Contents

Introduction

A technical standard codifies technology for a society.

Guglielmo Marconi first demonstrated the potential of wireless communications in 1895. Since then, two-way radios have progressed steadily toward becoming a complex and extremely important tool. Two-way radios and the services they provide have evolved to a point at which they now permeate every aspect of modern-day life. In the public safety community, the two-way radio has become an indispensable tool. Its availability and effective use can mean the difference between success or failure and even life or death.

With the passage of time, additional options and alternatives are being offered by the two-way radio industry, making it unlikely that current radios will be able to communicate with next-generation radios. For the public safety community, it is imperative that its radios are interoperable and that its members are able to communicate with others responding to the same incident.

In some situations, interoperability can be mandated (e.g., centralized authoritarian government); however, because of the decentralized and independent nature of the U.S. public safety community, attempting to mandate interoperability would be fruitless. Interoperability between the radio equipment used by the thousands of public safety organizations within the United States and worldwide will come about only through cooperation and sharing. The development and adoption of technical standards have been very helpful in moving the two-way radio industry toward greater interoperability. But the technical standards development process requires the efforts and support of thousands of individuals and organizations.

Before industry can provide the equipment needed by the user, providers must obtain information from the user community. Numerous ways exist to communicate users' needs to equipment providers, but one of the best methods is to provide manufacturers with a well-conceived technical specification. To this end, standards development groups such as the Project 25 (P25) committee have been formed. Its work has made significant strides in informing the two-way radio industry of the public safety community's needs; however, much work still needs to be accomplished.

The P25 committee and many of the working groups that make up the various telecommunications standards development organizations are composed mostly of volunteers. These volunteers work long hours with little reward other than the satisfaction of understanding the importance of their efforts and their long-term effect on the public safety community and the public they serve.

This primer focuses on the land mobile radio (LMR) system standards development process and how to become involved in this highly rewarding work.

1. State of Affairs

In the early days of public safety radio, the technology of wireless communications was relatively simple, and few were involved in its development. Much of the design and development of portable equipment were performed by either the users themselves or the individuals they employed. Hollow state devices (tubes) and amplitude modulation (AM) were the norm. Equipment that used radio frequencies above 30 million cycles per second (30 megahertz [MHz]) was unheard of. A portable radio was defined as any radio not bolted to the floor. The concept of a radio that could be carried on the belt or be put in a pocket was futuristic. Interoperability was not an issue because there was not much need for that capability, and technology was not advanced enough to confuse the issue with alternatives. Public safety entities were mostly self-sufficient. The de facto modulation standard was AM; and capabilities such as encryption, digital modulation, and multichannel radios were generally unknown. The use of wireless equipment was limited because it was too big, had limited capabilities, was unreliable, and was too expensive for most budgets.

In earlier times, when public safety personnel needed to communicate among themselves, they did so face to face or they called their dispatcher. The dispatcher would relay messages face to face, in writing, or over the telephone. Communications among public safety elements (e.g., police, fire, medical, local, state, and federal) was limited, and wireless interagency communications was almost nonexistent. The extent to which interagency communications did not occur may have been attributed in part to not only technological limitations but also the political and jurisdictional boundaries of the times.

Since the invention of the transistor, wireless technology has advanced such that portable equipment is pocket size, highly reliable, and very affordable. Users have purchased multichannel radios by the millions. Now that wireless communications are more readily available and affordable, the demand for interagency communications has increased and the need for interoperability is on the rise.

The technical specifications and modulation standard for most conventional radio systems used in the public safety environment were attributed mostly to the influence of users on the vendor community. Most public safety agencies have developed systems in the very high frequency (VHF) and ultra high frequency (UHF) bands, using analog frequency modulated (FM) equipment. Where users are equipped with multichannel radios, interoperability requirements are often accommodated by each user adding the other user's frequency to his or her own radio or by sharing a common frequency. If the demand for additional channels had not far outstripped their availability, and if security had not become a major concern, the public safety community might have been able to get by with the status quo in future years. However, the demand for additional information transmission (i.e., voice, data, imagery, video) requires more channels (more spectrum), and, when combined with an increasing requirement for improved system security and the ability to talk across political and jurisdictional boundaries, it calls for significant change.

To complicate matters, vendors have recently made available more complex systems with much-needed features that are based on proprietary protocols and operate in spectrum (800 MHz) that most old systems cannot reach. Many agencies have chosen to implement the newer technology to obtain the added features or additional spectrum; this has resulted in "islands" of systems that are not compatible with the equipment and systems of those around them.

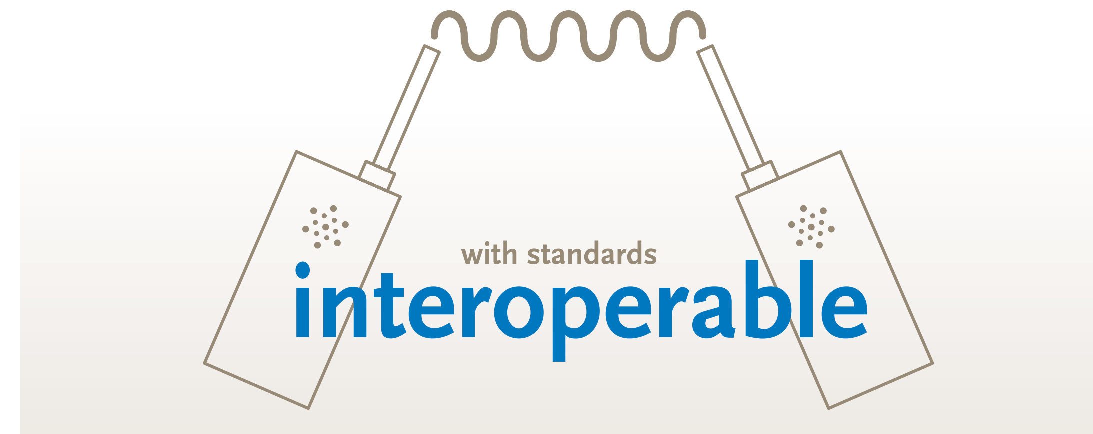
Serving the future wireless communications needs of the public safety community cannot be left to chance or to a few individuals. If the users' needs are to be met cost effectively, a team effort will be required. The complexities of wireless technology and the public demands on the public safety community necessitate cooperation.

Considerable concern exists, in the public safety community that the agencies' ability to effectively cooperate and share resources is being limited by the wireless industry's inability to provide cost-effective solutions. If the wireless industry is to meet the public safety community's needs, it must understand those needs and then be enticed to serve them.

In earlier times the limited need for interoperability was accommodated by

sharing

the same operating frequency or by other nonradio means.



2. The Rationale for Standardization

Standards are the underlying "laws" that govern the development of local, national, and international services, networks, and procedures. Telecommunications networks worldwide use formal telecommunications standards to physically interconnect their systems and ensure that they perform as expected. Without agreements and the standards that codify them, wide-area voice, data, and video communications would not be possible.

Imagine what it would be like if the railroads of America did not agree on a standard gauge for their railroad tracks or refused to share tracks. How many different rail systems would be needed to provide the services of our present railroad system? Could you picture the web of power transmission lines that would be needed if every power company insisted on different power line frequencies (e.g., DC, 50 Hz, 60 Hz, and 120 Hz)? Unless the public safety wireless community can develop, and agree to abide by, a common set of technical standards, the community could end up with systems that do not interconnect, are ineffective, and are very expensive.

The use of open standard interfaces and application programming interfaces could alleviate many of the interoperability problems faced today and help foster growth and innovation in the industry. Software and hardware vendors could use these standard interfaces to create products to sell directly to end customers, who could then add these products to their systems at any time during the system life cycle. Open standard interfaces would also encourage vendors to invest in new products with the knowledge that those products would work with the currently deployed systems.

Companies worldwide are experiencing fundamental changes in the way they are managed and operated. Managers are continually evaluating strategies and practices to determine how to maintain and build market share, reduce costs, increase productivity, and achieve a competitive edge. This effort applies to companies of all sizes and across all industries. Over the years, for the global marketplace to function effectively, international trade agreements and standards have been developed.

Standards are not a new phenomenon; they have existed for years. At one time, standards were considered needlessly complex, full of tedious technical jargon, and of little importance. Now, standards are building blocks for a broader business goal. Standards are essential if the telecommunications industry is to continue to be innovative and able to reduce costs, improve quality, and successfully market its goods and services.

Interest in standardization has expanded from the engineering offices to the executive offices. Strategic use of standardization is a management tool and an instrument for developing a blueprint for the future. By using standardization to streamline processes and trim costs, businesses can secure a competitive advantage and remain competitive in the face of national and global market changes.

The days when standards were used only for manufacturing are gone. Now, standardization can benefit all, whether a manufacturer, a processor, one of the many service providers, or a consumer. Standardization moves beyond product specifications and service requirements to encompass broad domestic issues such as the environment, healthcare, safety, and consumer protection programs. In short, standards are fundamental to securing success and creating a better way of living.

Standards are important to every company and consumer because they influence the design, manufacturing, and marketing of products around the world. Open standards, when adopted worldwide, create larger markets instead of many fragmented markets. In larger markets, everyone can benefit from the effect of economies of scale and other economic factors that help reduce cost and increase value.

3. Why You Should Support Standardization

In 1989, the Association of Public Safety Communications Officials International, Inc. (APCO); National Association of State Telecommunications Directors (NASTD); and Federal Government agencies acknowledged the need to establish common system standards to address public safety radio communications. This initiative stemmed from the recognition that the lack of common standards for private land mobile radio (LMR) systems would have a negative effect on the public, the public safety community (system user), and the manufacturer (system provider).

Without common standards, the system user would suffer because of lack of compatibility, limited integration of products of different manufacturers, long development cycles, high cost for retrofitting, limited interoperability, and lack of cost-incentive competition.

Manufacturers would suffer because of long, costly development processes. (The vendor must design, build, and test each product before the consumer can take delivery.) In addition, manufacturers' investment in new products would be limited by failure to recoup investments in currently offered products. Without consistent standards, newer devices and systems would be difficult to integrate into legacy systems and would probably require a complete system replacement. Such a replacement would increase the cost of ownership to the consumer and therefore expose the manufacturer to risk or loss of business because consumers would search for more cost-effective replacements.

Worst of all, the public would suffer as a result of the less effective and timely delivery of public safety services and equipment.

If common standards that address the needs of the entire public safety community are to be realized, the universal participation of the public safety community is critical. Standards development organizations and equipment manufacturers need to understand the needs of the community if they are to have any hope of serving those needs. Since the best source of information about public safety community needs generally is the members of the community, it is essential that you, as a member of the public safety community, get involved.

4. Standards Bodies

Standards development organizations (SDO) exist at the international, regional, and national levels. The following organizations are the primary SDOs in the telecommunications industry.

4.1 International Telecommunication Union

At the international level, the International Telecommunication Union (ITU) serves as the formal standards development body for telephony and radio. The ITU is a treaty organization of the United Nations (UN), which is composed of representatives from most nations. Established in 1865, the ITU is the oldest telecommunications standards organization. Originally, the ITU was known as the International Telegraph and Telephone Consultative Committee (in French, the acronym was CCITT). As an organization of governments, the ITU is also the most formal and highly structured of the telecommunications standards development organizations.

The ITU standards work is divided into two sections: ITU-Telecommunications (ITU-T) and ITU-Radiocommunications (ITU-R). Each section is organized into study groups, which are divided into working parties, and divided further into questions. A rapporteur (French, meaning facilitator) leads the work conducted in a question, and the working meetings are termed rapporteur meetings.

4.2 European Telecommunications Standards Institute

The European Telecommunications Standards Institute (ETSI) acts as the formal standards development organization for the European community. The ETSI, formed in 1988 by a Commission of the European Communities, assists in the process of technical harmonization in telecommunications, broadcasting, and office information technology. Recently, the ETSI, and its U.S. counterpart, the Telecommunications Industry Association (TIA), entered into a formal agreement known as the Public Safety Partnership Project (PSPP). The purpose of this partnership is to develop common requirements and technical specifications for broadband terrestrial mobility applications and services that will then become regional standards.

4.3 Telecommunications Industry Association

The Telecommunications Industry Association (TIA) is the formal organization responsible for developing many U.S. telecommunications standards. The TIA is closely aligned with the Electronic Industries Association (EIA), an organization that originated in 1944. The American National Standards Institute (ANSI) accredits the TIA.

standards lead to interoperability

4.4 American National Standards Institute

It is often difficult to determine whether a standards committee is formal or informal. In the United States, formal standards committees are accredited by ANSI. ANSI has served in its capacity as administrator and coordinator of the U.S. private sector voluntary standardization system for more than 80 years. Founded in 1918 by five engineering societies and three government agencies, the institute remains a private, nonprofit membership organization supported by a diverse constituency of private and public sector organizations.

ANSI represents the interests of nearly 1,000 company, organization, government agency, and institutional and international members through its office in New York City and its headquarters in Washington, DC.

ANSI does not itself develop American National Standards (ANS); rather, it facilitates development by establishing consensus among qualified groups. ANSI ensures that its guiding principles—consensus, due process, and openness—are followed by the more than 175 distinct entities accredited under one of the federation's three methods of accreditation (organization, committee, or canvass). In 1999, the number of approved ANSs reached an all-time high of 14,650. ANSI-accredited developers are committed to supporting the development of national (and in many cases, regional or international) standards and addressing the critical trends of technological innovation, marketplace globalization, and regulatory reform.

The value that the complex accreditation process offers to potential users and implementers of standards is fourfold:

- Standards work is coordinated to avoid two different standards committees creating different standards for the same functions.
- Standards committees maintain their standards as long as a minimal level of use exists.
- The standards process works to prevent domination by any one group and to allow all reasonable technical input to be heard.
- Intellectual Property Rights (IPR) are identified and their negative effects minimized during the standards creating process.

4.5 U.S. Standards Development Organizations

Appendix A provides a list of formal U.S. standards developing organizations that have been accredited by ANSI.

4.6 National, Regional, and International Standards Development Organizations

Appendix B lists formal standards bodies for many nations, and Appendix C lists international and regional standards organizations. These lists are not all-inclusive, nor do they imply endorsement of any particular company or organization.

4.7 Nonaccredited Standards Development Organizations

Several nonaccredited standards groups (e.g., ATM Forum, Frame Relay Forum, and Project 25) develop their work and then introduce it to formal standards committees. These groups help provide valuable input and supplement the work of the formal committees. Occasionally, as in the case of the Internet Engineering Task Force (IETF), informal standards work is so desirable that it becomes acknowledged as a de facto standard by its widespread acceptance. At times, the work of nonaccredited standards groups is an attempt to present a manufacturer's proprietary approach in a better light. The approach may be desirable (e.g., Microsoft Messaging Application Programming Interface [MAPI]) yet fail to provide the four-dimensional value of formal standards work as outlined previously. A notable exception is P25, which is a user-based group that supports the values of the formal standards work and is working closely with TIA to develop the ANSI/TIA/EIA-102 suite of standards and specifications.

5. The Standards Process

Most formal standards have undergone a rather long and often labor-intensive process on their way to becoming standards, but they all have one thing in common: they started as an idea in someone's mind. Seldom does a bad idea become a standard, yet many great ideas never achieve that due to many reasons, not the least of which is a lack of resources and understanding of the process.

The standards process may be separated into a number of steps starting with the first, which is having a worthwhile idea. Step two is to document the idea. It will not get anywhere in the standards development process if it cannot be shared with others. Documentation may be as simple as drawing a picture or describing the idea in a narrative format. If it is a really great idea, and you think it is worthy of becoming a formal standard, you may wish to document the idea in accordance with the instructions contained in the TIA Style Manual. The TIA Style Manual may be found at www.tiaonline.org/standards/sfg/styleweb.pdf. The process described in this document is specific to the TIA process, but the basic steps are consistent with those of most other formal standards organizations.

When the idea has been documented, share it with others, refine the concept, and begin developing consensus. At this point, you could turn it over to someone else, such as a manufacturer, to move along the development process, or step forward and champion the idea yourself.

Ideas that are intended to become part of the TIA-102 suite of public safety wireless standards should be presented to the P25 Steering Committee. It is not a requirement that they are submitted to the committee, but by doing so, the presenter may expect to receive help in developing the proposed standard, gaining consensus, and moving it through the process.

The guidelines established in the TIA Engineering Manual should be closely followed when working with the TIA. The process is very formal and exact and has been proven over the years to be very effective and necessary when working with large and highly diverse groups.

A potential project is initiated by a technical contribution to one of the engineering committees or subcommittees. If there is support for this contribution and committee (or subcommittee) members are willing to work on the project, a Project Initiation Notice (PIN) form is completed and submitted to TIA for approval. After the project is approved and has been assigned a project number (PN), committee members create a draft of the proposed standard.

When the draft is near completion, the formulating committee circulates it internally on a ballot called a "Committee Letter Ballot" or "PN ballot." This ballot identifies any unresolved issues and establishes consensus within the formulating group. Every effort is made to resolve comments received. During this phase of the standards-making process, the document draft is not released to the public.

If the document is intended to be an ANSI standard, the draft (including the changes resulting from the PN ballot) must be circulated as an industrywide ballot, also known as a "Standards Proposal" (SP) or Pink Ballot. The purpose is to gain industry consensus. The PN prefix changes from "PN" to "SP" during the balloting phase. Any interested party may cast a vote; it is not necessary to be a TIA member. A party can

Standards Development Process

respond in three ways: affirmative, affirmative with comment, or negative with comment. Every attempt is made to resolve comments received at this phase of balloting. During this phase, the SP ballot is available to the public and may be purchased from Global Engineering Documents.

When industry consensus of the final draft is reached, the document is forwarded with all of its balloting history to the Technical Standards Subcommittee (TSSC), which is a review group at TIA. If the document is intended to be an ANSI standard, the same information is forwarded to the ANSI Board of Standards Review (BSR) with a request for approval. The TSSC and BSR ensure that TIA and ANSI due process and other requirements have been met. After this review, the document is approved for publication as a TIA standard.

Standards are prepared under the certification of ANSI. They are balloted in an industry ballot in which any industry member (whether or not a TIA member) can vote. Interim standards issued before 1988 have the prefix EIA, whereas standards issued between 1988 and 1992 have the prefix EIA/TIA. Standards issued since 1992 have the prefix ANSI/TIA/EIA. All ANSI standards must be reviewed every 5 years to ensure that they remain current. At this review, the standard may be reaffirmed, modified (revised), or rescinded.

A TIA Interim Standard (IS) may be published when there is an urgent need. ISs are intended as temporary or trial-use and must be reaffirmed every year. ISs are balloted only within the formulating committee. They are not sent for industry ballot, nor does the ANSI BSR approve them.

6. The Project 25 Process

Recognizing the need for common standards, APCO, NASTD, and Federal Government agencies established Project 25, a steering committee for selecting voluntary common system standards for digital public safety radio communications (the P25 Standard). TIA provides assistance in this process.

The output of the process is a set of technical specifications that define the parameters of a P25 system. The P25 suite of standards and bulletins provides for P25-compliant systems and equipment interoperability and compatibility requirements. P25 systems provide digital LMR services for private radio communications systems for local, state, federal, and tribal public safety organizations and agencies. The P25 standards and bulletins provide for communications between and within various P25 systems and system elements. Manufacturers use these documents to develop equipment that meets the objectives of interoperability. The family of standards and bulletins applies to land mobile equipment authorized or licensed under National Telecommunications and Information Administration (NTIA) or Federal Communications Commission (FCC) rules and regulations.

The public safety user community initiated the process for developing the P25 standards. The standards development process begins with the presentation of user needs to the P25 Steering Committee, which meets regularly. Any public safety agency can engage the steering committee to identify solutions and standard approaches relating to LMR use. The committee submits a Statement of Requirements document to the APCO P25 Interface Committee (APIC), an interest group formed in response to the need for continued user community and industry dialog regarding the evolution and use of the standard. APIC comments on the Statement of Requirements, finalizes the requirement process, and then shares these requirements with the manufacturers. Through APIC, users and manufacturers cooperate to define the appropriate operation and technical documents to address the Statement of Requirements. When all parties agree on the technical and operational content of the given requirements, APIC compiles the results and submits the appropriate P25 standard documents to TIA Technical Research Group 8 (TR-8), which has been assigned to address all P25 standard documents. TIA TR-8 then reviews and comments on the proposed standard documents and ensures operational and technical feasibility. Once TIA TR-8 approves the proposed document, TIA assigns an appropriate document number and publishes the document as a bulletin, a TIA standard, or an ANSI standard. The TIA's designation for the Project 25 standards is the TIA 102 series.

The P25 process developed the 102 series to provide detailed technical specifications for digital LMR communications systems. Like the overall P25 process, the process for generating the 102 series of specifications has been led by the users' steering committee. Standardization work is performed by TIA in accordance with the standards process defined in TIA's engineering manual. This process results in a suite of ANSI/TIA/EIA standards, TIA/EIA ISs, and TIA Technical Service Bulletins (TSB).

The P25 standard enables compliant radios to communicate in analog mode with legacy analog radios and in either digital or analog mode with other P25 radios. In addition, P25 systems can be maintained and upgraded cost effectively over the system's life cycle, thereby meeting user requirements, achieving interoperability, prompting committed manufacturers to provide compliant products, fostering competition, and achieving cost-effective solutions.

7. Status of the Project 25 Standard

To illustrate the complexity of the standards process and give the reader insight into the results of the process, the current status of the P25 suite of standards is provided here.

7.1 Phase I

The P25 Phase I standards documents define the services and facilities required for a P25 Phase I-compliant system. Ultimately, the standard ensures that any manufacturer's compliant subscriber radios would have access to the services described in the standard documents, regardless of the origins of the system infrastructure. The standard also ensures that all the services it defines are accessible to subscribers from other systems and across system boundaries. In addition, the standard provides open interface to the RF subsystem to facilitate interlinking of different vendors' systems.

The P25 Phase I standard also specifies the level of standardization, level of interoperability, systems interworking, and backward compatibility. The level of standardization specifies the services and interfaces that the standard addresses. It does not imply that all services must be implemented in any specific P25 system. Rather, if a service is implemented, it should comply with the standard. All service and system feature implementations remain a system operator decision.

In addition, the P25 Phase I standard defines interoperability as an ability to offer a visiting subscriber a set of services appropriate to the service provided by the hosting network. This feature is a system operator option. However, if the operator chooses this option, it must comply with the P25 standard. This option does not prevent agreements among system operators to provide higher levels of interoperability. The P25 Phase I standard specifies three levels of interoperability:

- Mutual Aid
  This is a minimum mandatory requirement through which subscriber units can select and operate on available analog mutual aid channels to communicate with fixed network equipment or in a direct unit-to-unit communication.
- Predefined Roaming
  This level allows roaming for joint operation, or in emergencies, on preprogrammed channels.
- Full Roaming
  This option allows system providers to link multiple systems to provide a wider area of service that may support full roaming service.

System interworking allows disparate systems to link and provide common services. It enables users to extend their coverage area because the interlinked systems are considered as one system by the subscriber unit. When this option is selected, the system providers must provision for an intersystem interface as a mandatory requirement. The backward compatibility in the P25 standard states that Phase I equipment, regardless of the manufacturer, must have at least the capability to operate both in analog and in the standardized digital mode defined in the ANSI/TIA/EIA 102 series. In addition, manufacturers can provide, as an option, backward compatibility with their own existing analog systems.

The P25 Phase I technical requirement specification identifies three types of services: telecommunications, subscriber, and network. The availability of these services depends on the type of system and the system provider's needs. The three types of services are identified as follows:

- Telecommunications Services
  Are composed of a network's abilities to provide for the transfer of user information through the network and are subdivided into three categories:
  - *Bearer services*
    Provide user information transport between network access points and include circuit-switched unreliable data, circuit-switched reliable data, packet-switched confirmed delivery data, and packet-switched unconfirmed delivery data.
  - *Teleservices*
    Provide complete facilities for transfer of user information, including terminal functions. These services are built on a bearer service of the network. Teleservices include broadcast voice call, unaddressed voice call, group voice call, individual voice call, circuit-switched data network access, packet-switched data network access, and preprogrammed data messaging.
  - *Supplementary services*
    Provide modifications or enhancements to bearer service or teleservice capabilities. These services are not offered as stand-alone and may be associated with several bearer services or teleservices. Supplemental services include encryption, priority call, preemptive priority call, call interrupt, voice telephone interconnect, discreet listening, silent emergency, radio unit monitoring, talking party identification, and call alerting.
- Subscriber Unit Services
  Provide for information exchange between the subscriber unit and controlling devices within the system. Subscriber unit services include the following:
  - *Intrasystem roaming*
  - *Intersystem roaming*
  - *Call restriction*
  - *Affiliation*
  - *Call routing*
  - *Encryption update.*
- Network Services
  Provide the system operator with efficient services for both conventional and trunked operation and include the following:
  - *Registration*
    - *Registration within the same system*
    - *Conventional operation*
    - *Trunking operation*
  - *Roaming*
  - *Authentication*
  - *Subscriber terminal disable and enable*
  - *Network management and administrative services*
    - *Network management interface*
    - *Call statistics*
    - *Traffic recording.*

Table 1 shows the availability of the above services within a P25 system. If a service is listed as mandatory, a P25 system must provide the service according to the specified standard. If a service is listed as standard option, the service is optional; however, if the vendor elects to implement that service, it must provide the service in compliance with the specified standard. According to the P25 standard, two types of systems exist: conventional and trunked. All P25 radios must be able to operate in both types of systems and to provide the services indicated in the table.

Table 1: P25 Service Availability Matrix

Service	Conventional	Trunked
Telecommunications Services		
Bearer Services		
Circuit-switched unreliable data	Standard option	Standard option
Circuit-switched reliable data	Standard option	Standard option
Packet-switched confirmed delivery data	Standard option	Standard option
Packet-switched unconfirmed delivery data	Standard option	Standard option
Teleservices		
Broadcast voice call	Not applicable	Mandatory
Unaddressed voice call	Mandatory	Not applicable
Group voice call	Standard option	Mandatory
Individual voice call	Standard option	Mandatory
Circuit-switched data network access	Standard option	Standard option
Packet-switched data network access	Standard option	Standard option
Preprogrammed data messaging	Standard option	Standard option
Supplementary Services		
Encryption	Standard option	Standard option
Priority call	Not applicable	Standard option
Preemptive priority call	Not applicable	Standard option
Call interrupt	Standard option	Standard option
Voice telephone interconnect	Standard option	Standard option
Discreet listening	Standard option	Standard option
Silent emergency	Standard option	Standard option
Radio unit monitoring	Standard option	Standard option
Talking party identification	Standard option	Standard option
Call alerting	Standard option	Standard option
Subscriber Unit Services		
Intrasystem roaming	Standard option	Standard option
Intersystem roaming	Standard option	Standard option
Call restriction	Not applicable	Standard option
Affiliation	Not applicable	Standard option
Call routing	Not applicable	Standard option
Encryption update	Standard option	Standard option
Network Services		
Registration	Standard option	Mandatory
Roaming	Mandatory	Mandatory
Authentication	Standard option	Standard option
Subscriber terminal disable and enable	Standard option	Standard option
Network management and administration services	Standard option	Standard option

Table 2 is a listing of the standards documents that have been published to address Phase I of the P25 standard.

***Table 2:** Standards Documents*

Title	APIC Document No.	TIA TR8 Document No.	Document Status/ Published Date
1.0 Project 25 System and Standard Definition	N/A	TSB102-A	November 1995
2.0 FDMA Common Air Interface (CAI)	N/A	ANSI/TIA/EIA102BAAA	September 1999
3.0 CAI Conformance Testing	N/A	TSB102BAAB-A	April 1999
4.0 CAI Reserved Values	N/A	ANSI/TIA/EIA102BAAC	May 2000
5.0 CAI Operational Description for Conventional Channels	N/A	TSB102BAAD	October 1994
6.0 Vocoder Description	N/A	ANSI/TIA/EIA102BABA	May 1998
7.0 Vocoder Mean Opinion Score (MOS) Test	N/A	ANSI/TIA/EIA102BABB	May 1999
8.0 Vocoder Reference Test	N/A	ANSI/TIA/EIA102BABC	April 1999
9.0 Vocoder Selection Process	N/A	TSB102BABD	May 1996
10.0 Transceiver Measurements Methods	N/A	ANSI/TIA/EIA102CAAA	June 1999
11.0 Transceiver Performance Recommendations	N/A	IS102CAAB	May 1999
12.0 Trunking Overview	N/A	TSB102AABA	April 1995
13.0 Trunking Control Channel Formats	N/A	ANSI/TIA/EIA102AABB	June 2000
14.0 Trunking Control Channel Messages	N/A	ANSI/TIA/EIA102AABC	May 2000
15.0 Link Control Word Formats & Messages	N/A	TSB102AABF	May 1996
16.0 Conventional Control Messages	N/A	TSB102AABG	July 1996
17.0 Trunking Procedures	N/A	TSB102AABD	October 1997
18.0 ISSI Overview—Update	N/A	TSB102BACC	APIC System Task Group
19.0 ISSI Messages Definition—Update	N/A	TSB102BACA	June 2000
20.0 ISSI Conformance	N/A	TSB102BACB	APIC System Task Group
21.0 Telephone Interconnect Requirements and Definitions (Voice Service)	N/A	ANSI/TIA/EIA102BADA	March 2000
22.0 Data Overview	N/A	ANSI/TIA/EIA102BAEA	March 2000
23.0 Packet Data Specification	N/A	ANSI/TIA/EIA102BAEB	March 2000
24.0 Circuit Data Specification	N/A	ANSI/TIA/EIA102BAEC	June 2000
25.0 Radio Control Protocol Specification	N/A	ANSI/TIA/EIA102BAEE	March 2000
26.0 Network Management Interface Definition	N/A	TSB102BAFA	July 1999
27.0 Security Services Overview	N/A	TSB102AAAB	January 1996
28.0 DES Encryption Protocol	N/A	ANSI/TIA/EIA102AAAA	June 2000
29.0 DES Encryption Conformance	N/A	ANSI/TIA/EIA102AAAC	June 2000
30.0 OTAR Protocol	N/A	TSB102AACA-1	June 2000
31.0 OTAR Operational Description	N/A	TSB102AACB	January 1997
32.0 OTAR Conformance	N/A	TSB102AACC	February 1997
33.0 Lockdown Overview	P25.940811.2.2	N/A	APIC Inter. Task Group

These 33 documents are categorized as follows:

- System and standards definition
- Service category description
- System category description
- Equipment category description.

Each category is defined in the following subsections.

7.1.1 System and Standards Definition

The Project 25 System and Standards definition document (TSB 102-A) addresses the structure needed to relate the various documents used in the description and definition of the P25 systems. It presents not only an overview of the P25 concept but also guidelines for locating information essential to other specific requirements.

7.1.2 Service Category Description

The service category documents define the features that a P25 Phase I compliant system might have. These documents are listed in Table 3 and described below.

Table 3: P25 Service Category Standard Documents

Standard Document	Document Reference
DES Encryption Protocol	ANSI/TIA/EIA102AAAA
Security Services Overview	TSB 102.AAAB
DES Encryption Conformance	ANSI/TIA/EIA102AAAC
Trunking Overview	TSB 102.AABA
Trunking Control Channel Formats	ANSI/TIA/EIA102.AABB
Trunking Control Channel Messages	ANSI/TIA/EIA102AABC
Trunking Procedures	TSB 102.AABD
Trunking Conformance	TSB 102.AABE*
Link Control Word Formats and Messages	TSB 102.AABF
Conventional Control Messages	TSB 102.AABG
OTAR Protocol	TSB 102.AACA-1
OTAR Operational Description	TSB 102.AACB

* This document has not been released.

- DES Encryption Protocol document (ANSI/TIA/EIA102.AAAA)
  Defines the voice and the data modes of operation of DES encryption and decryption in a manner compatible with information transfer through a P25 system, especially the common air interface (CAI).
- Security Services Overview document (TSB 102.AAAB)
  Provides an overview of the encryption services available in a P25 system.
- DES Encryption Conformance document (ANSI/TIA/EIA102.AAAC)
  Provides a series of conformance tests for the DES Encryption Protocol to ensure that equipment conforms to the formats specified in the DES Encryption Protocol.
- Trunking Overview document (TSB 102.AABA)
  Provides a high-level overview of P25 trunked systems, including commonality with conventional systems, mixture of services, registration, voice services, secondary control, voice or data control, and protected trunking.
- Trunking Control Channel Formats document (ANSI/TIA/EIA102.AABB)
  Defines the format of trunking control channel transmissions for P25 systems, compatibility with the CAI, and both encrypted and nonencrypted formats.
- Trunking Control Channel Messages document (ANSI/TIA/EIA102.AABC)
  Defines all messages constructed from formats further identified by the trunking control channel formats.
- Trunking Procedures document (TSB 102.AABD)
  Describes all procedures for accessing the control channel and working channels.
- Trunking Conformance document (TSB 102.AABE) *not yet completed*
  Will define conformance tests ensuring that equipment is compatible with the specified trunking procedures.
- Link Control Word Formats and Messages document (TSB 102.AABF)
  Defines all link control words for voice transmissions, including both trunking and conventional modes on P25 systems.
- Conventional Control Messages document (TSB 102.AABG)
  Defines the control messages of trunking that may be applied to conventional systems. These control messages are extensions to the basic CAI.
- OTAR Protocol document (TSB 102.AACA-1)
  Defines the messages and basic procedures for providing OTAR and related key management services. The document includes methods of encrypting and sending encryption keys and other related key management messages through the CAI in a way that protects them from disclosure, and in some cases, from unauthorized modification.
- OTAR Operational Description document (TSB 102.AACB)
  Is a supplement to the Key Management and OTAR Protocol describing the operational procedures as sequences of messages and basic procedures, defined in the Link Control Word Formats and Messages (TSB 102.AABF), for performing key management and OTAR functions.

7.1.3 *System Category Description*

The system category documents define the core part of the P25 Phase I standard. They are divided into six subcategories: CAI, vocoder, ISSI, telephone interconnect, data, and network management interface. These subcategories are described in the documents listed in Table 4.

***Table 4:** P25 System Category Standard Documents*

Standard Document	Document Reference
FDMA Common Air Interface (CAI)	ANSI/TIA/EIA 102.BAAA
CAI Conformance Testing	TSB 102.BAAB-A
CAI Reserved Values	ANSI/TIA/EIA 102.BAAC-A
CAI Operational Description	TSB 102.BAAD
Vocoder Description	ANSI/TIA/EIA 102.BABA
Vocoder MOS Conformance Testing	ANSI/TIA/EIA 102.BABB
Vocoder Reference Test	ANSI/TIA/EIA 102.BABC
Vocoder Selection Process	TSB 102.BABD
ISSI Message Definitions	TSB 102.BACA Inter-RF
ISSI Conformance	TSB 102.BACB Inter-RF
ISSI Overview	TSB 102.BACC
Telephone Interconnect Requirements and Definitions	ANSI/TIA/EIA 102.BADA
Data Overview	ANSI/TIA/EIA 102.BAEA
Packet Data Specification	ANSI/TIA/EIA 102.BAEB
Circuit Data Specification	ANSI/TIA/EIA 102.BAEC
Radio Control Protocol Specification	ANSI/TIA/EIA 102.BAEE
Network Management Interface Definition	TSB 102.BAFA
Network Management Interface Conformance	TSB 102.BAFB*

*This document has not been released.

- CAI document (ANSI/TIA/EIA102.BAAA)
  Defines the over-the-air interface configurations between a mobile subscriber unit functional group and one or more base radio functional groups at a site, at multiple sites within an RF subsystem, and within any RF subsystems in which the subscriber unit might roam. It also defines the reference configuration between mobile and portable subscriber units in a talk-around configuration.
- CAI Conformance Testing document (TSB 102.BAAB-A)
  Lists a series of conformance tests for the CAI to ensure that equipment conforms to the formats specified in the CAI standard and is interoperable with other equipment conforming to the standard.
- CAI Reserved Values document (TSB 102.BAAC-A)
  Is a supplement to the CAI standard listing all of the reserved values for the fields of information intended to be interpreted by the CAI standard. It is not intended to be used or understood by itself.

- CAI Operational Description (TSB 102.BAAD)
  Is another supplement to the CAI describing simple operational procedures sufficient for basic operation in conventional systems.
- Vocoder Description (ANSI/TIA/EIA102.BABA)
  Describes the functional requirements for the transmission and reception of voice information using the digital communication media described in the CAI documents. The vocoder standard was intended to define the conversion of voice from an analog representation to a digital representation. The digital format consists of a net bit rate of 4.4 kilobits per second (kbps) for voice information and a gross bit rate of 7.2 kbps after error control coding.
- Vocoder MOS Conformance Testing document (ANSI/TIA/EIA102.BABB)
  Employs MOS testing to evaluate an implementation of a P25 vocoder. This document provides a method for testing interoperability of an implementation of a P25 vocoder with the P25 reference vocoder.
- Vocoder Reference Test document (ANSI/TIA/EIA102.BABC)
  Provides a method of testing an implementation of a P25 vocoder with respect to the P25 Vocoder Reference Description document. This test method requires proprietary test equipment.
- Vocoder Selection Process document (TSB 102.BABD)
  Provides a historical reference to the selection of the P25 vocoder, along with the method of testing candidate vocoders, evaluation metrics, and test results for the candidate vocoders.
- ISSI Message Definition document (TSB 102.BACA)
  Defines the messages to be used between an RF subsystem gateway functional group in one RF subsystem and a corresponding RF subsystem gateway functional group in other RF subsystems.
- ISSI Conformance document (TSB 102.BACB)
  Lists a series of conformance tests for the RF subsystem interface to ensure that equipment not only conforms to the formats specified in the RF subsystem interface but also is interoperable with other equipment conforming to the standard.
- ISSI Overview document (TSB 102.BACC)
  Provides a high-level overview of the P25 ISSI, summarizing the protocol and message structure, mobility management, and intervening network adaptation.
- Telephone Interconnect Requirements and Definitions (ANSI/TIA/EIA102.BADA)
  Defines the interface between a RF subsystem and a public or private switched telephone network.
- Data Overview document (ANSI/TIA/EIA102.BAEA)
  Provides an overview of the data services in a P25 system, including circuit and packet data. The document also specifies the requirement to transport multiple packet protocols, including TCP/IP, X.25, and SNA. Overall, the P25 system standard specifies two categories of data services in three categories of data configurations, for six distinct service/configuration combinations. A P25-compliant data system should support one or more of the service/configuration combinations.
- Packet Data Specification (ANSI/TIA/EIA102.BAEB) and the
  Circuit Data Specification document (ANSI/TIA/EIA102.BAEC)
  Define the detailed interfaces, protocols, and procedures involved in interfacing with a data-capable P25 standard radio unit via the standard mobile data peripheral interface and the end-system interface. The data services may be provided across conventional or trunked service channels. The packet data bearer service allows two or more fixed or mobile end terminals (i.e., hosts) to communicate via the wireless network and/or Ethernet. The service is characterized as an Internet Protocol (IP) (RFC791) bearer

service that provides connectionless, best-effort datagram delivery between bearer service access points. Error correction and detection, and encryption services are provided across the air interface by elements of the radio subnetwork. The circuit data bearer service allows two fixed or mobile end terminals (i.e., hosts) to communicate in a point-to-point configuration via the wireless network and/or the intervening PSTN network. Nontransparent two-way communications are supported between bearer service access points in wireless networks and the PSTN.

- Radio Control Protocol Specification document (ANSI/TIA/EIA102.BAEE)
  Defines the Radio Control Protocol (RCP) for use in P25 digital radio systems for packet data communications services. The current packet data service specification is defined in the Packet Data Specification (ANSI/TIA/EIA102.BAEB). RCP, along with the Internet Control Message Protocol (ICMP), defines the control signaling protocol across the A interface. Control signaling refers to transactions that are not directly concerned with the transfer of user information between the mobile host and destination host.
- Network Management Interface Definition document (TSB 102.BAFA)
  Defines the interface between one or more RF subsystems and an attached network manager or other interconnect network management system. This part of the P25 standard defines the interface between a RF subsystem gateway functional group within one RF subsystem and a network management end system.
- Network Management Interface Conformance document (***102.BAFB)
  Lists a series of conformance tests for the network management interface to ensure equipment conformance to the formats specified in the Network Management Interface Definition and ensures that equipment is interoperable with other equipment conforming to the standard.

7.1.4 Equipment Category Description

The equipment category documents define the proper measurement methods to verify that all CAI signaling conforms to the standard. These documents are listed in Table 5 and described below.

Table 5: *P25 Equipment Category Standard Documents*

Standard Document	Document Reference
Digital C4FM/CQPSK Transceiver Measurement Methods	ANSI/TIA/EIA 102.CAAA
Digital C4FM/CQPSK Transceiver Performance Recommendations	IS 102.CAAB

- Digital C4FM/CQPSK Transceiver Measurement Methods document (ANSI/TIA/EIA 102.CAAA)
  Standardizes parameter titles, definitions, test conditions, and the methods for measuring the performance of P25 transceiver equipment within the scope of the standard. The transceiver measurement methods also ensure a meaningful comparison of the results of measurements made by various observers on different equipment.
- Digital C4FM/CQPSK Transceiver Performance Recommendations document (IS 102.CAAB)
  Establishes minimum specifications for P25 transceiver equipment performance measured in accordance with IS 102.CAAA.

7.2 Phase II

The P25 Phase I approach targeted the transition from the 25 kHz to 12.5 kHz digital channel bandwidth. Phase I also ensured that all radios are capable of 25 kHz analog frequency modulation and 12.5 kHz digital C4FM operation. In contrast, P25 Phase II is intended to ensure the final transition to 6.25 kHz bandwidth using the CQPSK modulation technique. The primary difference between Phase I and Phase II is the modulation scheme.

The TIA's primary concern was the possibility of achieving 6.25 kHz channel bandwidth efficiency through a time division multiple access (TDMA) scheme. Further, to grant equal contribution from various manufacturers and to maintain an open and unbiased process, the P25 committee requested proposals to address the issue. These proposals must adhere to two requirements:

- A TDMA radio must have a Phase I mode of operation (nontrunked minimum) for operation with other P25 radios.
- A TDMA radio must be able to patch digital audio (i.e., have a common vocoder) and signaling information to and from other P25 radios.

This solicitation was based on the inherent advantage of the TDMA concept, in which the physical channel is subdivided into several logical channels, effectively increasing channel capacity. This increase is crucial in urban areas where radio channel capacity is scarce.

In addition to addressing the transition to a 6.25 kHz channel bandwidth, the P25 Phase II was planned to address not only a standard for console interface but also a standard interface between repeaters and other subsystems (e.g., trunking system controller). Several other standard interface projects have been proposed. Such standards would include a man-machine interface for console operators and would facilitate centralized training, equipment transitions, and personnel movement.

Several radio systems have demonstrated spectrally efficient digital systems for public safety users. The TIA actually received proposals describing seven digital, spectrally efficient radio systems. Three of these systems use frequency division multiple access (FDMA), three use TDMA, and one uses a novel method called frequency hopping multiple access (FHMA). The three FDMA systems are Project 25, Tetrapol, and Enhanced Digital Access Communications System (EDACS®) Aegis® (by M/A Com, formerly ComNet Ericsson). The three TDMA systems are TETRA, Digital Integrated Mobile Radio System (DIMRS), and Integrated Digital Radio (IDRA). Geotek, Inc., makes the FHMA system. Three of the seven systems are proposed primarily for public-oriented networks (DIMRS, IDRA, and Geotek); three are proposed mainly for private networks (Project 25, Tetrapol, and EDACS Aegis); and TETRA is being proposed as a solution for both public and private networks. On November 19, 1999, the P25 Steering Committee approved proposals to include two-slot TDMA and four-slot TDMA modulation schemes as part of the P25 Phase II standard.

Table 6 lists the currently released standard documents that address Phase II implementations.

Table 6: *Standards Documents Addressing Phase II Implementations*

Title	APIC Document No.	TIA TR8 Document No.	Document Status/ Published Date
1.0 Common Air Interface (CAI)	N/A	ANSI/TIA/EIA102BAAA-1	September 1999
2.0 CAI Conformance Testing	N/A	TSB102BAAB-A-1	April 1999
3.0 Transceiver Measurements Methods	N/A	ANSI/TIA/EIA102CAAA	June 1999
4.0 Transceiver Performance Recommendations	N/A	IS102CAAB	May 1999
5.0 Console Interface Overview	N/A	N/A	APIC Console 1/0 Task Group
6.0 Fixed Station Interface Overview	P25.000119.1.0	N/A	APIC Fixed Station Task Group

7.3 Phase III

Recognizing the need for high-speed data for public safety use as expressed in the Public Safety Wireless Advisory Committee (PSWAC) final report, the P25 standard committee established the P25/34 committee to address Phase III. Similarly to the P25 approach, the standard committee established the P25/34 user forum to address this issue. This standard would address the operation and functionality of a new aeronautical and terrestrial wireless digital wideband public safety radio standard that could be used to transmit and receive voice, video, and high-speed data in a ubiquitous, wide-area, multiple-agency network.

On June 1, 1999, the P25/34 committee released the Statement of Requirements for a wideband aeronautical and terrestrial mobile digital radio technology standard for the wireless transport of rate intensive information.

During the ETSI April 2000 meeting, a draft agreement between ETSI and TIA proposing the creation of a Public Safety Partnership Project (PSPP) was approved. On May 25, 2000, ETSI Director General Mr. Karl-Heinz Rosenbrock and TIA Vice President Mr. Dan Bart formally signed the PSPP.

The inaugural meeting of the PSPP took place October 23–26, 2000, in Sophia Antipolis, France.

The ETSI and TIA agreed to work collaboratively for the production of mobile broadband specifications for public safety as initiated by ETSI Project TETRA (under the name of DAWS) and by TIA and APCO under APCO's Project 34.

8. How You Can Get Involved in the Standards Process

There are a number of ways to become involved in developing technical standards. Much work needs to be accomplished, and a critical need exists for technically competent volunteers.

You can get involved in a variety of ways, ranging from simply communicating your needs to becoming fully immersed in the activities of a formal standards development organization. One of the simplest ways to input information into the standards development process is to communicate your requirements to a manufacturer and trust that it will carry the information forward through the process.

In the case of P25, you can participate on a TIA engineering committee, subcommittee, or working group in two ways. The first, and most common way, is for your company to become a TIA general member. If your company is eligible for TIA general membership and has paid its membership dues to TIA's membership department, you may participate on the engineering committees or subcommittees at no additional cost. Note that only one voting member is allowed per company, committee, or subcommittee. Additional representatives from the same company on the same subcommittee are designated as "nonvoting" members.

For those individuals who are interested in helping develop the standards for high data rate wireless applications, participation in the Public Safety Partnership Program may be appropriate. Additional information about the program as well as instructions on how to become involved can be found at http://www.ps2p.org/home.htm.

The second way to participate is for your company to pay "nonmember engineering participation fees." This option is exercised by a company that is eligible for TIA general membership, chooses not to join as a corporate member, yet still wishes to participate actively on the engineering committee or subcommittee. A company or organization that is ineligible for TIA general membership may also participate by paying a nonmember engineering participation fee. Fees for a committee, subcommittee, or working group sponsored by each TIA division (e.g., Wireless Communications, User Premises Equipment, Fiber Optics, Network Equipment, and Satellite Communications) vary according to the activity level within the respective committee and are assessed annually.

Finally, note that an individual representing a local, state, or Federal Government organization can participate at no cost as a nonvoting member on the various committees. TIA has reciprocal agreements with other industry trade associations and permits individuals from these associations to participate on the standards-setting engineering committees as nonvoting members.

9. Cost Considerations

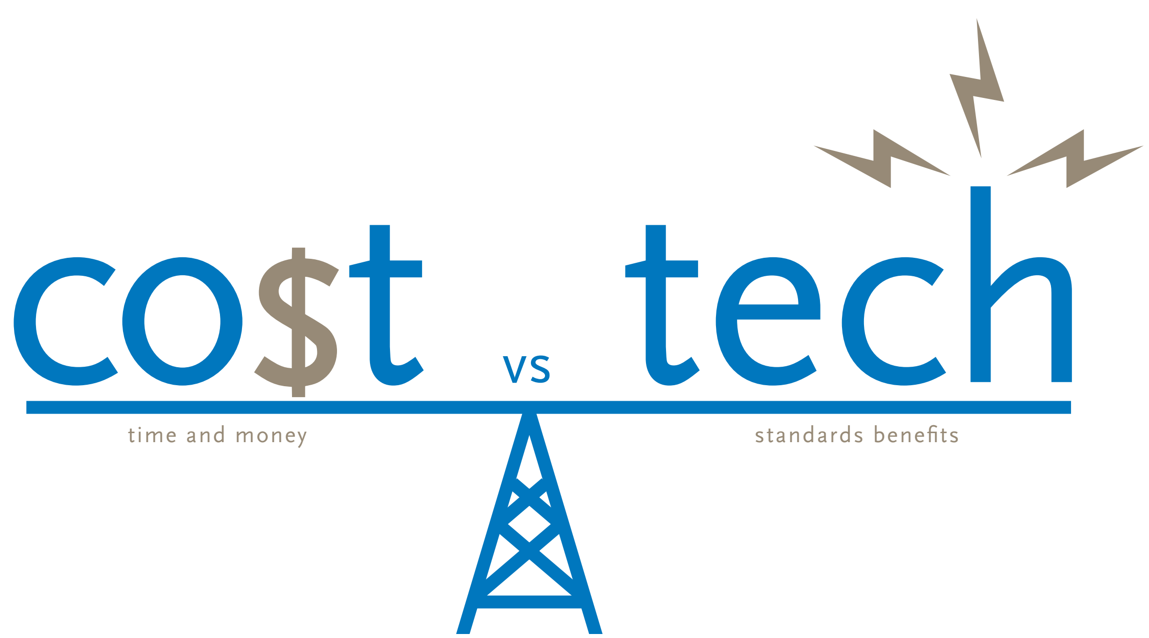
One might ask "What are the costs associated with getting involved in the standards process, and how can these costs benefit the involved agency in the long term?"

Not getting involved in the process requires the least short-term monetary investment. However, the monetary investment of getting involved needs to be balanced against the potential benefits.

Costs associated with being involved in the standards process are fairly predictable and tend to fall into two categories, time and money. Being involved means spending time studying and responding to the proposals of others, preparing proposals, traveling to and from meetings, attending meetings, and conversing frequently with others.

Being involved also requires a budget to cover the cost of frequent trips to attend meetings and the computer and telecommunications services needed to electronically access, process, and send information. For example, participation in the TIA TR-8 committee work would require at least four trips per year. The funds needed to cover association fees are comparatively minor and often waived.

The process is time intensive and requires a long-term commitment from those who get involved if they are to be effective. This process can test an individual's patience, demand his or her best efforts, and challenge an individual's technical and social skills. However, it can also be very rewarding to the individual as well as convey enormous benefit to the public safety community and the public it serves.



Appendix A

United States Standards Developing Organizations

Accredited Standards Committee (ASC)
American Forest & Paper Association
American Gear Manufacturers Association
American Petroleum Institute (API)
American Welding Society (AMWELD)
Arcnet Trade Association
Air-conditioning and Refrigeration Institute (ARI)
ASME International
Association for the Advancement of Medical Instrumentation (AAMI)
Association of Home Appliance Manufacturers
Association for Information and Image Management
Automotive Industry Action Group
Data Interchange Standards Association (DISA)
Electronic Industries Alliance (EIA)
Factory Mutual
Health Industry Business Communications Council (HIBCC)
Human Factors and Ergonomics Society (HFES)
Health Level Seven (HL7)
Information Technology Industry Council (ITI)
Institute of Electrical and Electronic Engineers (IEEE)
Institute for Interconnecting and Packaging Electronic Circuits (IPC)
The International Society for Measurement and Control (ISA)
National Committee for Information Technology Standards (NCITS)
National Council for Prescription Drug Program (NCPDP)
National Fire Protection Association (NFPA)
National Fluid Power Association
National Information Standards Organization (NISO)
The Association for Suppliers of Printing and Publishing Technologies (NPES)
NSF International
Society of Automotive Engineers (SAE) International
Civilian American and European Surface Anthropometry Resource Project
Society of Motion Picture and Television Engineers
Telecommunications Industry Association (TIA)
Underwriters Laboratories, Inc. (UL)
U.S. Product Data Association
VMEbus International Trade Association (VITA)

Appendix B

National Standards Bodies

Australia
Standards Australia (SAA)

Canada
Standards Council of Canada (SCC)

Finland
Finnish Standards Association (SFS)

France
Association Française de Normalisation (AFNOR)

Germany
Deutsches Institut fur Normung (DIN)

Italy
Ente Nazionale Italiano di Unificazione (UNI)

Japan
Japanese Industrial Standards Committee (JISC)

Malaysia
Standards and Industrial Research of Malaysia (SIRIM)

Netherlands
Nederlands Normalisatie-Instituut (NNI)

Norway
Norwegian Standards Association

Slovenia
Standards and Metrology Institute (SMIS)

United States of America
National Standards System Network (NSSN)

Appendix C

International and Regional Standards Organizations

European Committee on Standardization (CEN)
International Commission on Illumination (CIE)
EC Dialogue with Business
European Telecommunications Standards Institute (ETSI)
Committee of the National Chamber of Commerce in Belgium
European Association for the Coordination of Consumer
Representation in Standardization (ANEC)
European Union (EU)
European Workshop Open Systems (EWOS)
Interamerican Accreditation Cooperation (IAAC)
International Conference of Building Officials
International Electrotechnical Commission (IEC)
Internet Engineering Task Force (IETF)
International Organization for Standardization (ISO)
International Federation for Information Processing (IFIP)
International Telecommunication Union (ITU)
Internet Society
The Unicode Consortium
World Wide Web Consortium (W3C)