applications.

The ITS Standards Development for Public Safety Interoperability program is sponsored by several Federal departments and programs with a keen interest in public safety interoperability, including: National Institute of Standards and Technology Office of Law Enforcement Standards, Department of Justice Office of Community Oriented Policing Services, Department of Homeland Security's (DHS) Office for Interoperability and Compatibility, Federal Partnership for Interoperable Communications, and the DHS Chief Information Officer's Wireless Management Office. This work is being done in conjunction with projects underway in multiple public safety organizations and is closely tied to other ITS public safety projects.

In FY 2008, ITS will continue to work on the development of technical standards to extend and enhance operability and interoperability in public safety telecommunications.

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Project 25 Compliance Assessment Program

Outputs

- Support of the TIA Project 25 Compliance Assessment Working Group.
- Processes and procedures document describing approval and operation of Project 25 compliance assessment laboratories.
- Grant guidance language for Federal Project 25 equipment grant programs, defining Project 25 compliance requirements.

Engineers from the Institute achieved significant milestones in FY 2007 in their continued efforts to implement a compliance assessment program for Project 25 land mobile radio (LMR) equipment. Consequently, formal competency assessment of test labs is poised to begin in 2008.

The Project 25 Compliance Assessment Program (P25 CAP) was initiated in response to Congressional mandates that Project 25 equipment purchased with grant funds should meet "the requirements of a conformity assessment program"[1] and that grantors should at a minimum "require that all grant dollars for interoperable communication be used for Project 25 compliant equipment that meet the requirements of a conformity assessment program."[2] The Program kicked off in April 2005.

Project 25 LMR technology is being rolled out in phases and the compliance program is being structured accordingly. The full suite of P25 standards will eventually define eight open interfaces: The Common Air Interface (CAI) was the first interface developed and is the most mature of the eight, so compliance assessment will begin with that interface. As the program matures, testing will encompass for each interface the essential elements of compliance as defined by the Telecommunications Industry Association (TIA) including:

- Performance — measurements that verify the specifications for a component or sub-system.
- Conformance — bit-by-bit, message-by-message protocol verification.
- Interoperability — functional "can-you-hear-me-now" type testing to validate equipment interchangeability.

The Project 25 Steering Committee plans to adopt Telecommunications Systems Bulletins (TSBs) that define a key subset of tests for which manufacturers will demonstrate compliance. Test laboratories will produce and keep detailed test reports for each device or system evaluated. Manufacturers with products that meet the TSB requirements will issue a Supplier's Declaration of Compliance (SDoC) in accordance with the program guidelines. Each SDoC will contain a product's test configuration, enumerate the tests that were conducted, and indicate the test case verdicts. For the benefit of P25 equipment purchasers, manufacturers will produce at-a-glance type summary test reports using a common report template. This will simplify interpretation of the results and facilitate product comparisons. Summary test reports substantiate the SDoCs and will go a long way toward increasing the public safety community's confidence in Project 25 equipment functionality.

The framework for the laboratory assessment and recognition component of the program was jointly developed by engineers at ITS and NIST and reviewed by industry representatives. This process culminated in October 2007 with the publication of NIST Handbook 153, *Laboratory Recognition Process for Project 25 Compliance Assessment*. Handbook 153 was patterned after ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*, but with several key differences. First, the program offers qualified laboratories a means of being *recognized* by specialists in conformity assessment for competence executing P25 tests. This is in contrast to the more formal *accreditation* process followed by organizations such as NIST's National Voluntary Laboratory Accreditation Program. Also, the P25 CAP was specially tailored to facilitate testing at manufacturers' development or systems troubleshooting laboratories that generally do not have quality management

1 House Report 109-241 - "Making Appropriations for the Department of Homeland Security for the Fiscal Year Ending September 30, 2006, and for Other Purposes."

2 Senate Report 109-088 - "Department of Commerce and Justice, Science, and Related Agencies Appropriations Bill, 2006."

Project 25 Compliance Assessment Program Lead Assessor Training at ITS in FY 2007. Those pictured include ITS staff as well as two contract assessors for the program (photograph by E.D. Nelson).

systems in place. Accordingly, the program places greater emphasis on technical competence of the laboratory personnel and the reproducibility of tests than on quality system management.

Besides developing the lab recognition handbook, ITS engineers have supported the program in a number of other ways. They developed rules for governance of the program and drafted preliminary program policies. They trained to serve as Subject Matter Experts for on-site assessments of prospective laboratories. Earlier in 2007 they released the Radio Performance Measurements automated testing software suite to streamline testing of radios. Finally, they drafted the latest revision of TIA-102. CABC, *Interoperability Testing for Voice Operation in Trunked Systems*, one of the two key standards required for program rollout. Next year the Department of Commerce ISSI Test and Evaluation System (DIETS), jointly developed by ITS and NIST engineers, promises to play a key role in conformance testing of the ISSI.

The Project 25 Compliance Assessment Program is voluntary in nature; participating Project 25 manufacturers need not test their products nor declare compliance. However, as the law mandates, public safety agencies seeking to use grant funds to purchase Project 25 equipment must select from compliant equipment with an accompanying SDoC.

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Department of Commerce ISSI Evaluation and Test System (DIETS)

Outputs

- An ISSI reference implementation.
- Software capable of conformance testing the ISSI protocol.

The importance of the Project 25 (P25) suite of standards has been conveyed by Congress through several pieces of recent legislation. With Congress providing grants to all levels of government (local, State, and Federal) for the acquisition of public safety telecommunications equipment, the suite of P25 standards is necessary to ensure interoperability among the different levels of government. Congress considers the Inter-RF Sub-System Interface (ISSI), one of seven P25 interfaces, to have top priority for completion.

ISSI can be thought of as a network protocol that can utilize a standard network interface card (NIC). The intent is for this interface to be present in future deployments of P25 Radio Frequency Sub-Systems (RFSS). The ISSI of different RFSSs can be inter-connected using various mediums, the most common being Ethernet. When the ISSIs of various RFSSs are interconnected, IP packets that contain encoded voice can be transmitted and received. The ISSI is important to public safety agencies because it will foster competition among vendors who manufacture RFSSs. Over time, this increased competition should drive down the cost of P25 infrastructure. The other important reason for an ISSI interface is to promote interoperability between the vendors who manufacture RFSSs. This allows the consumer to implement a P25 network of RFSSs from multiple vendors.

Testing of the ISSI Interface

A balloted scope one version of the P25 ISSI Messages and Procedures for Voice Services (TIA-102.BACA) specification was formally released in August 2006. Conformance tests are being developed, and a formal published version of the ISSI conformance test document is expected in early 2008. These tests will verify that the vendor implementation under test conforms at a message level to what is specified in TIA-102.BACA.

To verify objectively that a vendor conforms to TIA-102.BACA, a reference implementation of the ISSI protocol stack has been developed. This software reference implementation is referred to as the Department of Commerce ISSI Evaluation and Test System (DIETS). ITS developed this software in conjunction with the National Institute of Standards and Technology (NIST) Advanced Network Technologies Division. Since DIETS was implemented in Java, the software can be loaded on a regular desktop PC with a Linux or Windows operating

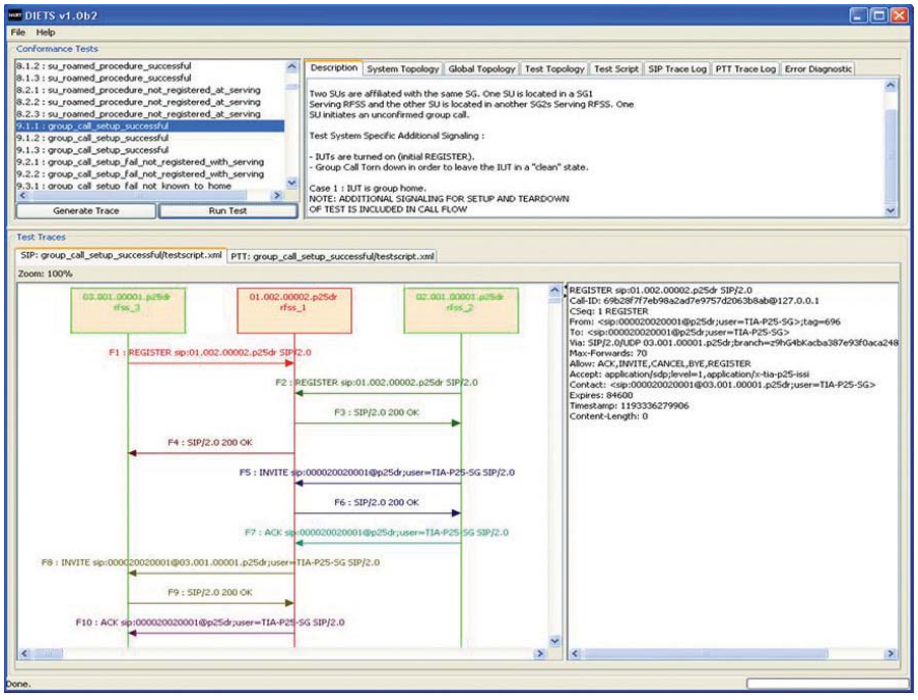

Figure 1. DIETS Conformance Test Tool Graphical User Interface (GUI).and SIP MSC for Test Case 9.1.1: Unconfirmed Group Call Successful.

system. DIETS can emulate one of four different roles in a P25 ISSI-based network: (1) calling serving RFSS, (2) calling home RFSS, (3) called home RFSS, and (4) called serving RFSS. DIETS will be placed in a test configuration, as defined in the conformance test document, which will fulfill one of the four roles depending on the test case under consideration. The number of vendor RFSSs and roles may vary depending on the test case requirements.

When attempting to determine a vendor's conformance, the preferred configuration is to test in isolation the ISSI of a single vendor's RFSS. This scenario implies that there is only one vendor RFSS with a real ISSI and the rest of the ISSI interfaces are emulated by DIETS. The number of emulated ISSIs and the role of the emulated interfaces will vary depending on the conformance test case under consideration.

Since DIETS does not currently have the capability to emulate the P25 common air interface, the behaviors of (or events generated by) subscriber units are emulated in the DIETS software. The conformance tests are implemented in XML scripts. The user can modify the specific test parameters in these scripts as necessary. As an example, the number of subscriber units involved in the conformance test is a parameter that the user can modify. From the DIETS graphical user interface (GUI), the user selects a conformance test case to execute. Figure 1 shows the layout of the DIETS GUI. After the test case has completed execution, the user can then view the session initiation protocol (SIP) and real-time transport protocol (RTP) Push-to-Talk (PTT) messages that were exchanged between ISSIs in a graphical message sequence chart (MSC). Upon completion of test case execution, DIETS will declare either pass or fail. Figures 1 and 2 illustrate the MSCs generated as a result of executing test case 9.1.1 — Unconfirmed Group Call Successful. Raw IP packet data can be rendered by clicking on the message of interest in the MSC. DIETS has a packet capture ability that is based on the Ethereal packet capture (PCAP) engine. This gives DIETS the capability to capture the messaging that occurs between all ISSIs (emulated or real) that are involved in a given test.

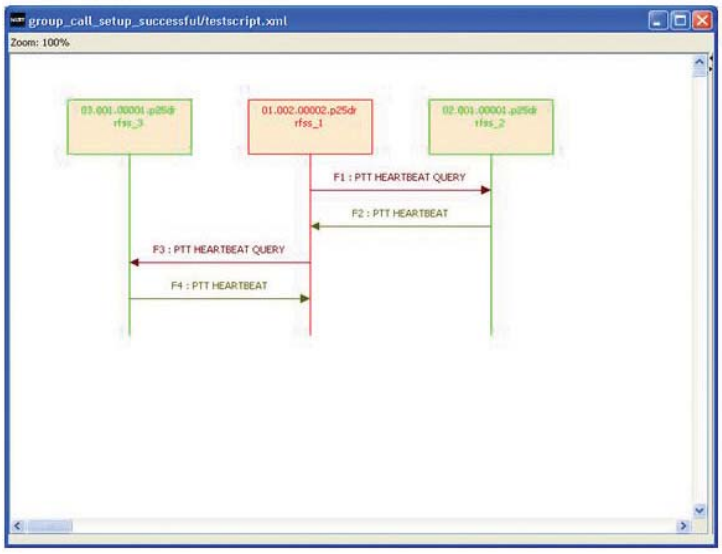

Figure 2. RTP PTT MSC for Test Case 9.1.1: Unconfirmed Group Call Successful.

Future Direction of DIETS

In addition to the ISSI, there are two other wireline interfaces that DIETS is being expanded to test: the Fixed Station Interface (FSI) and the P25 Trunked Console Sub-System Interface (CSSI). The FSI standard, TIA-102.BAHA, was formally published in 2006. The CSSI was published in April 2007, and this standard is an addendum to TIA-102.BACA.

The purpose of the FSI is to enable connectivity of a fixed station (i.e., base station) to an RFSS. The FSI can be thought of as a protocol stack. The intent of this interface is to allow interoperability between vendors' fixed stations and RFSSs. The medium that will interconnect FSIs is not limited to Ethernet. The purpose of a CSSI is to enable the connectivity of a dispatcher's console to an RFSS. The CSSI is very similar to the ISSI.

The conformance test document TIA-102.CADA for the FSI has been published. As for the CSSI, the conformance test case development may begin at the end of 2008. By mid-2008, DIETS will have been expanded to enable objective message level conformance testing of the FSI. In addition to expanding its capability to test additional P25 interfaces, DIETS is being expanded to test the performance of the ISSI according to the Project 25 ISSI Measurement Methods for Voice Services standard. This is scheduled for completion by early 2008.

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Emergency Telecommunications Service (ETS) Standards Development

Outputs

- Technical contributions to ATIS Technical Committee PRQC.
- Technical contributions to ITU-T Study Group 9.

In the aftermath of the 2001 terrorist attacks, the Federal Government has become very interested in priority treatment for emergency communications. While the Government Emergency Telecommunications Service (GETS) has served emergency workers well for many years, it has been limited to the Public Switched Telephone Network (PSTN) in the United States. The Emergency Telecommunications Service (ETS) is envisioned as a GETS-like service that will be available internationally and encompass virtually all wireless and wireline communications networks. Types of traffic to be carried include voice, video, database access, text messaging, e-mail, FTP, and web-based services.

The ETS Standards Development project conducts laboratory studies, requirements and specification development, and security analyses to further the approval of standards supporting National Security/ Emergency Preparedness (NS/EP) and Critical Infrastructure Protection (CIP) initiatives. This project is funded by the National Communications System (NCS) — a part of the Department of Homeland Security (DHS). The work supports NCS in its mission to protect the national security telecommunications infrastructure, and to ensure the responsiveness and availability of essential telecommunications during a crisis.

The ETS Standards Development project provides contributions to three standards development organizations. These are the International Telecommunication Union's Telecommunication Standardization Sector (ITU-T) Study Group (SG) 9 and two American National Standards Institute (ANSI)-accredited groups: the Alliance for Telecommunications Industry Solutions (ATIS)'s Performance, Reliability, and Quality of Service Committee, PRQC, and the Society of Cable Telecommunications Engineers (SCTE). ITU-T SG 9 is the Lead Study Group, internationally, on integrated broadband cable and television networks and the SCTE produces North American Standards for the cable industry. PRQC works in the areas of Quality of Service (QoS), Reliability, and User-Plane Security, and produces North American Standards. In SG 9, ITS develops and verifies Recommendations to support preferential telecommunications services and user authentication. One major goal of this project is to ensure that future ETS mechanisms and the current GETS service will interoperate over broadband cable television networks in their delivery of voice, data, and multimedia communications.

In PRQC, ITS provides ETS expertise relating to priority support and network security. During FY 2007, an ITS engineer served as co-editor of several ANSI and ATIS Standards and Technical Reports. These provide guidelines, specifications, and requirements for aspects of ETS communications and network and computer security. An ITS engineer serves as the Chair of PRQC's Security Task Force where he leads security standardization for the Network User Plane. He also chairs the ATIS Joint Ad-Hoc Technical Committee for Issues PRQC A0029 and TMOC 95, which works across all relevant ATIS committees to provide a common security baseline suite of standards for telecommunications security in current and Next Generation networks (NGN).

The standardization work in ITU-T SG 9 is focused on the IPCablecom and IPCablecom2 families of Recommendations. These Recommendations define the protocols and signaling to be used on broadband cable television networks to support telephony, multimedia, and Internet access. The IPCablecom Recommendations have been standardized in ITU-T SG 9, and equipment implementing them is currently in production worldwide. IPCablecom2 has recently been approved and equipment will be deployed in the coming years. One goal of this project is to identify where additions or changes might be needed to support GETS-like capabilities. This effort also involves work with the Internet Engineering Task Force (IETF), since many of the underlying protocols used in IPCablecom (as well as some of the ETS mechanisms) are under development in the IETF. An ITS engineer served as editor and principal author of ITU-T Recommendation J.260, "Requirements for preferential telecommunications

over IPCablecom networks," in SG 9. An ITS engineer also serves as the editor of Draft new ITU-T Recommendations J.pref, "Specifications for preferential telecommunications over IPCablecom networks," J.prefp2, "Specifications for preferential telecommunications over IPCablecom2 networks," and J.preffr, "Framework for implementing preferential telecommunications in IPCablecom networks." J.pref and J.prefp2 will provide specifications to satisfy the requirements set forth in J.260, and J.preffr will provide a longer-term framework for standardizing preferential services and emergency user authentication in cable networks.

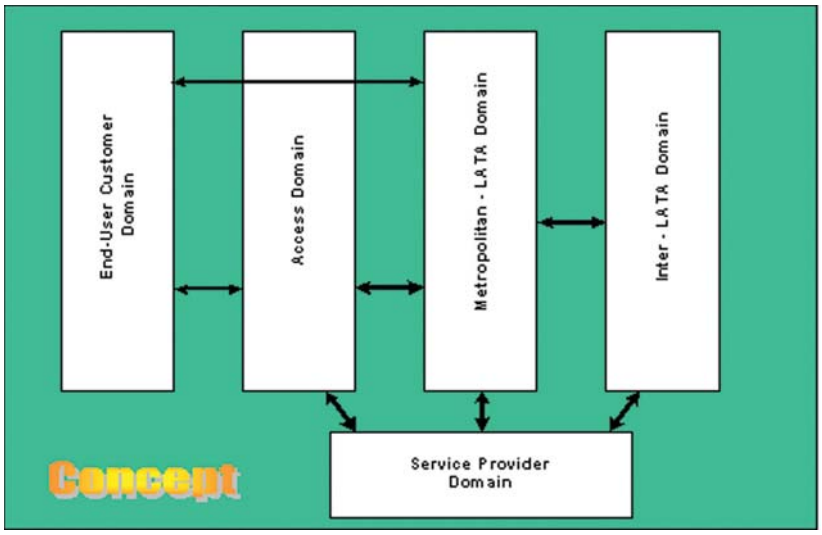

Figure 2. Typical Trust-Security domains to consider.

Another important study under way at ITS is a series of tests of GETS over IPCablecom networks. The evolution of GETS from a PSTN-only service to one that will interoperate over the wireless, IPCablecom, and Next Generation networks is an NCS goal. Another goal of this effort is determining the security needs of ETS — most notably authentications — in IPCablecom networks.

Figure 1 shows the IPCablecom releases. The IPCablecom architecture continues to evolve as new capabilities are added, and as such is comprised of several releases. Release 1.0 provides support for a telephony application using media terminal adaptors. It is specified in the initial release of ITU-T Recommendations J.160-178. Release 1.5 provides incremental new capabilities and adds SIP for session management within and among IPCablecom networks. It is specified in the revisions to ITU-T Recommendations J.160-178. The Multimedia release separates out the QoS capabilities and defines a generic QoS architecture. It is specified in ITU-T Recommendation J.179. Release 2 adds support for SIP-based endpoints, and a SIP-based service platform that may be used to support a variety of services. IPCablecom2 is based upon Release 6 of the IP Multimedia Subsystem (IMS). The IMS is the product of the 3rd Generation Partnership Project (3GPP). The diagram is taken from J.360, "IPCablecom2 Architecture Framework." Note that IPCablecom2 includes provisions for backwards compatibility with previous IPCablecom releases.

Figure 1. IPCablecom releases.

Figure 2 shows the typical Trust/Security domains that must be considered when developing a security plan for telecommunications networks. Note that the service provider is responsible for all but the customer premises domain.

In FY 2008, ITS will continue to work on the development and standardization of ETS in ATIS PRQC, SCTE, and ITU-T SG 9. The projects will address technologies in the NGN and interactions with the IPCablecom networks. This work on ETS must of necessity be conducted with the help of representatives from network providers and cable television equipment manufacturers, as well as NCS. The work in FY 2008 will focus on priority and security in the NGN ETS as well as GETS and ETS specifications in the IPCablecom and IPCablecom2 networks.

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Multimedia Quality Research

Outputs

- Technical contributions to VQEG.
- Technical contributions to ITU-T Study Group 9.

The transmission of audio/video (multimedia) signals over wireline and wireless channels has increased exponentially in the past decade. In particular, the distribution of multimedia signals over wireless links to devices such as laptops, personal digital assistants (PDAs), and cellphones is widespread and the need for quality measurements is great. The widespread use of digital technology for the transmission of audio and video signals has led to the need for new objective quality assessment methods based on human perception. ITS has a long history of successful research in the areas of voice and video quality assessment. Until recently, however, the development of an objective measure of overall multimedia quality has not been adequately addressed.

Multimedia is defined here as the combination of audio and video in the communication of information. The objective of the ITS Multimedia Quality Research project is to characterize and analyze the fundamental aspects of multimedia quality assessment. A primary goal of this research is to develop an algorithmic system to objectively assess multimedia quality by combining audio quality, video quality, and audiovisual synchronization information.

In 2003, International Telecommunication Union — Telecommunication Standardization Sector (ITU-T) Recommendation J.148 was approved by Study Group 9, entitled "Requirements for an objective perceptual multimedia quality model." ITS staff contributed significantly to this Standard. Figure 1 is a diagram from J.148 showing the basic components of a multimedia quality assessment system. The boxes marked "Audio Quality" and "Video Quality" represent subsystems that assess the audio and video quality. The box marked "Differential Delay" outputs a measure of the error in synchronization between the audio and video channels in the audiovisual signal.

The box marked "Multimedia quality integration function" is the subsystem that will combine the previous subsystems' outputs to predict the overall multimedia quality. It will apply specific rules to the information provided by the other subsystems. The form of these rules will be based on data derived from subjective quality experiments. The aim is to

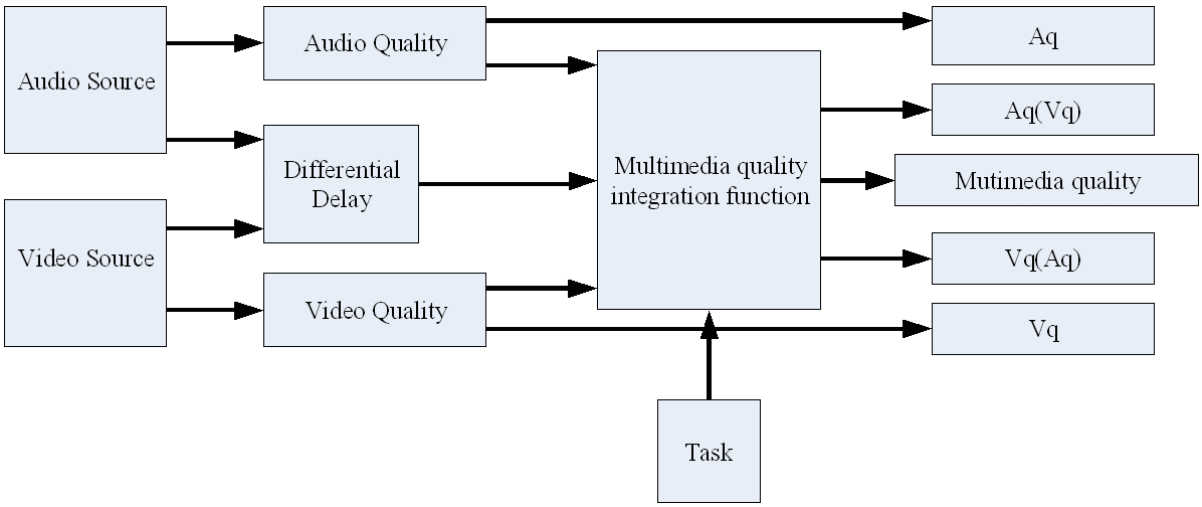

Figure 1. Basic components of a multimedia model.

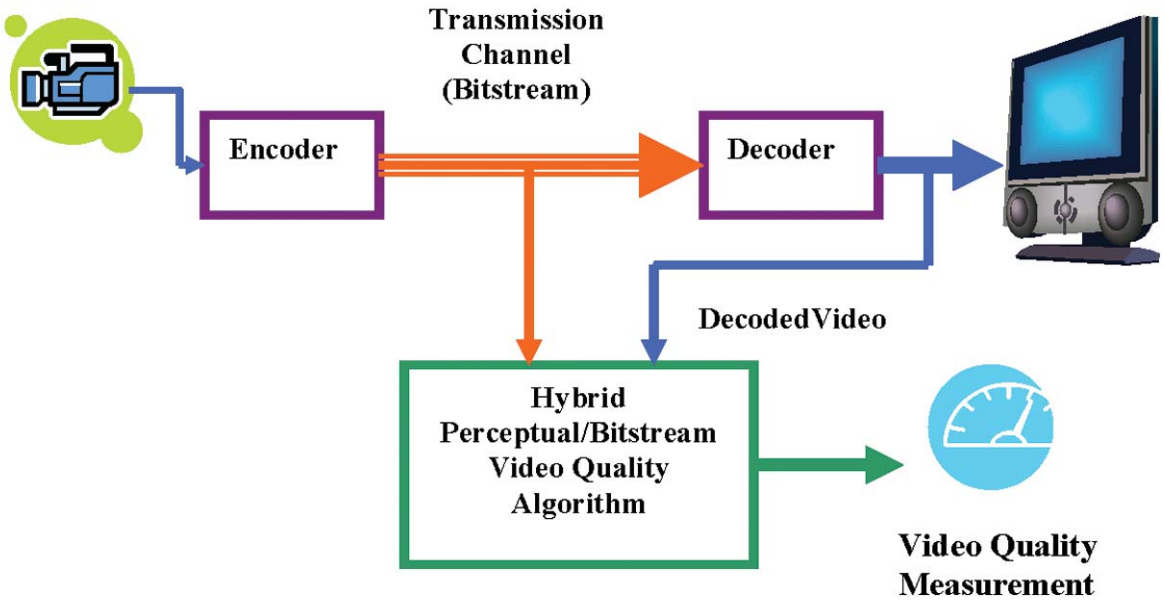

Figure 2. Diagram of the Hybrid Perceptual/Bitstream video quality approach.

produce a set of integration rules that enable the multimedia model to accurately predict human quality perception of systems and services under test. Therefore the validity of the model must be shown by comparing the performance of the model against quality ratings obtained from subjective tests for a range of test materials.

The complete multimedia model provides five outputs. The primary output is a predicted measure of overall multimedia quality. Four subsidiary outputs provide predictions of perceived quality for the audio (denoted Aq), video (denoted Vq), audio accounting for any influence the video may have (denoted Aq(Vq)), and video accounting for any influence the audio may have (denoted Vq(Aq)).

Subjective testing has played an important part in ITS efforts to develop voice and video quality assessment methods. For multimedia research, subjective testing is no less important. Objective quality assessments are based on data derived from subjective quality experiments. A series of multimedia subjective tests will be executed to explore the relationships between the quality parameters for audio, video, and audiovisual synchronization. This will provide data for the development of the integration function.

This work is being done in conjunction with projects underway in the Video Quality Experts Group (VQEG) and the ITU-T Joint Rapporteur Group on Multimedia Quality Assessment (JRG-MMQA). The JRG-MMQA is an official body of the ITU and is formed from members of ITU-T Study Groups 9 and 12.

In FY 2008 this project will also conduct research into the Hybrid Perceptual/Bitstream models in conjunction with projects in progress in VQEG and the JRG-MMQA. Tools will be developed to aid in the processing of transport and bitstreams containing audiovisual signals (see Figure 2).

Also in FY 2008, ITS will continue to work on the development of a multimedia quality assessment model by conducting subjective experiments and analyzing the results.

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Wireless Network Measurement Methods

Outputs

- Public safety 4.9-GHz indoor propagation and throughput measurements.
- Wireless channel measurement techniques for high speed data networks.

Federal operations have historically exhibited a heavy dependence on wireless networks, but these have typically been of the land mobile radio variety, with analog modulation methods and simple network topologies. In recent years, a more data-centric view of Federal operations has gained favor, probably fueled by the wide availability of high speed enterprise local area networks and the increased data processing ability of the ubiquitous desktop computer. This philosophy requires the ability to transmit significant volumes of digital data over the telecommunication medium being used, and its effects are being felt in the design of wireless networks.

Modern wireless networks are apt to be heavily weighted toward data transmission, with digital modulation and sophisticated protocol overlays. Since the Internet Protocol (IP) is so well known, it is often the kernel protocol of choice, but it may be encapsulated at the MAC and physical layers by other protocols like 802.11 or 802.16. New topologies, such as mesh networking, are also being investigated. Finally, since these technologies often require greater spectral allocations than traditional voice services, spectrum reallocations to reassign spectrum for wireless data networking are becoming more commonplace.

As wireless technologies mature, manufacturers and standards bodies introduce test methods and instrumentation to investigate their behavior. However, at the introduction of a new wireless networking technology, or when a legacy technology is implemented within a new spectral regime, test methods and instrumentation must be developed. The ITS Wireless Network Measurement Methods project is charged with meeting these requirements.

Currently, the system under investigation is an 802.11j wireless data network operating in the licensed 50-MHz spectral band between 4.945 GHz and 4.995 GHz. This band has been assigned to public safety organizations and is also the spectral support for the 802.11j networking protocol. ITS engineers have studied this network operating within several different propagation environments, including outdoor to indoor, and indoor professional and residential environments.

The primary metric used in these measurements has been network throughput, as this is the parameter most visible to a public safety user. This parameter typically correlates well with received radiated channel power, so that conditions of high received power represent high throughput environments. However, the discrete time characteristic of digital modulation, coupled with the behaviors of network protocols, can give rise to paradoxical situations where good reception does not automatically translate into high throughput.

A situation of this type has occurred in the measurements illustrated in Figure 1. These measurements depict the behavior of an 802.11j network inside the corridors of an oil treatment plant. The middle row of numbers represents throughput in megabits per second and the lower row represents signal strength in dBm. An example of the anomalous condition described is seen in the values given for test points 4, 5, and 6. Between test point 4 and test point 5 the received signal strength decreases by 8 dB, but the measured throughput increases. Conversely, between test point 5 and test point 6 the received signal strength returns to its former level, but throughput drops by 22%! Another indication that the radio

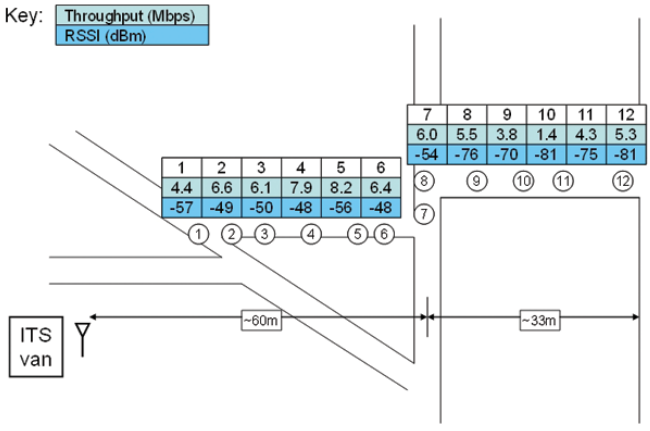

Figure 1. Throughput and signal strength measurements at an oil treatment plant.

Figure 2. Photograph of the propagating environment (photograph by G. Koepke, NIST).

channel is behaving oddly is the *a priori* knowledge that the system under test normally supports throughput values of 11 megabits per second when the received signal strength exceeds -80 dBm, as it does at almost all of these test points. Indeed, at test point 3 the received signal strength has exceeded the -80 dBm threshold by 30 dB, but the throughput is only 55% of its expected value.

A clue to the probable cause of this behavior is given in Figure 2. In this picture it is clear that the radio transmission environment consists of a dense network of pipes and metallic objects that offer a rich multipath environment for the radio signal. As radio symbols are transmitted, they can bounce off objects and become delayed enough to interfere with succeeding symbols, leading to intersymbol interference and errors in reception. In this case, the 802.11j protocol specifies that the packet must be retransmitted. If the proportion of retransmitted packets rises high enough, throughput degradation will be evident.

Specialized swept frequency measurements can be post processed to simulate an extremely short RF pulse, from which the multipath delay of the channel can be measured. This is an example of the type of new measurements that must be devised to evaluate radio channels used for high speed data networks. An understanding of the radio metrology, as well as knowledge of the protocols under use, is necessary to properly evaluate the propagation environment necessary for such networks.

The project is also investigating the use of inexpensive software defined radio (SDR) platforms as dynamically reconfigurable test instruments for new spectral domains, or tests that require flexibility not present in commercial test instruments. SDR-based instruments can also be used to bridge the gap between the fundamentally analog radio domain and the digital world of standard wired network tracing tools. This allows the creation of wireless network protocol analyzers to allow visibility of the intermediate wireless space between digital transmitters and receivers.

Measurements like these allow the accurate prediction of coverage areas within complex indoor environments. In addition to providing insights into the benefits and limitations of targeted wireless networking technologies, these tools may be used to help predict wireless coverage for public safety professionals in emergency situations.

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