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APCO Project 25
System and Standards Definition

TSB102-A

(Revision of TSB102)

NOVEMBER 1995

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Representing the telecommunications industry
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(From Project No. 3591, formulated under the cognizance of the TIA TR-8 Mobile and Personal Private Radio Standards Committee.)

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MEMORIAL TO STU MEYER

This document is dedicated to the memory of Stuart Meyer who was chairman of the APCO Project 25 / TIA Interface Committee (APIC). It is fitting that this document which is the "directory" of the next generation of radio standards be dedicated to Stu whose five decades of involvement in the Land Mobile industry resulted in many contributions to the formulation of standards and rules.

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Project 25 System and Standards Definition

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TSB102

Foreword

(This foreword is not part of this document)

This Telecommunications Systems Bulletin (TSB) is being promulgated and will be maintained by the TR-8 Private Radio Technical Standards committee, responsible subcommittees, and working groups under the sponsorship of the Telecommunications Industry Association.

While not finished, TR-8 believes that an urgent need exists for and that this document accurately portrays a significant amount of technical information regarding emerging digital technologies for the Land Mobile Services, especially APCO Project 25. Therefore TR-8 has chosen to recommend it for publication as a TSB and thereby expedite its expected benefits to the industry.

Generally, the APCO Project 25 System and Standards Definition and various elements thereof have been developed by TIA TR-8 to be consistent with the Statement of Requirements adopted by the APCO Project 25 Steering committee. This Standards family includes and borrows heavily from the combined work of various industry and government agency representatives organized under the TIA APCO Project 25 Ad Hoc Interface Committee.

This document presumes that APCO/NASTD/FED will establish an overall APCO Project 25 System standard or specification, including a Common Air Interface previously recommended by TIA. It further presumes that TIA will set standards based upon the APCO/NASTD/FED APCO Project 25 standards or specifications.

This TSB provides APCO Project 25 Overview, a General System Model, other applicable standards, a Glossary, and a Statement of Requirements. While all reasonable efforts have been made to ensure the accuracy of this document, it should be understood that significant work remains in fully developing the APCO Project 25 family of standards and bulletins and that this document will be updated as necessary to ensure an accurate representation of APCO Project 25 systems as other implementation requirements become available.
The reader's attention is called to the possibility that compliance with the APCO/NASTD/FED APCO Project 25 Standard or any TIA standard for equipment conforming to the APCO/NASTD/FED APCO Project 25 Standard may require the use of one or more inventions covered by patent rights. By publication of those standards and bulletins, if any, no position is taken with respect to the validity of those claims or any patent rights in connection therewith. The patent holders so far identified have, however filed statements of willingness to grant licenses under those rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such licenses. Details may be obtained from the publisher.

1 INTRODUCTION

1.1 Scope

1.1.1 Scope of The APCO Project 25 System and Standards Definition

The APCO Project 25 System and Standards Definition provides, in a general way, a definition and description of a APCO Project 25 system's architecture, interfaces and system elements. General expectations of the APCO Project 25 system and the organization of a family of APCO Project 25 standards and bulletins are included in this document. More detailed APCO Project 25 information is included in the individual APCO Project 25 standards and bulletins.

1.1.2 Scope of the family of APCO Project 25 Standards and Bulletins.

The APCO Project 25 family of standards and bulletins, together, define, describe, | and otherwise document APCO Project 25 system and equipment requirements necessary for system interoperability and compatibility. APCO Project 25 systems generally provide digital land mobile radio services for private radio communications systems and more specifically such services for local, state and national public safety organizations and agencies. These standards and bulletins provide for communications between and within various APCO Project 25 systems and system elements.

The family of standards and bulletins is applicable to land-mobile equipment licensed under National Telecommunications And Information Administration (NTIA), Federal Communications Commission (FCC), or Interagency Radio Advisory Committee (IRAC) rules and regulations. The family or specific standards and bulletins within the family, may be applicable in situations other than those noted above. Interested parties are encouraged to use the standards and bulletins as appropriate but are cautioned to carefully compare the standards and bulletins with the specific requirements of their application or equipment.

1.2 Object

The objective of this APCO Project 25 System and Standards Definition is to define and document various baseline or common parameters and concepts associated with a APCO Project 25 system. These common parameters and concepts will serve as a foundation for the coherent development of the remaining standards and bulletins within the APCO Project 25 family. Furthermore, this foundation will promote a uniform understanding of the contents of the remaining standards and bulletins. This uniform understanding will enhance the usefulness of the project 25 standards and bulletins. To those ends much of the content of this document is background material regarding system or equipment models, functional expectations, and organization of the APCO Project 25 standard family.

Specifically included are a general system model of a APCO Project 25 compliant digital radio system. The general system model defines the system elements plus intra- and inter- system interfaces and naming conventions of these elements and interfaces. Additionally, the technical requirements for the APCO Project 25 system and a description of the content and relationship

between the family of standards and bulletins are included.

1.3 Standard Definitions

Refer to Appendix B for definitions of various terms and acronyms found in the APCO Project 25 Standards and Bulletins family.

1.4 Revisions

March 1994	Published as TSB102.
June 1995	Ballot Version 6 with update changes.
September 1995	Publish Revision A with ballot comment revisions.

2 APCO Project 25 (an overview)

This overview presents the APCO Project 25 system ... both conventional and trunked. It reflects the APCO Project 25 Statement of Requirements presented in Appendix C.

In general radio systems can be separated into trunked and conventional systems. A conventional system is characterized by relatively simple geographically fixed infrastructure (or even no infrastructure) that serves to repeat radio calls from frequency to another. A trunked system is characterized by a controller in the infrastructure which assigns calls to specific channels. Thus, a trunked system can share more radio users on fewer channels to achieve an improvement in spectrum utilization.

As described, the APCO Project 25 system introduces a new radio system definition. The advent of specific definitions for critical system interfaces will permit the use of compatible hardware and software product from a number of suppliers. These definitions form a path for future continued development of advanced technology for interoperable Land Mobile Radio systems.

2.1 APCO Project 25 Open System Interfaces

The APCO Project 25 system is a standard system. By this, it is meant that the system block diagram defines several open interfaces. This is illustrated in Figure 2-1. The APCO Project 25 open interfaces are indicated by solid black labeled lines. Note that not all interfaces are open, but many interfaces ARE to be open. It is intended that equipment on either side of any open interface may be supplied by any manufacturer.

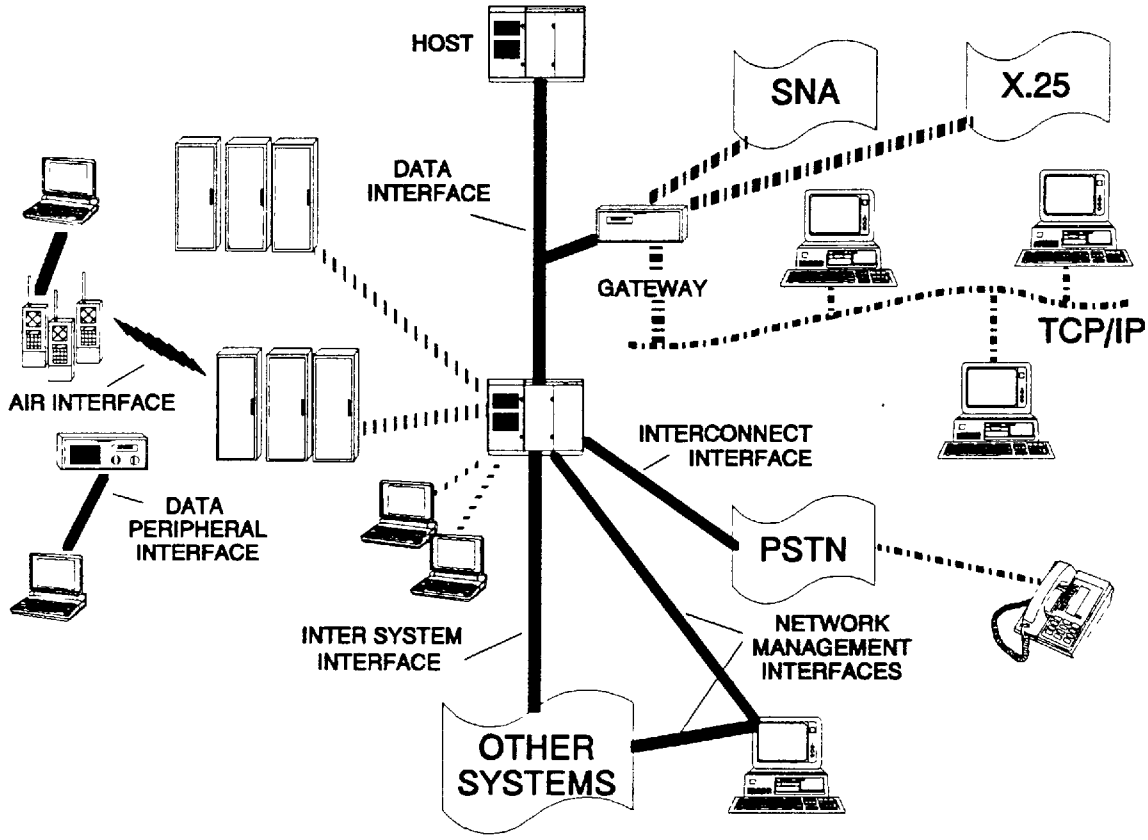

Figure 2-1 Open System Interfaces

The following section describes the concept of an "RF-Subsystem". Following this description each of these interfaces will be examined, one at a time.

2.2 RF-Subsystem

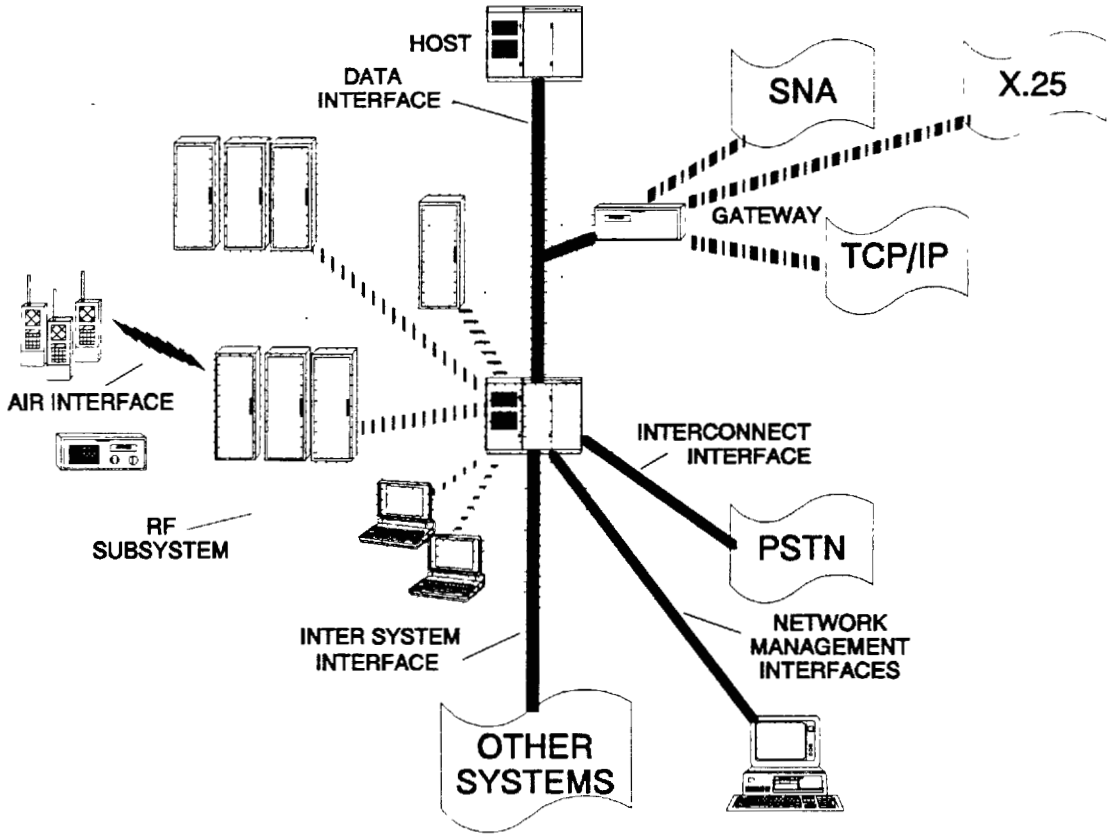

Figure 2-2 RF-Subsystem

The RF-Subsystem is an infrastructure, bounded by the five open APCO Project 25 interfaces and a standard computer network gateway interface outside the shaded area in Figure 2-2. The RF-Subsystem is any collection of site equipment, be it single station or multiple station, and single site or multiple site. Its only requirement is that its station equipment supports the Common Air Interface, and that it contain all necessary control logic to support call processing and the open intersystem interfaces. These become the building blocks for wide-area system construction. Regardless of the RF-Subsystem configuration, it will connect with any other equipment or RF-Subsystems regardless of THEIR configuration.

The computer network gateway depicted in the figure shows a device which can convert the protocols used in the lower layers of a computer communication network, from one network control protocol to another. What is shown in the figure is a gateway which can convert SNA or X.25 to IP and ethernet. These devices allow the interconnection of computer networks. They are widely available in the computer industry today, and need not be defined specifically for the APCO Project 25 system.

2.3 Common Air Interface

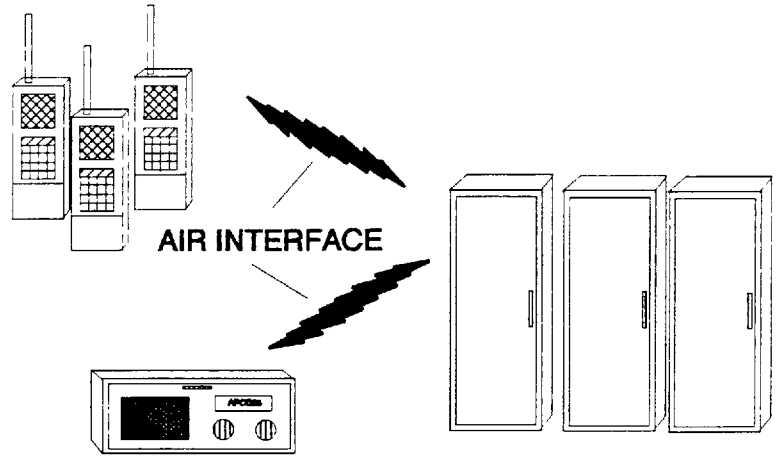

Figure 2-3 Common Air Interface

A major interface in the APCO Project 25 system standard is the Common Air Interface illustrated in Figure 2-3. Mobile and portable equipment from any manufacturer may be freely combined in any APCO Project 25 system. A base line of radio features will be guaranteed from any system to work through any manufacturer's radio.

Each RF-Subsystem manufacturer may, however, augment the basic feature set to include new features which may only be supported on that manufacturer's mobiles and portable's to provide added value. This new term, "RF-Subsystem," is defined by the APCO Project 25 open system architecture, and will become as well known as "DOS" in the new era of compatible APCO Project 25 systems.

Site equipment is of variable density with the requirement for one Common Air Interface, whether there are multiple stations or only a single station at any site. Essentially, there will be no equipment technical differences in the future APCO Project 25 systems as known today by the categories "conventional" and "trunked". The only difference between conventional and trunking WILL BE in the supported feature set and access method, and NOT in the mobile/portable subscriber units, or RF-Subsystems (stations controllers, etc.) in regards to digital APCO Project 25 compatible systems.

2.4 Data Peripheral Interface

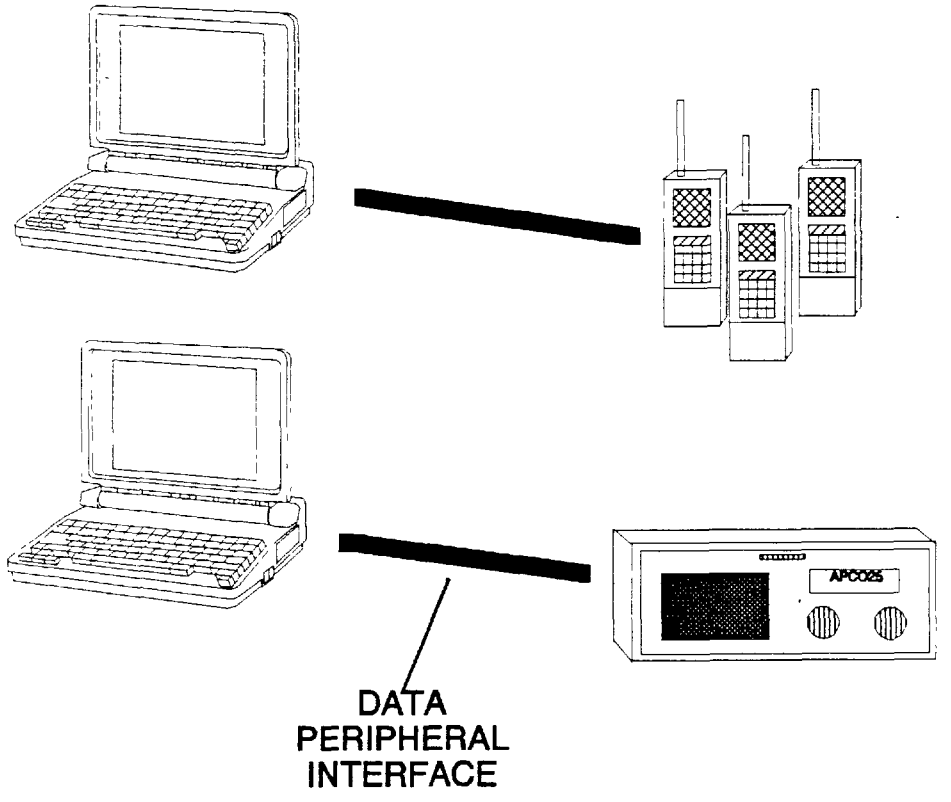

Figure 2-4 Data Peripheral Interface

Both mobiles and portable subscriber units may support a port through which laptops, terminals, or subscriber unit peripherals may be connected. It is required that protocols be supported on this open interface which are, in turn, passed transparently into X.25, SNA, or TCP/IP computer networks at another open interface on the fixed equipment side. Transparency of the "pipe" is listed as a requirement, and it is expected by Federal Government users that application layer standards emerge for the connection of various peripheral devices such as fingerprint and retinal scan imaging devices.

2.5 Intersystem Interface

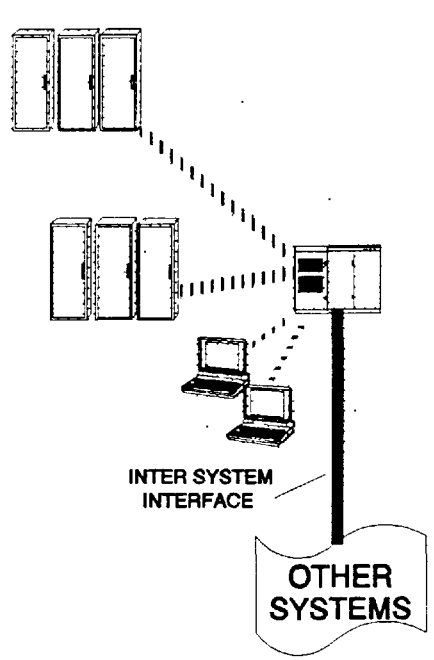

Figure 2-5 Intersystem Interface

The Inter-RF Subsystem Interface is a key open RFSS for APCO Project 25 communications systems. It is the interface which permits RFSSs to be interconnected into wide area networks. The system designer may configure a wide area system requiring a limited service coverage area or extended service coverage area.

The Inter-RF Subsystem Interface also provides an interface, using industry standard protocols, that permits interoperability between communication systems utilizing different technologies (FDMA, micro-cell, TDMA). different manufacturers and even different RF bands. Although a given APCO Project 25 mobile or portable radio may only roam freely between systems with the standard APCO Project 25 digital air interface, the APCO Project 25 ISSI has the potential to bridge a gap ever wider, such as between a customer's private radio network and a customer's Private telecommunications network which conforms to the ISSI interface.

2.6 Telephone Interconnect Interface

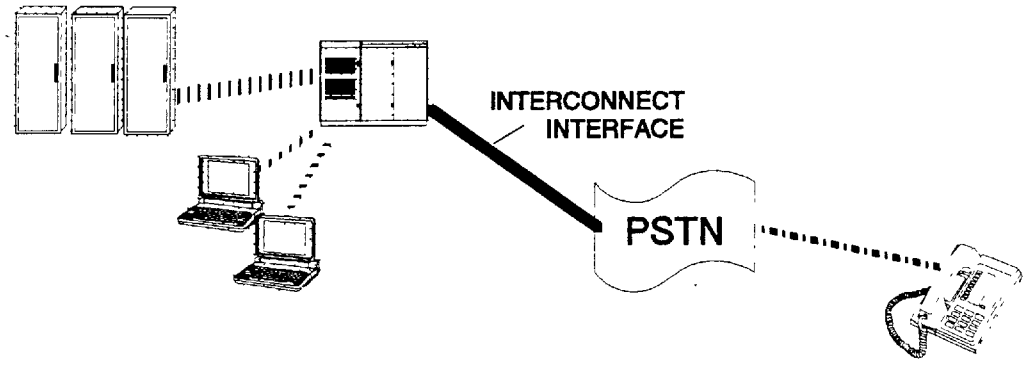

Figure 2-6 Telephone Interconnect Interface

As always, every RF-Subsystem may support an open telephone interconnect interface to a telephone network. APCO Project 25 requirements support both analog and ISDN telephone interfaces.

Here, along with the open intersystem interface, is an avenue for future enhancement of functionality within the guidelines of the open standard.

2.7 Network Management Interface

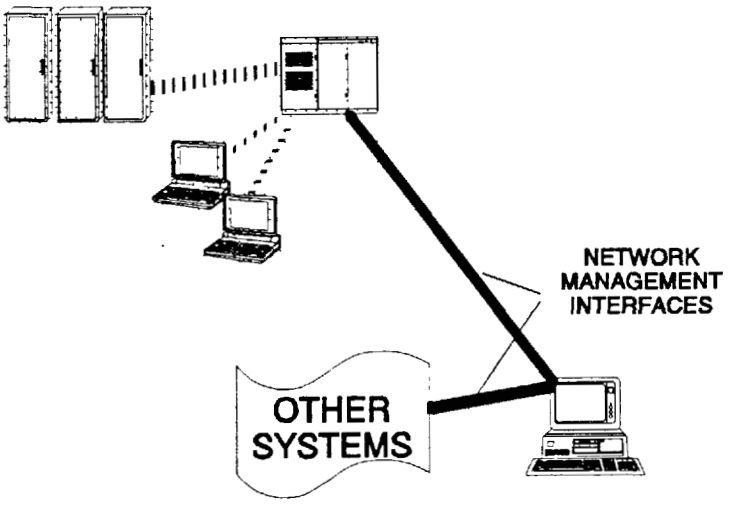

Figure 2-7 Network Management Interface

APCO Project 25 adopted a uniform network management interface to all RF-Subsystems, regardless of manufacturer. Within any manufacturer's RF-Subsystem, all five classical elements of network management must be supported according to a single selected network management scheme. It is expected that a network management scheme will be selected that will bring with it the ability to manage RF-Subsystems with available network management system equipment. In addition, a major customer's existing network management system, including computer and telecommunications equipment, may well be able to encompass APCO Project 25 radio systems, as well.

2.8 Host and Network Interfaces

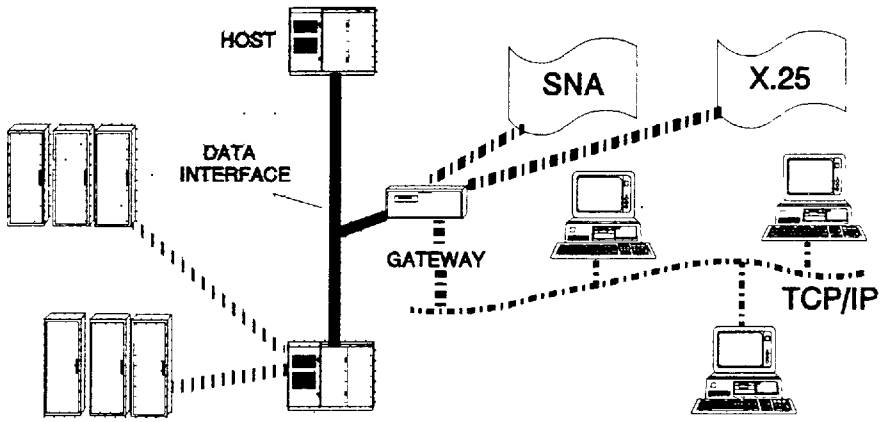

Figure 2-8 Host and Network Interfaces

Perhaps the most complex interfaces are those for host computer or network connectivity. Four different types of data connectivity is spelled out in the APCO Project 25 requirements. These include a native open interface for connecting host computers, as well as the requirement to support three different flavors of existing computer network interfacing. In practicality, this might result in only three different interfaces, if the host computer native interface is selected to be one of the other three interfaces (such as TCP/IP).

2.9 APCO Project 25 Overview Summary

Actually of more significance to the physical interface is the logical requirement of APCO Project 25 that, in the case of the three network interfaces, communications to subscriber unit linked data ports must be indistinguishable from communications on those networks to any other logically addressable device. Essentially, every subscriber unit may support a computing device which is (logically from the standpoint of an existing application) indistinguishable from preexisting fixed computing devices. While radio IS different, getting started with data may be as easy as connecting a computer in a vehicle and "logging in" to any host applications already in existence on the

network.
In addition to the first step of a Digital Radio at 12.5 kHz channel spacing the APCO Project 25 system will also be capable of migrating to a narrower channel spacing as technology allows.

As can be seen, the APCO Project 25 system is defined by a set of open interfaces. Within the current requirements, there is room to develop the definitions of these interfaces.

Of the APCO Project 25 open interfaces, only one of the six has to do with the specifics of the Common Air Interface. The establishment of six open interfaces will facilitate the migration to new RF transmission technology where it may be achieved without modification to the other five open interfaces.

3 APCO Project 25 GENERAL SYSTEM MODEL

3.1 Introduction

The objective of this section is to define the general system model of an APCO Project 25 compliant digital radio system. The purpose of the system model is to define system naming conventions of the open system interfaces. These open system interfaces will be the subject of additional standards documents.

From an architectural specification perspective, a system is completely described by the attributes that can be observed at various interfaces, including physical, electromagnetic, protocol, service, capability, maintenance, operation and performance characteristics. The key to defining, and even recognizing, a system is the specification of these interfaces.

3.2 General Model Definitions

All APCO Project 25 systems are physical implementations of interconnected elements. In this architectural specification, all systems elements will be represented according to their architectural attributes. These architectural attributes define a new language to describe a system. This language is independent of the specific system, and is independent of Land Mobile Radio systems as well. It is a descriptive language for system architecture used today by telecommunications (as found in the CCITT specification for ISDN) and computer industries (as found in the CCITT specifications for OSI). Within this architectural language, physical elements are mapped into functional groups, and interfaces into reference points. The following are based upon CCITT definitions, modified appropriately for this specification of APCO Project 25 systems.

3.2.1 Reference configurations

Reference configurations are conceptual configurations useful in identifying various possible physical user access arrangements to an APCO Project 25 system. Two concepts are used in defining reference configurations: reference points and functional groupings. Layout and application examples of reference configurations are given in the following sections.

3.2.2 Functional groups

Functional groups are sets of functions which may be needed for an APCO Project 25 system, i.e., mobile/portable subscriber unit, base station, site controller, multi-site controller, etc. In any particular APCO Project 25 system, specific functions in a functional group may or may not be present, as the system specification includes conventional, trunked, multi-station sites, Note that specific functions in a functional group may be performed in one or more pieces of equipment.

3.2.3 Functions

Functions, loosely defined, are the actions which define a functional group, i.e., mobile/portable subscriber unit receiver, transmitter, data port interface, radio controller, etc. In any given product implementation, however, the mapping of physical elements to functional groups is not necessarily one-to-one. A more strict definition of a function which defines a functional group is an action which sources or sinks data from or to another function.

3.2.4 Reference points

Reference points are the conceptual points dividing functional groups. A reference point will correspond to a physical interface between pieces of equipment where an open interface standard exists. However, not all physical interfaces correspond to a reference point (e.g., a cable between two pieces of equipment that divide the functions of a single functional group) will not be included within the scope of this specification. Also, not all physical interfaces between functional groups are to be open interface standards, or reference points.

3.3 Reference Configurations - Detailed Model

3.3.1 Typical repeater configuration

Figure 3-1 depicts a reference configuration for a typical arrangement of functional groups in an example repeater configuration. The interfaces between the functional groups shown in bold are the reference points. The interfaces between functional groups not designated as reference points are not necessarily interconnected as shown in this diagram, which would serve only as an example. Other than the reference points, this interconnection of functional groups within a mobile or portable subscriber unit, or within an RF-Subsystem, would be up to each manufacturer.

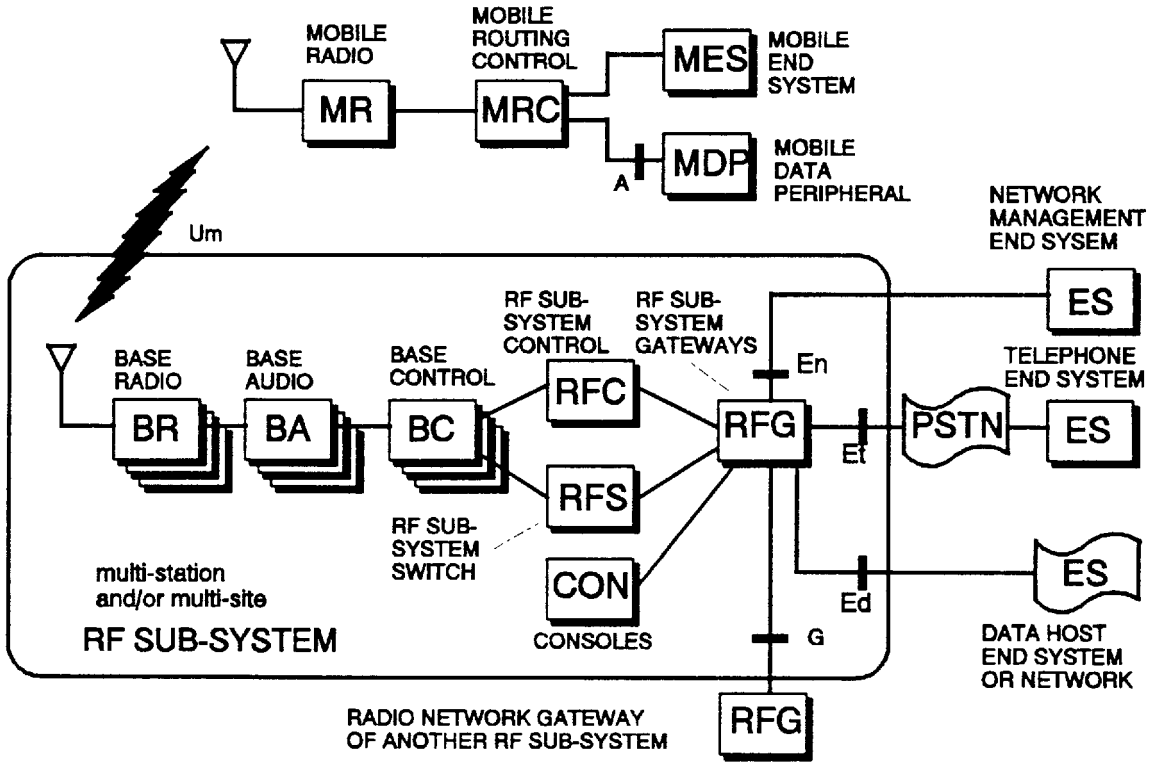

Figure 3-1 Typical Repeater (example) Reference Configuration

3.3.2 Non repeater configuration

Figure 3-2, depicts a reference configuration for a non-repeater configuration, or talk-around. Note that this is a distinct configuration of a subset of the same functional groups and reference points as the first, more generic configuration.

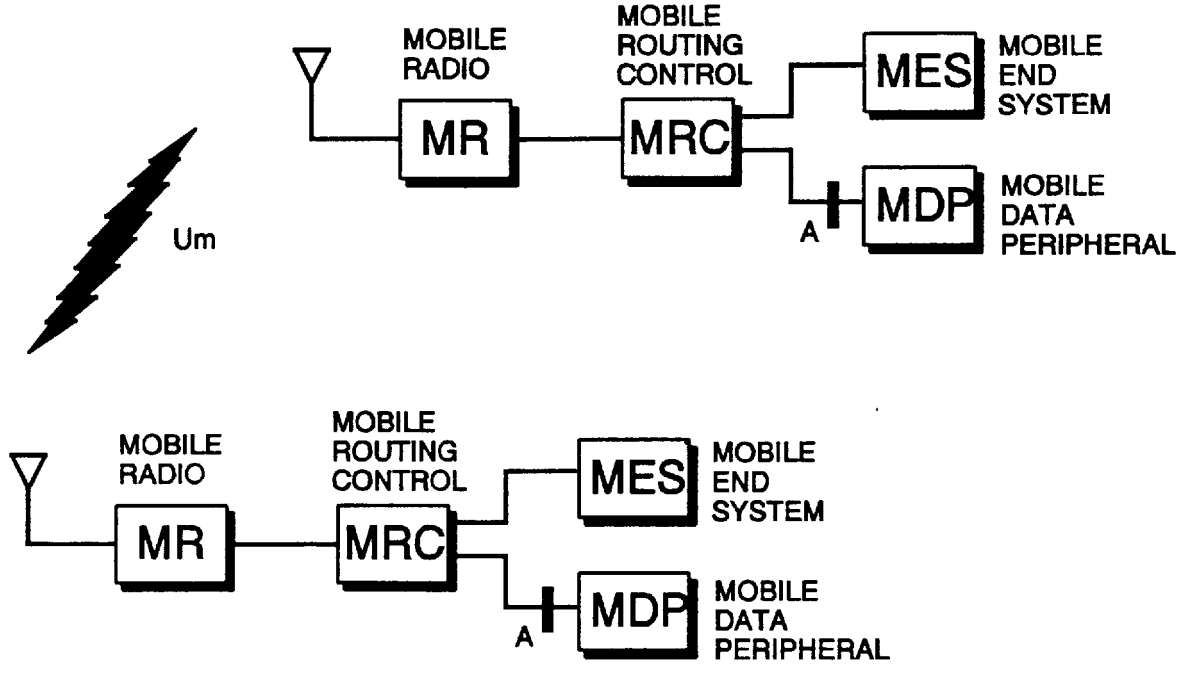

Figure 3-2 Typical Non-Repeater Reference Configuration

3.4 Specification Formats

A uniform specification format will be created for each reference point. Each specification shall be formatted following CCITT models for layered communications protocols, consisting of the following individual sections.

1. Physical Layer
2. Data Link Layer
3. Network Layer
4. Transport Layer
5. Session Layer
6. Presentation Layer
7. Application Layer

Some layers may NOT be present in individual reference point specifications, for example, the Common Air Interface may not include specifications for layers 4 or higher for data services, as communications between those layers might be completely specified by the data end-system gateway specification and the subscriber unit data peripheral interfaces.

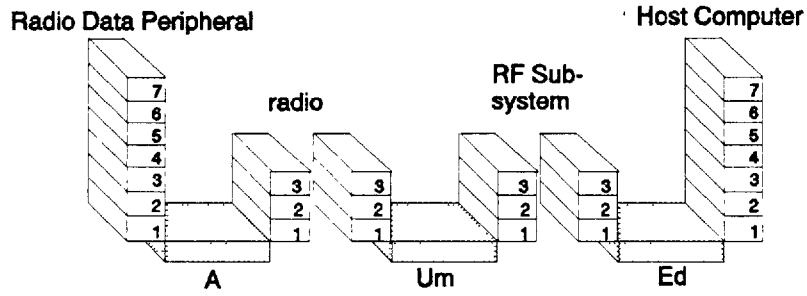

Figure 3-3 Example Layered Communications

4 APCO Project 25 STANDARDS ORGANIZATION

This section explains the structure of the APCO Project 25 Standards and Bulletins and provides an overview of the contents of the various standards and bulletins. The standards and bulletins are arranged into 3 separate categories of documents corresponding to different aspects of a APCO Project 25 system. This section will provide a tool to illustrate the relationship between as well as the subject matter of the various standards and bulletins.

The APCO Project 25 Standards and Bulletins will include this overview and definitional document and three categories of documents dealing, respectively, with services, systems, and equipment level standards and bulletins. All aspects of a particular standards and bulletins topic or subject will be in a particular category. This may include, for example, documentation dealing with Definitional, Method of Measurement, Performance Requirement, or Certification and Compliance aspects of a particular subject. The committee recognizes that some subjects may not readily fit in one category and therefore may arbitrarily assign such a subject to a particular category.

4.1 Document Designation And Reference Tables

All APCO Project 25 documents will carry a designation of the form ***102 _ _ _ _ where "****" may include TSB (Telecommunications Systems Bulletin), IS- (Interim Standard) or TIA (Telecommunication Industry Association Standard) as appropriate for the particular document. These designations are defined in the TIA Engineering Manual. This part of the document designation may change with maturity and as other requisites of the standards and bulletins process are satisfied.

The numerals 102 indicate the APCO Project 25 group of documents.

The spaces following 102 are occupied by alpha characters assigned using the following convention. This overview and definitional document, APCO Project 25 System and Standards Definition, will be designated ***102. The categories, of services, systems, and equipment, mentioned above, are designated by the left most alpha character.

Specifically:

This Standards and Systems Definition:	***102
The services category:	***102.A_ _ _
The systems category:	***102.B_ _ _
The equipment category:	***102.C_ _ _

The next two alpha characters will be used to designate a particular subject or topic within a category and the last alpha character will be used to designate a particular standards document dealing with that subject. Graphically the structure of the APCO Project 25 Standards and Bulletins is illustrated in Figure 4-1.

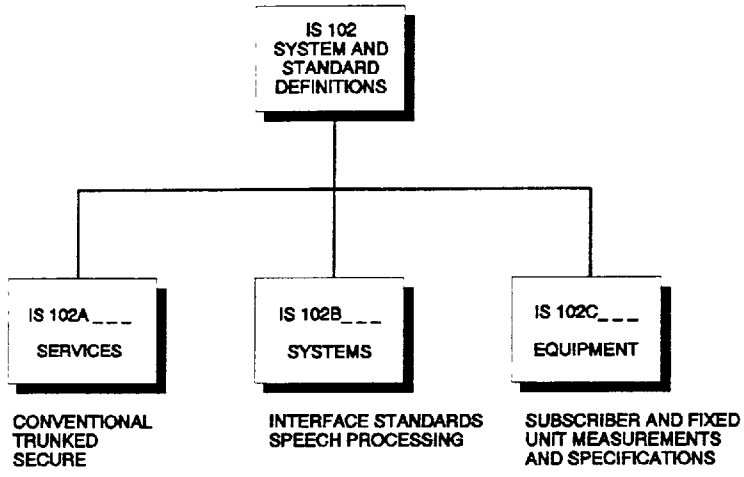

Figure 4-1 Grouping of Documents

Each block with a category designation and title represents a series of related documents. The subjects listed underneath each block are representative samples of the standards and bulletins needed within that category. Tables of all the documents either completed or proposed for each category along with other pertinent information about the documents are provided below. The TIA designation may be a committee working document number.

Table 4-1 Standards Concerning Project 25 Structure & Definitions

Description of Standard	TIA Designation	Description of Content
Project 25 System & Standard Definitions	TSB102	Definitional

Table 4-2 Standards Concerning Project 25 Services (*** 102A_ _ _)

Description of Standard	TIA Designation	Description of Content
DES Encryption Protocol	IS-102.AAAA	Definitional
Security Services Overview	***102.AAAB	Definitional
DES Encryption Conformance	IS-102.AAAC	Conformance
Trunking Overview	TSB102.AABA	General
Trunking Control Channel Formats	TSB102.AABB	Definitional
Trunking Control Channel Messages	TSB102.AABC	Definitional
Conventional Control Messages	***102.AABG	Definitional
Trunking Procedures	***102.AABD	Definitional
Trunking Conformance	***102.AABE	Conformance
Link Control Word Formats & Messages	***102.AABF	Definitional
OTAR Protocol	***102.AACA	Definitional
OTAR Operational Description	***102.AACB	Definitional
Lock Down Test Procedures	APCO25.940811.1.5	

Table 4-3 Standards Concerning Project 25 Systems (*** 102B_ _ _)

Description of Standard	TIA Designation	Description of Content
Common Air Interface (CAI)	TSB102.BAAA	Definitional
CAI Conformance Testing	TSB102.BAAB	Conformance
CAI Reserved Values	TSB102.BAAC	Definitional
CAI Operational Description	TSB102.BAAD	Descriptive
Vocoder Description	IS-102.BABA	Definitional
Vocoder Mean Opinion Score (MOS Testing)	IS-102.BABB	Conformance
Vocoder Reference Test	IS-102.BABC	Conformance
Vocoder Selection Process	TSB102.BABD	Historical
Inter RF-Subsystem Interface Message Definitions	***102.BACA	Definitional
Inter RF-Subsystem Interface Conformance	***102.BACB	Definitional
Inter RF-Subsystem Interface Overview	***102.BACC	Conformance
Tel. Interconnect Requirements & Def.	***102.BADA	Definitional
Data Overview	TSB102.BAEA	Descriptive
Packet Data Specification	TSB102.BAEB	Specification
Circuit Data Specification	TSB102.BAEC	Specification
Radio Control Protocol Specification	***102.BAEE	Specification
Network Management Interface Definition	TSB102.BAFA	Definitional
Network Management Interface Conformance	***102.BAFB	Conformance

Table 4-4 Standards Concerning Project 25 Equipment (*** 102C_ _ _)

Description of Standard	TIA Designation	Description of Content
Transceiver Measurement Methods	TSB102.CAAA	Measurement
Transceiver Performance Recommendations	TSB102.CAAB	Specifications

4.2 Document Descriptions

This section summarizes the content of the categories and each specific document.

4.2.1 Description of the APCO Project 25 System Structure

This document, APCO Project 25 System and Standards Definition (SSD) TSB102, provides the structure needed to relate the various documents used in the description and definition of the APCO Project 25 systems. The format is intended present not only an overview of the APCO Project 25 concept but also to permit users of this document to locate information essential to their specific requirements.

4.2.2 Description of the APCO Project 25 Service category

4.2.2.1 IS-102.AAAA DES Encryption Protocol

This document defines the mode of operation of DES encryption and decryption in a manner compatible with information transfer through a APCO Project 25 system, especially the Common Air Interface described in section 4.2.3.1. The document describes both voice and data encryption procedures.

4.2.2.2 ***102.AAA_ Security Services Overview

This document (when completed) will provide an overview of the encryption services available in a APCO Project 25 System. It provides the context to understand why services are required and gives a general high level description of how they are provided.

4.2.2.3 IS-102.AAAC DES Encryption Conformance

This document (when completed) will provide a series of conformance tests for the DES Encryption Protocol described in section 4.2.2, 4.2.2.2. These tests are intended to assure that equipment actually conforms to the formats specified in the DES Encryption Protocol.

4.2.2.4 TSB102.AABA Trunking Overview

This document provides a high level overview of APCO Project 25 Trunked Systems. It summarizes commonality with conventional systems, mixture of services, registration, voice services, secondary control, voice or data on control and protected trunking.

4.2.2.5 ***102.AABB Trunking Control Channel Formats

This document defines the format of trunking control channel transmissions for APCO Project 25 systems. The formats are compatible with the Common Air Interface defined by TSB102..BAAA and both encrypted and non-encrypted formats are defined.

4.2.2.6 ***102.AABC Trunking Control Channel Messages

This document defines all messages for APCO Project 25 Trunking. All messages are constructed from formats further identified by TSB102.AABB Trunking Control Channel Formats.

4.2.2.7 ***102.AABD Trunking Procedures

This document describes all procedures for accessing the control channel of APCO Project 25 Trunking systems. Further, all procedures for accessing working channels is also defined. All procedures reference messages defined by TSB102.AABC Trunking Control Channel Messages.

4.2.2.8 ***102.AABE Trunking Conformance

This document will define conformance tests for APCO Project 25 Trunking systems. Draft of this document is not yet available.

4.2.2.9 ***102.AABF Link Control Word Formats and Messages

This document defines all link control words for voice transmissions on APCO Project 25 systems. This will include both trunking and conventional.

4.2.2.10 ***102.AABG Conventional Control Messages

This document defines the control messages of trunking for APCO Project 25 that may be applied to conventional systems. These control messages are extensions to the basic Common Air Interface; see section 4.2.3.1.

4.2.2.11 TSB102.AACA OTAR Protocol

This document defines the messages and basic procedures for providing OTAR (Over-The-Air-Rekeying) and related key management services. It describes methods of encrypting and sending the encryption keys and other related key management messages through the Common Air Interfacing such a way that they are protected from disclosure, and in some cases unauthorized modification.

4.2.2.12 ***102.AACB OTAR Operational Description

This document is a supplement to the Key Management and OTAR Protocol. It will describe (when completed) the operational procedures, as sequences of messages and basic procedures defined in Section 4.2.2.9, to perform Key Management and OTAR functions.

4.2.2.13 APCO25.940811.1.5 Lock Down Test Procedures

This document (when completed) will provide a series of lock down tests to verify interoperability. Section 4.2.2.9.

4.2.3 Description of the APCO Project 25 System category

4.2.3.1 TSB102.BAAA Common Air Interface (CAI)

This document defines the Common Air Interface for all reference configurations described in the general system model. In a first reference configuration, this is between mobile and portable subscriber units and the base stations of any RF-Subsystems. According to the APCO Project 25 General System Model, this is the Um interface 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 where the subscriber unit might roam. In a second reference configuration, this is directly between mobile and portable subscriber units in a talk-around configuration.

4.2.3.2 TSB102.BAAB CAI Conformance Testing

This document lists a series of conformance tests for the Common Air Interface. These tests are intended to assure that equipment actually conforms to the formats specified in the Common Air Interface. Conformance will assure that equipment is interoperable with other equipment conforming to the standard. These test are different and distinct from performance tests given in the Transceiver performance measurements and specifications described in section 4.2.4 which measure the actual limits of equipment performance. The performance and conformance test are mutually complementary.

4.2.3.3 TSB102.BAAC CAI Reserved Values

This document is a supplement to the Common Air Interface (CAI) that lists all of the reserved values for the fields of information. This is intended to be interpreted with the CAI and is not intended to be understood by itself.

4.2.3.4 TSB102.BAAD CAI Operational Description

This document is a supplement to the Common Air Interface (CAI) and describes simple operational procedures. These procedures are sufficient for basic operation in conventional systems. They are not intended to describe operation in a trunked system although some of these procedures may apply. This document is intended to be interpreted with the CAI and is not intended to be understood by itself.

4.2.3.5 IS-102.BABA APCO Project 25 Vocoder Description

This document describes the functional requirements for the transmission and reception of voice information using the digital communication media described in the Common Air Interface,

TSB102.BAAA. This standard is specifically intended to define the conversion of voice from an analog representation to a digital representation that consists of a net BIT rate of 4.4 kBPS for voice information, and a gross BIT rate of 7.2 kBPS after error control coding.

4.2.3.6 ***102.BABB Vocoder Mean Opinion Score (MOS) Conformance Test

This document is a conformance test document which employs Mean Opinion Score (MOS) testing to evaluate an implementation of a APCO Project 25 Vocoder. This document is intended to provide a method for testing inter-operability of an implementation of a APCO Project 25 Vocoder to the APCO Project 25 Reference Vocoder.

4.2.3.7 ***102.BABC APCO Project 25 Vocoder Reference Test

This document provides a method of testing an implementation of a APCO Project 25 Vocoder with respect to the APCO Project 25 Reference Vocoder. The test method requires proprietary test equipment.

4.2.3.8 TSB102.BABD Vocoder Selection Process

This document provides a historical reference to the selection of the APCO Project 25 Vocoder. The method of testing candidate vocoders, evaluation metrics, and test results for the four candidate vocoders in included.

4.2.3.9 ***102.BACA Inter RF-Subsystem Interface Message Definition

This document defines the messages to be used on the interface between RF-Subsystems of any manufacturer. According to the APCO Project 25 General System Model, this is the G interface, see Figure 3-1, between an RF-Subsystem Gateway functional group within one RF-Subsystem, and a corresponding RF-Subsystem Gateway functional group within other RF-Subsystems.

4.2.3.10 ***102.BACB Inter RF-Subsystem Interface Conformance

This document lists a series of conformance tests for the RF-Subsystem Interface. These tests are intended to assure that equipment actually conforms to the formats specified in the RF-Subsystem Interface. Conformance will assure that equipment is interoperable with other equipment conforming to the standard.

4.2.3.11 ***102.BACC Inter RF-Subsystem Interface Overview

This document provides a high level overview of the project 25 ISSI. It summarizes the protocol and message structure, mobility management, and intervening network adaptation.

4.2.3.12 ***102.BADA PSTN Interconnect Interface Definition

This document defines the interface between an RF-Subsystem and a public or private switched telephone network (PSTN). According to the APCO Project 25 General System Model, this is the Et

interface, see Figure 3-1, between an RF-Subsystem Gateway functional group within one RF-Subsystem, and a telephone end-system, connected through a public or private switched telephone network.

4.2.3.13 TSB102.BAEA Data Overview

This document provides an overview of the data services available on a APCO Project 25 System. This document serves the need to permit an APCO Project 25 radio and radio system to support circuit and packet data. Additionally, this document serves the requirement to transport multiple packet protocols, including TCP/IP, X.25 & SNA. The APCO 25 system defines 2 different categories of data services in 3 different categories of data configurations for a total of 6 distinct service/configuration combinations. An APCO Project 25 compliant data system supports one or more of the service/configuration combinations.

4.2.3.14 TSB102.BAEB Packet Data Specification

This specification serves to define the detailed interfaces, protocols, and procedures involved in interfacing with a data capable APCO Project 25 standard radio unit via the standard mobile data peripheral interface (A), and end-system interface (Ed). Defined are packet services, in all 3 configurations: radio-radio, radio-repeater, and radio-FNE (Fixed Network Equipment), supported by point-to-point radio data peripheral interfaces (A). The data services mapping to APCO 25 CAI formats are defined, which may be provided across conventional or trunked service channels.

This 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 (RFC791) bearer service which 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.

4.2.3.15 TSB102.BAEC Circuit Data Specification

This document serves to define the detailed interfaces, protocols, and procedures involved interfacing with a data capable APCO Project 25 standard radio unit via the standard mobile data peripheral interface (A), and (optionally) an APCO Project 25 standard FNE (Fixed Network Equipment), data end-system interface (Ed). Defined are circuit services, in all 3 configurations: radio-radio, radio-repeater, and radio-FNE, supported by point-to-point radio data peripheral interfaces (A).

This 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. Non-transparent two-way communications are supported between bearer service access points in wireless networks and the PSTN.

4.2.3.16 ***102.BAEE Radio Control Protocol Specification

This document defines the Radio Control Protocol (RAP) for use in APCO Project 25 digital radio systems for packet data communications services. The current Packet data service specification is defined in the APCO Project Packet Data Specification (TSB-102.BAEB, August 29, 1994). Familiarity with this document is assumed.

RAP, along with the Internet Control Message Protocol (ICMP), defines the control signalling protocol across the "A" interface. Control signaling refers to transactions which are not directly concerned with the transfer of user information between the mobile host and the destination host.

4.2.3.17 ***102.BAFA Network Management Interface Definition

This document defines the interface between one or more RF-Subsystems and an attached network management Manager or other interconnect network management system. According to the APCO Project 25 General System Model, this is the En interface, see Figure 3-1, between an RF-Subsystem Gateway functional group within one RF-Subsystem, and a network management end-system.

4.2.3.18 ***102.BAFB Network Management Interface Conformance

This document lists a series of conformance tests for the Network Management Interface. These tests are intended to assure that equipment actually conforms to the formats specified in the Network Management Interface. Conformance will assure that equipment is interoperable with other equipment conforming to the standard.

4.2.4 Description of the APCO Project 25 Equipment category

4.2.4.1 TSB102.CAAA Digital C4FM/CQPSK Transceiver Measurement Methods

This document standardizes parameter titles, definitions, the test conditions, and the methods of measurement used to ascertain the performance of APCO Project 25 transceiver equipment within the scope of this standard, and makes possible a meaningful comparison of the results of measurements made by different observers and on different equipment.

4.2.4.2 TSB102.CAAB Digital C4FM/CQPSK Transceiver Performance Recommendations

This document establishes minimum performance specifications for APCO Project 25 transceiver equipment when measured according to TSB102.CAAA.

5 APCO Project 25 TECHNICAL REQUIREMENTS

5.1 Scope of This Section

This section is a Technical Requirements Specification (TRS) for the APCO Project 25 system. It is based on the APCO Project 25 Statement of Requirements, but is presented as a series of technical requirements, from a system point of view, rather than as a user requirement. It provides the starting point for the system design, and it is the main criteria against which alternative system designs can be judged. It will introduce some logical grouping of functions but it should remain implementation independent.

The TRS defines precise performance requirements: where appropriate this includes quantitative values (e.g. a formula to define 'Grade of Service').

5.2 Introduction

5.2.1 Objectives of this Section

This section is intended to give a technical 'translation' of all of the required services and facilities identified in the user requirements detailed in the APCO Project 25 Statement of Requirements included in this document as appendix C. As part of the translation, the following details will be added:

Required level of standardization;
Inter-operability requirements;
Identification of major functional groupings.

5.2.2 Abbreviations

A full list of abbreviations can be found in appendix B, APCO Project 25 Glossary.

5.3 Services and Facilities: Key Considerations

The APCO Project 25 system is designed to provide mobile and portable services to professional users for communication with their own organizations and associate entities. A typical application of services could be dispatcher control of Public Safety Officers with fast call set-up times.

The objective of this section is to define the services and facilities required for the APCO Project 25 system. The intention of the standard is to ensure that any manufacturer's compliant subscriber radios have access to the services described in this document, regardless of system infrastructure origins. The further intention of the standard is to ensure that services, so defined and at the system operator's discretion, are accessible by subscribers from other systems and across system boundaries. This will facilitate subscriber operation on different systems should that be required. A further intention of the standard is to provide open interfaces to the RF subsystem, so that systems supplied by different vendors can be interlinked, and that peripheral systems such as data applications and network management need not be vendor specific. These open interfaces are defined in section 5.6.

The APCO Project 25 Standard shall cover digital speech and/or data services including optional connections to fixed telephony and data networks. The APCO Project 25 Standard shall be equally adaptive to all public safety mobile radio frequency bands and blocks of spectrum. The APCO Project 25 Standard will allow for a wide range of systems including single-base site systems as well as multi-site wide-area coverage systems (both multi-frequency and simulcast). The APCO Project 25 Standard will not disallow services and user features not specifically defined in the standard but will protect against unintentional interaction between radios implementing non-standard, value-added, manufacturer specific features. The APCO Project 25 Standard will not address specific applications but rather shall provide teleservices on which the applications can be developed.

5.3.1 Level of Standardization

The level of standardization indicates the services and interfaces which will be specified for standardization.

This does not imply that all services will be implemented in any specific APCO Project 25 system. Implementation remains a system operator decision. However, if such a service is implemented, it shall comply with the standard. This is a "Standard Option".

5.3.2 Level of Interoperability

Interoperability is defined as the facility to offer a visiting subscriber a set of services appropriate to the services provided by the visited network.

The provision for interoperability is a system operator option. If the option is chosen then the interoperability shall be in accordance with the APCO Project 25 Standard. This does not preclude agreements between system operators to provide higher levels of interoperability.

The levels of interoperability shall be:

5.3.2.1 Mutual Aid

This is the minimum mandatory requirement. Subscriber units shall include the ability to select and operate on available analog mutual-aid channels for communications with the fixed network equipment as well as direct unit-to-unit.

5.3.2.2 Predefined Roaming

The ability, pre-programmed into the radio, to enable roaming for joint operations or emergencies.

5.3.2.3 Full Roaming

This applies to region-wide systems, where the component parts of the system are linked, and the system providers cooperate in providing a wide-area service which may support full roaming service.

5.3.3 Systems Interworking

Subject to mutual system operator agreement, this facility provides a user with the ability to extend its coverage area, whether the systems are overlapping, adjacent or completely separated.

In the case of interworking, systems are linked (for common services) so that they are considered one system by the mobile, even in the case of discontinuous coverage.

The provision for an inter-system interface is mandatory when system interworking is required. The interface shall comply with the Inter System Interface Reference [see section [TBD] for applicable standards and bulletins].

5.3.4 Backwards Compatibility

Phase one equipment, irrespective of the manufacturer, must have at least the capability to operate both as analog (20K0E3E, 16K0F3E), employing standard signalling (TIA603), and the standardized digital mode defined in the TSB/IS 102 series.

As an option, a manufacturer's system shall provide for backward compatibility with its own existing analog system(s). This shall include at least mobile and portable radios.

The system shall support existing 12.5 kHz channelization where already established. Where permitted within 25 kHz channelling, the system shall support operation on 2 for 1, 12.5 kHz channelization.

As an option, a manufacturer's system shall provide for full backwards compatibility/interoperability

with existing DLEA systems employing 12.0 kbps CVSD single bit CFB-DES and DES-XL (extended range) with OTAR-Multikey.

This backward compatibility and interoperability requirement includes, but is not limited to:

- interoperable/emulation capability for preamble based signalling as employed in 12.0 kbps CFB-DES/Multikey OTAR usage and for DES-XL cryptographic synchronization.

The option may include mobile and/or portable radio units, and/or fixed infrastructure/base stations.

A full description of the interface, together with the services to be supported, will be provided in document No. [TBD].

5.4 Services Supported

Services supported by a APCO Project 25 system can be grouped into several broad classes based on the type and the endpoints of the information flows. The availability of services will depend on the type of APCO Project 25 system and the desires of the system provider.

The predominant services are telecommunications services. Telecommunications services are composed of those service capabilities of a network which provide for the transfer of user information through the network. An example of such telecommunications services for APCO Project 25 is voice calling.

Services to the subscriber are those services which access and manage subscriber information resident either in the network or in the subscriber terminal. An example of such subscriber services for APCO Project 25 is over-the-air rekeying.

Services to the system operator are those services which access and manage information related to the operation of the network. An example of such operator services for APCO Project 25 are the capabilities inherent in network management. These services are found in Section 5.5.5.4.

5.4.1 Description Method

The purpose of the descriptions contained in this TRS is to provide user-oriented descriptions, in technical language, of the various services. The descriptions are high level, describing the end-to-end characteristics of the service as perceived by the user. Technical details are limited to those which illustrate the intended functionality. They are not intended to provide implementation details.

Services are described in relation to the system model, as shown in Figure 5-1 and Figure 5-2. Part of each service description is the specification of reference points where such services may be accessed. Reference points are defined in section 5.6.4.

5.4.2 Telecommunications Services

Telecommunications services are subdivided into three categories based on the network capability required to provide them.

Bearer Services are those telecommunications services which provide user information transport between network access points. These services are typified by lower-layer functionality, typically limited to OSI layers 1 through 3. The user may choose any set of high-layer protocols (layers 4-7) but the bearer service will not ascertain compatibility between users at these layers.

Teleservices are those telecommunications services which provide complete facilities for transfer of user information, including terminal functions. These services are typified by both lower-layer (OSI layers 1 through 3) and higher-layer (OSI layer 4-7) functionality. Teleservices may be built on a named bearer service of the network or may require unique bearer capability which is not separately definable.

Supplementary services are those telecommunications services which modify or enhance the capabilities of a bearer service or a teleservice. Supplementary services cannot be offered alone. They must be associated with some other bearer or teleservice. The same supplementary service may be associated with several bearer or teleservices.

5.4.2.1 Bearer Services

The following bearer services are defined for APCO Project 25:

5.4.2.1.1 Circuit Switched Unreliable Data

A two-way data service between radio network access points providing a constant 9.6 kbps rate of information transfer with a (possibly) variable bit error rate. No forward error correction or retransmission techniques are used. Service is accessible at reference points A and Ed.

5.4.2.1.2 Circuit Switched Reliable Data

A two-way data service between radio network access points providing a bit error rate not to exceed 10^{-6} but with a (possibly) variable rate of information transfer. Forward error correction and/or retransmission techniques may be used.

Service is connection oriented. Network resources are allocated on a call by call basis, (no sharing once a call/connection has been established). Service is accessible at reference points A and Ed.

5.4.2.1.3 Packet Switched Confirmed Delivery Data

A two-way data service between radio-network access points providing a variable rate of information transfer at BER not to exceed 10^{-6}. Multi-access channel sharing techniques are used to provide a service which maximizes the utilization of network resources for information transfers which are of a short burst nature. Error correction/protection services are provided by the radio network. Confirmation of delivery is provided.

Service may be connection oriented or connectionless. Network resources are allocated on a shared basis among multiple calls or connections. Service is accessible at reference points A and Ed.

5.4.2.1.4 Packet Switched Unconfirmed Delivery Data

A two-way data service between radio network access points offering delivery of unconfirmed packets. Error correction and detection services can be provided by the network. Confirmed delivery is not provided, hence the service is inherently unreliable.

Service is connectionless. Network resources are allocated on a shared basis among multiple calls or connections. Service is accessible at reference points A and Ed.

5.4.2.2 Teleservices

The following teleservices will be supported by APCO Project 25:

5.4.2.2.1 Broadcast Voice Call

This service provides one-way voice calls from an originating user to one or more other users. The target user group may be a subset of all of the system users or it may be all of the system users. The service is accessible at points C and B.

5.4.2.2.2 Unaddressed Voice Call

This Service provides two way voice calls from any user to an indefinite collection of one or more users. All parties within the coverage of the Unaddressed Voice Call can hear each other. The collection of users may be a subset of all the system users or it may be all of the system users, since the scope of the call is set by coverage, not addressing. The service is accessible at the points C and B.

All parties in the group can hear each other. The group may be a subset of all of the system users or it may be all of the system users

5.4.2.2.3 Group Voice Call

This service provides two-way voice calls between one user and a predetermined group of users, of which the originating user is a member. All parties in the group can hear each other. The service is accessible at points C and B.

The members of the group have one common, predefined number by which they are addressed. A terminal may be statically programmed for one or more groups or dynamically assigned by a dispatcher or system operator.

5.4.2.2.4 Individual Voice Call

This service provides two-way voice calls between one user and another individual user. The service is accessible at points C and B. Individual calls may be initiated by any user of the system. Calls may be placed to any other registered system user.

5.4.2.2.5 Circuit Switched Data Network Access

A two-way data service between user endpoints which provides wireless access to communications and value-added services supported by land-based circuit switched networks. The service is accessible at reference points A and Ed. Protocols at the reference points may be identical, in which case the mobile access point would appear to the user as functionally identical to the switched network access point.

Alternatively, different low-layer protocols may be used at the two access points. This service would typically utilize a bearer service for transit through the radio system and would include additional gateway or interworking functions at both the subscriber and fixed terminations.

5.4.2.2.6 Packet Switched Data Network Access

A two-way data service between user endpoints which provides wireless access to communications and value-added services supported by land-based packet switched networks. Service is provided between reference points A and Ed. Protocols at the reference points may be identical, in which case the mobile access point would appear to the user as functionally identical to the switched network access point.

Alternatively, different low-layer protocols may be used at the two access points. This service would typically utilize a bearer service for transit through the radio system, and would include additional gateway or interworking functions at both the subscriber and fixed terminations.

5.4.2.2.7 Pre-programmed Data Messaging

A two-way data service providing delivery of fixed-meaning predetermined messages. Message meanings are agreed in advance and may be compressed to extremely small physical messages for actual transmission. The service is accessible at reference points B and C.

This service would utilize a bearer service for transit through the radio system and would include additional terminal functions at both the subscriber and fixed terminations. This service is used to provide status signalling in dispatch applications.

5.4.2.3 Supplementary services

The following supplementary services will be supported by APCO Project 25:

5.4.2.3.1 Encryption

This service is supplementary to all bearer service and all teleservices. It provides for encryption of user information within the radio system. Encryption is not provided for information before it enters or after it leaves the radio system. The service is accessible at reference points A, B, C, Et, Ed and G.

End-to-end encryption is only provided when both terminal devices are APCO Project 25 devices, which may be subscriber units or consoles. Encryption is provided end to end for calls across RF subsystem boundaries, but not for calls between terminals attached to a fixed network and interconnected to the radio network.

5.4.2.3.2 Priority Call

This service is supplementary to broadcast, group and individual calls. A call that has priority will be given preferential access to resources. If the required resources are unavailable (i.e. occupied by

another user), a call with priority will be placed in queue ahead of all calls with lower priority. A minimum of five levels of priority are required. This service is accessible at reference points B and C.

5.4.2.3.3 Preemptive Priority Call

This service is supplementary to broadcast, group and individual calls. A call that has preemptive priority will always have resources allocated to it, even if this means that other calls will be disconnected. If the required resources are unavailable (i.e. occupied by another user), a call with preemptive priority will automatically cause the call with the lowest priority using such resources to be disconnected. The resources released will be given to the preemptive priority call. No action is needed by the user. A minimum of five levels of priority are required. This service is accessible at reference point B and optionally at point C.

5.4.2.3.4 Call Interrupt

This service is supplementary to individual calls, but may interrupt any type of voice call, provided the individual is one of the call parties (it may not be possible to interrupt an individual while in a group call, unless that individual is the call originator). A dispatcher will be able to interrupt any call enabled by the system, by directing the call to the individual with the proper priority. The system may include the dispatcher, or may disconnect the third party in the call. The service is accessible at reference point B.

5.4.2.3.5 Voice Telephone Interconnect

This service is supplementary to broadcast, group and individual calls.
This service allows calls between a telephone network user and one or more radio system users. It may be initiated from either the radio system side or the telephone network side. As an option, the system shall support full duplex telephone interconnect. The service is accessible at reference points B, C and Et.

5.4.2.3.6 Discreet Listening

This service is supplementary to broadcast calls, group calls and individual calls. It allows a user to selectively listen in on any call. That is, the user may select salient aspects of the call, such as group ID, to decide whether to listen or not. The service is accessible at reference point B and optionally at C.

5.4.2.3.7 Silent Emergency

This service is supplementary to broadcast calls, group calls and individual calls. The service causes a subscriber radio to initiate a call by itself, without the operator explicitly initiating the call by depressing the PTT switch (e.g. it may be initiated by the radio user pressing an emergency switch). The purpose of the service is to allow the dispatcher and/or other users to listen to activities at the site of the subscriber radio, in the event of possible danger to the radio user. The service is accessible at reference point C.

5.4.2.3.8 Radio Unit Monitoring

This service is supplementary to individual calls. The service causes a subscriber radio to initiate a call by itself, without the operator explicitly initiating the call by depressing the PTT switch, the call being initiated remotely by a radio dispatcher. The purpose of the service is to allow the dispatcher to listen to activities at the site of the subscriber radio, in the event of possible danger to the radio user. The service is accessible at reference point B.

5.4.2.3.9 Talking Party Identification

This service is supplementary to Broadcast calls, Group calls and Individual calls. This service provides the identification of the transmitting radio user at all of the receiving points. This service is accessible at reference points B and C.

5.4.2.3.10 Call Alerting

This service is supplementary to individual calls. This service provides the ability for the call originator to leave his identity with the called party for subsequent call back. The service operates only as a prompt for the called party to return the call. This service is accessible at reference points B and C.

5.4.3 Services to the Subscriber

Services to the Subscriber provide for interchange of information between the subscriber units and controlling devices within the system. These services relate to the transfer of information to and from the subscriber to facilitate subscriber access to the system and other system services, including telecommunications services.

5.4.3.1 Intra System Roaming

This service allows subscriber units to change their point of attachment within a radio system. The services available to the unit at the new point of attachment will depend on the service capabilities of the radio system. This service may be manual or automatic.

5.4.3.2 Inter System Roaming

This service allows subscriber units to obtain services from systems other than their home systems. The services available on the foreign system are subject to mutual system operator agreement. This service may be manual or automatic.

5.4.3.3 Call Restriction

This service allows the radio user to restrict the services which may be accessed from a specific radio at a specific time. This service may be initiated by the radio user or the system operator.

5.4.3.4 Affiliation

This service allows the subscriber to alter its affiliation status to other units within the system. This permits the subscriber to change from one talk group to another.

5.4.3.5 Call Routing

This service allows the user to use the system's capabilities to determine how to process a call in order to reach an intended target in a resource-efficient manner.

5.4.3.6 Encryption Update

This service allows the subscriber to obtain current encryption key information to support secure communications with appropriate targets. The service may be initiated by either the subscriber or the system.

5.4.4 Availability of Services for Different System Types

The services described in section 5.4.3 will be available on APCO Project 25 systems in accordance with system type and other specifications within this section. Where a service is mandatory for a APCO Project 25 system type, such a system must provide that service. Where a service is a standard option, and a APCO Project 25 system provides that service, it shall be provided in compliance with the standard. Technological limitations may preclude some systems from supporting certain services.

5.4.4.1 Types of systems

Two system types are defined: conventional, and trunked. All APCO Project 25 radios shall be capable of operation in both types of systems.

5.4.4.1.1 Conventional Systems

Conventional systems are limited-capability systems which possess no centralized management of channel access. All aspects of system operation are under manual control of the system users. Operating modes within conventional systems include both direct (radio-to-radio) and repeater (through an RF repeater) operation.

5.4.4.1.2 Trunked Systems

Trunked systems provide for management of virtually all aspects of radio system operation, including channel access and call routing. Most aspects of system operation are under automatic control, relieving the system user of the need to directly control the operations of system elements.

Trunked systems shall meet all mandatory requirements and shall offer as options the same desirable features as APCO Project 16A. Where APCO Project 25 and APCO Project 16A requirements conflict, APCO Project 25 requirements shall supersede.

5.4.4.2 Availability

Table 5-1 and Table 5-2 show service availability by system type. The service is further denoted as either mandatory or standard option for that system type (see section 5.4.4).

Table 5-1 Service Availability - Bearer and Teleservices

Telecommunications Services		
Bearer services	**CONVENTIONAL**	**TRUNKED**
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	**CONVENTIONAL**	**TRUNKED**
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
Pre-programmed Data Messaging	Standard Option	Standard Option

Table 5-2 Service Availability - Supplementary and Subscriber

Supplementary services	**CONVENTIONAL**	**TRUNKED**
Encryption	Standard Option	Standard Option
Priority Call	Not Available	Standard Option
Preemptive Priority Call	Not Available	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
Services to the Subscriber	**CONVENTIONAL**	**TRUNKED**
Intra-system Roaming	Standard Option	Standard Option
Inter-system Roaming	Standard Option	Standard Option
Call Restriction	Not Available	Standard Option
Affiliation	Not Available	Standard Option
Call Routing	Not Available	Standard Option
Encryption Update	Standard Option	Standard Option

5.5 Network Procedures

5.5.1 General

In order to provide an efficient service to the system operator, a number of standard services need to be supplied by the system. These services are needed for both conventional and trunked operation, but the operational details may differ. The following services will be defined in the standard, but it is a system operator option as to whether they will be supported:

a) Registration.
b) Authentication.
c) Disable terminal.
d) Network management and call statistics.

5.5.2 Registration

5.5.2.1 Roaming Within The Same System

During the 'idle' state, the mobile terminal continuously evaluates the need to select another base station to provide a communication path. When the subscriber terminal decides to change base station, a registration procedure may be required. This is initiated by the subscriber terminal resulting in an update of the location register in the system.

The system may then send a request for authentication to the subscriber terminal. The received information from the mobile terminal is examined and checked against the information about the mobile terminal held by the system. If the system finds the authentication valid, an acknowledgement is sent to the subscriber terminal. If the authentication reveals unauthorized use, the system may prohibit further use of the subscriber terminal or may order a terminal shutdown.

5.5.2.1.1 Registration Area

A registration area is the area in which a subscriber can move freely without the need to update the location information maintained by the network. The subscriber can only be registered on one location at a time. In the case of a simulcast system, this location may be several sites geographically spaced, but sharing a common frequency allocation.

The system will page the mobile terminal in the registration area.

5.5.2.2 Conventional Operation

Some form of registration will be required in large conventional systems. The functional definition of registration operation will be in section Reference [TBD].

5.5.2.3 Trunking Operation

All but a single-site trunked system will require registration procedures. These will be defined in section Reference [TBD].

5.5.3 Roaming

5.5.3.1 Roaming Definition

Roaming is the procedure a subscriber unit utilizes to allow it to change fixed end control capability. This may occur when a subscriber unit comes in contact with a system whose control channel offers quality or a feature set which is more desired than the control channel currently selected.

Roaming can be viewed as having two modes. The first mode is "passive" and the other is "active". The following sections further define these sections.

5.5.3.1.1 Passive Mode

In the idle state, the subscriber unit monitors and evaluates the current control channel assignment. The subscriber unit will also have knowledge of any other control channel which has coverage in its area.

Each possible control channel will be logged in the subscriber unit's data base. Each control channel will be associated with the quality of communications as well as the available feature set from that control channel's RF subsystem controller.

The quality of the control channel will be determined by a signal strength indication which the subscriber unit determines directly from the control channel. A record of several past signal strengths will be stored in the subscriber unit's data base. This will allow the subscriber unit to evaluate the longevity of the quality of the control channel.

As an example, control channel candidates may have a series of signal strengths that indicates that the subscriber unit is moving either toward or away from the control channel's site. Also, the record of past signal strengths of a control channel candidate will provide a measure of stability of the signal which will minimize assignment of the subscriber unit to a control channel which is experiencing propagation anomalies.

5.5.3.1.2 Active Mode.

When a subscriber unit determines that the currently assigned control channel does not meet its minimum requirements for quality or functionality, the device initiates an active mode of roaming. In this mode, the subscriber unit will attempt to be reassigned to an adjacent control channel of which it has knowledge.

If the subscriber unit does not have a current "suggestion" for a next best control channel, the unit will perform a systematic search of all possible channels by synthesizing all available channel

frequencies. The unit will be programmed to periodically steer the search to a list of preset channel assignments and/or to the list of candidates which were being monitored.

5.5.3.2 Conditions Necessary for a Subscriber Unit to Roam.

The following sections identify the conditions under which a subscriber unit will choose to roam.

5.5.3.2.1 Not currently registered

This condition will exist when the unit is initially turned on or is not properly registered on a system.

5.5.3.2.2 Control channel falls below minimum signal quality

As a subscriber unit moves out of the coverage of a control channel, the control channel signal strength will fall below the minimum set level.

5.5.3.2.3 Control channel cannot provide minimum service capabilities.

At times, the subscriber unit may be assigned to a control channel which does not meet the unit's functionality requirements, however, it does meet the minimum quality requirements. For this case, the subscriber unit may elect to change control channels for one which will provide all the desired service capabilities.

5.5.3.2.4 The subscriber unit's registration is revoked.

There are two situations in which a registration may be revoked. The first would be when a subscriber unit is initially granted service while the unit's identification is being authenticated. If the system determines that the unit is not authorized service, the subscriber unit registration will be revoked.

The second situation would be if, as part of a controlled regrouping of users, a subscriber unit is forced to a different control channel that cannot support the required features of that subscriber unit. Under this situation, the subscriber unit is authorized, but cannot be supported.

Another possibility would be when a subscriber unit is to become a member of a communications group which utilizes a specific control channel in that geographic area. The assignment of the subscriber unit to a preferred control channel may reduce call processing time while the unit is assigned to the temporary working group.

5.5.3.3 Registration.

When a subscriber unit roams, there will be two types of registration available, full registration and unit presence indication.

5.5.3.3.1 Full Registration.

This type of registration will require the most control channel resource and processing capacity. There are four conditions for this type of registration. An explanation of these conditions follows:

1) Power-up registration
2) Intersystem roaming
3) Inter-WACN roaming
4) Forced Registration

Refer to the Registration section of the Trunking Procedures document for a more detailed coverage of the registration process.

5.5.3.3.1.1 Information from the Subscriber Unit.

For full registration, the subscriber unit must identify itself to the desired control channel. The subscriber unit will provide the full APCO-25 radio identity for the unit. Additional information may also be transmitted with the inbound data to provide any unique identification information related to the subscriber unit.

5.5.3.3.1.2 Information to the Subscriber Unit.

In an unsuccessful registration process, the requesting subscriber unit will either not receive a suitable response to its registration request (passive denial) or will receive an appropriate registration denial packet (active denial) on the outbound control channel.

In a successful registration process, the requesting subscriber unit will receive the following information:

a. Working unit identity to use in this system
b. System service template
c. Allowed system services
d. System status update
e. Control channel encryption parameters (if appropriate)

5.5.3.3.2 Unit presence indication

This type of registration will require a minimum of control channel resource and processing capacity. The following are three conditions for this type of registration:

1) Intrasystem roaming
2) Intersystem roaming
3) Registration updates

As the unit roams in a system which it has previously performed a full registration, the unit will generally not need to be given new system specific parameters. The unit will usually only need to

indicate that it prefers the currently assigned control channel.

As the unit moves among systems of a WACN, it may be able to perform the registration to a control channel in a short form, as long as the specifics of system services provided to the unit and other pertinent system parameters are not changed. When the communication system needs to verify the registration condition for the unit, the response to the communications system will normally be sufficient.

5.5.3.3.2.1 Information from the Subscriber Unit.

Typically, the unit will indicate its identity as the current working identity within the system. Also the unit may identify itself with a fuller APCO-25 radio address to include system and possibly WACN identity along with the unit identity.

5.5.3.3.2.2 Information to the Subscriber Unit.

Generally the unit will receive a confirmation of a successful registration to this control channel. If this registration process is outside of the previous system of registry, then a new working unit identity will also be assigned to the unit at the time of registry.

If the features which are supported by the new control channel are different from those of the previously assigned control channel, the newly registered unit will be given an update to include these changes.

5.5.3.4 Detailed Roaming Schemes

Roaming is the physical or logical movement of a unit from one control channel to another. The following are descriptions of roaming scenarios and comments concerning those scenarios.

Once a suitable control channel has been determined, the radio unit will attempt to register with that site's control channel. This will be accomplished by using the current working identity of the unit, and not the full APCO-25 radio identity.

When a subscriber unit requests a registration, the identity of the requesting unit will be checked in the visitor location registry (VLR) data base to determine if it is allowed access. If the unit is allowed access, the registration process continues normally. The VLR is updated to reflect the presence of this unit at the specific site. If this subscriber is not allowed access to this site's resources, then the RF subsystem's controller denies registration to the unit. The unit will then leave this control channel in search of another which will allow registration.

If this VLR does not yet contain any information concerning this subscriber unit, then it must reference the proper home location registry (HLR) for the unit's identity. The VLR will receive the pertinent information concerning the unit's identity from the HLR and make an appropriate decision to allow or deny registration.

When the unit achieves successful registration, the controller for the control channel will be notified

that the unit is now resident on that site. The information will then be forwarded to the HLR indicating the status and location of the subscriber unit.

If the unit is unable to acquire a suitable control channel from the known system parameters which are available to the radio, then the radio will begin a systematic scan of the frequencies in the entire frequency band. The unit will search for an appropriate trunking control channel candidate which offers a compatible WACN for this unit.

When a subscriber unit is allowed registration at an RF subsystem site, the RF subsystem site controller may limit the system services allocated to the unit. The information for the allowable services for this unit is contained in a subscriber access control (SAC) record.

While a radio is currently registered with a particular control channel site controller, the radio will continue to monitor the status of other control channel candidates. If the unit determines that a different control channel can provide superior service in either quality or features, the unit will abandon the current registration and re-register on the desired control channel. The function of monitoring other control channels will be a low-priority task and will not interfere with any active service processing by the unit.

The unit is addressable within this system by the current working unit identity for this unit. If this is the home system for this unit, the current working unit identity defaults to the unit ID for the unit.

The unit is always addressable in the communications system via the full APCO-25 radio unit address. This is independent of the current location within the communication system. This will be used within the interconnection network between systems, and will be converted to the current working-unit identity at the current control channel of registry for the unit.

5.5.3.4.1 Intra-WACN Roaming.

This involves the movement of the subscriber unit within the domain of a single system. It is assumed that the subscriber unit has previously performed a full registration process with the system. In general, when a unit moves within a single system, the unique identification of the subscriber unit will be accomplished through the current working-unit identity and will not require the use of the full APCO-25 radio identity.

5.5.3.4.1.1 Roaming Between Sites of a Single RF Subsystem.

The subscriber unit will be given adjacent site updates for all the other sites of this RF subsystem in the area of this site. Additionally, sites of other RF subsystems and potentially other systems will also be presented if they are within the locale of this site. The subscriber unit will retain this information locally and will use it to perform passive roaming operations to determine the figure of merit for these control channels.

When a unit must actively seek another control channel, these control channels in the unit's listing will be considered first. If a control channel of another site of the same RF subsystem provides satisfactory signalling, the unit will register to this control channel. The system update packets on the outbound control channel will provide the subscriber unit with WACN:SYSTEM:RF SUBSYSTEM information. Since this is another site of the previously registered RF subsystem within the same system, the unit may identify itself using the working-unit identity.

The VLR associated with the new site will probably be the same as that associated with the previous site, due to the fact that the sites are elements of the same RF subsystem of the communications system. In this case, the VLR handles the change of location locally. If the VLR for this site is different from that of the previous site, then this VLR must be updated with the information concerning this subscriber unit from the associated HLR. The HLR is also suitably updated to indicate the new location for this subscriber unit. The VLR of the previous site needs to be updated (by the HLR) that the subscriber unit is no longer to be considered a member of that VLR.

Assuming there is nothing unusual about the new site's operation, especially with regard to the operation already granted to the unit at the previous site of the same RF subsystem, there does not need to be any more update information presented to the unit to allow it to be functional upon this control channel.

5.5.3.4.1.2 Roaming Between Sites of Different RF Subsystems

The subscriber unit will be presented with adjacent site updates for all the other sites of this RF subsystem in the general locale of this site. Additionally, sites of other RF subsystems and potentially other systems will also be presented if they are within the locale of this site. The subscriber unit will store this information locally and will use it to perform the passive roaming operations to determine the figure of merit for these control channels.

When the unit must actively seek another control channel, the list of stored control channels will be considered first. If a control channel of a site of a different RF subsystem provides satisfactory signalling, the unit will register to this control channel. Since this is another site of the same system, the unit may identify itself using the working-unit identity.

The VLR associated with this site may be the same as the previous site of registry for this unit, in which case, the VLR handles the change in location locally. If the VLR for this site is different from that of the previous site, then the VLR must be updated with information concerning this subscriber unit from the associated HLR. The HLR is also suitably updated to indicate the new location for this subscriber unit. The VLR of the previous site needs to be updated by the HLR, that the unit is no longer a member of that VLR.

5.5.3.4.2 Inter-WACN Roaming

This is the process by which a unit moves between systems of a single WACN. It is assumed that the unit has performed a full registration upon some portion of the communication system prior to the movement from one system to another.

The unit will receive information from its current control channel concerning the control channels of sites adjacent to this location. This will include the control channels which form other elements of this system as well as control channels for other systems.

Additionally, the control channel updates may span networks. In this case, there would be updates concerning adjacent control channels for other WACNs as well as the above stated updates for elements of this WACN.

This update information will be retained by the subscriber unit and used first when the unit needs to search for a new control channel. If the unit is unable to find a usable control channel from these entries, then the unit will perform the systematic search of available spectrum to find a control channel for use.

The roaming unit will detect that it has entered the domain of another system of the WACN by the information presented on the control channel concerning the identity of the control channel (e.g. WACN:SYSTEM:RF SUBSYSTEM:SITE). When the unit determines this is a different system, the unit realizes that the previously valid working-unit identity is no longer valid for this unit. The unit will then request registration to this control channel, utilizing full APCO-25 radio identity.

The VLR associated with this site will connect to the HLR associated with the requesting unit to retrieve necessary information about the unit. When the VLR has sufficient information concerning the unit, the VLR will inform the unit as to whether its registration request is granted or denied.

If the request is denied, the unit will continue its search for other control channels to utilize. If the request is granted, the unit will be given a working unit identity to be used while the unit is within the domain of this system identity.

Additionally, any other necessary operational information, such as protection scheme parameters, is presented to the unit to allow it to function normally upon this control channel. If there are any service restrictions for this unit, they are also conveyed to the unit at this time. Subsequent roaming of this unit within the confines of this system is handled as described in the previous section.

The unit is addressable within this system by the current working unit identity for this unit. If this is the home system for this unit, the current working unit identity defaults to the unit ID for the unit.

The unit is still addressable in the communication system via the full APCO-25 radio unit address. This will be used within the interconnection network between the SYSTEMs, and will be converted to the current working-unit identity at the current control channel of registry for the unit.

5.5.3.4.3 Defined Procedure for Manual Roaming.

The manual version of roaming consists of allowing the subscriber user to manually select a preprogrammed WACN:SYSTEM:RF SUBSYSTEM for operation. The subscriber unit will no longer "automatically" attempt to find the best RF subsystem in the vicinity to provide service to the subscriber user, but instead will use the selected RF subsystem as the "only" one available.

If the subscriber unit is not currently in range of this user-selected WACN:SYSTEM:RF SUBSYSTEM, the subscriber unit will not be able to process any service requests issued by the subscriber user. Once the subscriber unit comes into range of this selected RF subsystem, it will attempt registration. Failing this registration for what ever reason, the subscriber unit will remain in the "no service allowed" mode. Being granted registration on this WACN:SYSTEM:RF SUBSYSTEM, the subscriber unit may begin normal system service operations.

The subscriber unit will remain in this mode until either the subscriber unit selects a different RF subsystem for the radio to register, or the user selects the automatic roaming mode of operation, in which the subscriber unit may scan for available WACN:SYSTEM:RF SUBSYSTEMs in the vicinity.

5.5.4 Authentication

The primary purpose of the authentication service is to help the system to identify unauthorized use of subscriber terminals. If unauthorized use of subscriber terminals is detected, a determination of appropriate countermeasures will be made. These may be pre-planned, automated or require system-manager intervention. As one of these countermeasures, the system may choose to disable the unauthorized subscriber terminal.

Unauthorized use of subscriber terminals includes:

a Impersonating a subscriber identity
b Failure to fulfil contractual obligations (bad debts, etc) while continuing to use the system (commercial application)
c Using a stolen subscriber terminal

Authentication will be a standard option, and be defined in Reference [TBD].

5.5.5 Disable terminal

Procedures to disable the participation of specific mobile and line-connected terminals from the system are defined in the standard. Corresponding re-enable procedures are also defined.

5.5.5.1 Disable procedures for conventional Operation

Radio-unit disable will be required in some conventional systems, and will be defined in Reference [TBD].

5.5.5.2 Re-enable procedures for conventional operation

[TBD]

5.5.5.3 Disable procedures for trunked operation

Radio-unit disable will be required in some trunked systems, and will be defined in Reference [TBD].

5.5.5.4 Re-enable procedures for trunked operation

[TBD]

5.5.6 Network management and administrative services

All information to be available at the network management interface shall be functionally defined.

There shall be a logical single point of entry, which may be connected to geographically separate input points, for management of system components and software levels. The system management shall allow vertical partitioning and delegation of control to the organization responsible for the operation of the partition.

Administrative services such as call statistics and traffic recording capability will not be standardized.

5.5.6.1 Network management interface

The interface is between one or more RF subsystems and a connected Network Management Center (NMC), so that the NMC can provide control for components of the radio system. Communications will be based on Internet (SNMP) an protocol, and a provider of the network management element shall support the protocol.

The specification shall be based on the appropriate layers of the OSI model. The interface will be as specified in document TSB102.BAFA.

5.5.6.2 Call statistics services

The requirement for obtaining call statistics is likely to vary greatly between different systems. The system manager will determine which call statistics are to be made available by the system.

It may be possible for co-operating systems to exchange some call statistics for intersystem working purposes. As an option co-operating systems shall be capable of exchanging such call statistics as the system manager may elect.

5.5.6.3 Traffic recording services

As an option, traffic recording services, shall have the capability to provide call traffic and associated call statistics in a suitable format to a recording device. The traffic recording will be possible for selected individual communications or for categories of target communications. Traffic recording will also be possible for all communications. Where the traffic-recording service is offered, a method for selecting which traffic to record will be necessary. The traffic-recording service shall only be made available to authorized users.

5.5.7 Service Availability

Table 5-3, below, shows network service availability by system type. The service is further denoted as either mandatory, standard option, or optional for that system type (see section 5.4.4).

Table 5-3 Service Availability

SERVICES	CONVENTIONAL	TRUNKED
Registration	Standard Option	Mandatory
Roaming	Mandatory	Mandatory
Authentication	Standard Option	Standard Option
Radio Unit Disable/re-enable	Standard Option	Standard Option
Provision of Network Management Interface	Standard Option	Standard Option
Call Statistics Service	Optional	Optional
Traffic Recording	Optional	Optional

5.6 Reference Model and Interfaces

5.6.1 General Model Definitions

All APCO Project 25 systems are physical implementations of interconnected elements. In this architectural specification, all systems elements are represented according to their architectural attributes. These architectural attributes define a new language to describe a system. This language is independent of the specific system, and is independent of LMR systems as well. It is a descriptive language for system architecture used today by telecommunications (as found in the CCITT specification for ISDN) and computer industries (as found in the CCITT specifications for OSI). Within this architectural language, physical elements are mapped into functional groups, and interfaces into reference points. The following are based upon CCITT definitions, modified appropriately for this specification of APCO Project 25 systems.

5.6.1.1 Reference Configurations

Reference configurations are conceptual configurations useful in identifying various possible physical user access arrangements to a APCO Project 25 system. Two concepts are used in defining reference configurations, reference points and functional groupings. Layout and application examples of reference configurations are given in the following subsections.

5.6.1.2 Functional Groups

Functional groups are sets of functions which may be needed in a APCO Project 25 system, i.e., mobile/portable radio, base station, site controller, multi-site controller, etc. Since the APCO Project 25 system specification includes conventional, trunked, and multi-station sites, specific functions in a functional group may or may not be present. Note that specific functions in a functional group may be performed in one or more pieces of equipment.

5.6.1.3 Function

Functions, loosely defined, are the actions which define a functional group, i.e., mobile/portable radio receiver, transmitter, data port interface, radio controller, etc. In any given product implementation, however, the mapping of physical elements to functional groups is not necessarily one-to-one. A more strict definition of a function which defines a functional group is an action which sources or sinks data to or from another function.

5.6.1.4 Reference Points

Reference points are the conceptual points dividing functional groups. A reference point will correspond to a physical interface between pieces of equipment where an open interface standard exists. However, not all physical interfaces correspond to a reference point (e.g., a cable between two pieces of equipment that divide the functions of a single functional group) and will not be included within the scope of this specification. Also, not all physical interfaces between functional groups are to be open interface standards, or reference points.

5.6.2 Reference Configurations - Detailed Model

5.6.2.1 Repeater Reference Configuration

Figure 5-1 depicts a reference configuration for a typical arrangement of functional groups in a repeater configuration. The interfaces between the functional groups are the reference points. The interfaces between functional groups not designated as reference points are not necessarily interconnected as shown in this example diagram. Other than the reference points, this interconnection of functional groups within a mobile or portable radio, or within an RF subsystem would be manufacturer specific.

5.6.2.2 Non-Repeater Reference Configuration

Figure 5-2 depicts a reference configuration for a non-repeater configuration, or talk-around. Note that this is a distinct configuration of a subset of the same functional groups and reference points as were depicted in Figure 5-1.

5.6.3 Functional Groups Figure 5-1 and Figure 5-2 (Page 58)

5.6.3.1 MES (Mobile End System)

In the mobile end system functional group, the term "mobile" is used as in Land Mobile Radio, which includes all mobile radios, portable radios, and fixed remote radios. The MES functions include the voice and/or data user interface built into the radio.

5.6.3.2 MDP (Mobile Data Peripheral)

The **MES** designates the **M**obile **D**ata **P**eripheral functional group. The mobile data peripheral functional group, includes all mobile, portable, and fixed remote data peripherals. The MDP functions include the data user interface of any data peripheral attached to the radio.

5.6.3.3 MRC (Mobile Router & Control)

The mobile router and control functions group includes functions of voice and/or data routing, as well as control of the Mobile Radio (MR).

5.6.3.4 MR (Mobile Radio)

The mobile radio functional group includes functions of transmission and reception of all RF signals.

5.6.3.5 BR (Base Radio)

The base radio functional group includes only the functions of modulation and demodulation of the radio frequency energy. Elements within the BR include the power amplifier (PA), RF front end, IF selectivity, and end-IF detection device.

5.6.3.6 BA (Base Audio)

The base radio audio and routing functional group includes the functions of frequency, level shaping and signal processing associated with the transmitted and received signals coupled to the BR. The interfaces to the BR and BC (see section 5.6.3.7) are manufacturer specific, and may be at any level, frequency, or mode.

5.6.3.7 BC (Base Control)

The base radio control functional group includes the automated control functions of an individual base station.

5.6.3.8 RFC (Radio Frequency Control)

The radio frequency control functional group include all logic for translating user-command signalling and control into base radio command signalling and control for one or more base stations. The RFC functions further include all logic for generating command signalling and control to a RFS functional group, if present. RFS is defined in section 5.6.3.9.

5.6.3.9 RFS (Radio Frequency Switch)

The radio frequency switch functional group functions include all switching for establishing interconnection paths between gateways and base stations, as directed, via command and control signalling from an RFC.

5.6.3.10 CON (Console)

The console functional group functions include all end-system functionality for the dispatcher(s) including the dispatcher's Man Machine Interface (MMI), control, and audio functions.

5.6.3.11 MSC (Mobile Service Switching Center)

The MSC is a switching center for services between radio sub-networks. The MSC is the combination of the RFC and RFS functional groups.

5.6.3.12 HLR (Home Location Register)

The HLR is a dynamic data-base service which tracks the mobility of subscribers associated with a particular radio sub-network, and who roam to other radio sub-networks.

5.6.3.13 VLR (Visitor Location Register)

The VLR is a dynamic data-base service which tracks the mobility of roaming subscribers which enter a radio sub-network, but who are associated with a different radio sub-network.

5.6.3.14 RFG (Radio Frequency Gateway)

The radio frequency gateway functional group functions include direct interface with any/all end systems with the exception of the console (where the end system may be an RFG into another radio sub-system), and any translation of command signalling between the end system/user and the RFC. The RFG functions further include any translation of end system/user payload between the user and the RFS. The RFG also includes interface between VLRs, HLRs, and MSCs between RF subsystems.

5.6.4 Reference Points

5.6.4.1 Introduction

The intention of this section is to systemize the major interfaces within the system and the interfaces between the system and its environment. It is also a list of those interfaces to be standardized. To standardize means to define the capabilities and functions and to determine to which layer in the OSI model the teleservices have to be specified, and specify these teleservices. The provision of an air interface is mandatory, whereas all other interfaces are standard options, and need not be provided on a system unless requested by a system operator. The labels in square brackets refer to the interfaces detailed in Figure 5-1 and Figure 5-2.

5.6.4.2 Air Interface [Um]

This interface is between the base station transceiver [BR] and the mobile transceiver [MR]. One channel bit-rate, modulation and link layer shall be utilized for all voice and data capabilities and, for single-channel operation, control, voice, and data features shall be integrated into a common channel. This interface is used for communication with mobiles and portables within the system. OSI layers 1 and 2 are specified, as is the implementation of the services. This interface is specified in document TSB102.BAAA.

5.6.4.3 ISSI (Inter RF-Subsystem Interface) [G]

This interface is between different RF-Subsystems [RFGs] and is used for speech and data interconnection of systems. The services and interface are still to be defined. This interface will be based on Q-SIG, using the Mobile Application Part (MAP). The OSI layers will be as specified in document P25.920901.4.

5.6.4.4 SMI (System Maintenance Interface) [En]

This interface is between an operations and maintenance center [ES] and a system [RFG]. This interface is used for network management and is specified in document TSB102.BAFA.

5.6.4.5 Telephony Interface [Et]

This is the interface between the fixed telephone network [ES] and the system [RFG]. The interface will support both analog and ISDN interfaces to the telephone network, for connection to both public and private networks, or an analog wireline modem interface to a dial-up data network.

The optional interface shall provide a PBX/PSTN interface which will allow radio users and control position operators to initiate and receive telephone calls. The system shall be able to manipulate such calls in the same manner as other radio system calls. Additionally, the system shall provide access to standard interconnect features.

5.6.4.6 Host and Data Network Interface [Ed]

This is the interface between the system [RFG] and public/private data networks [ES].

This interface will be an EtherNet (IEEE 802.3) interface, and OSI layers 1-3 will be specified. Connection to SNA or X.25 data systems will use data gateway equipment.

5.6.4.7 Radio Data Peripheral Interface [A]

This is the interface to external data equipment [MDP] from a mobile or portable [MRC]. This interface for packet data will be IP/serial link internet protocol, and OSI layers 1-3 will be specified. For circuit data this interface will use the AT-command set defined in TIA-602

5.6.4.8 Console User Interface to System [B]

This is the reference access point for services directed to or from the console functional group.

5.6.4.9 User Interface to Subscriber Unit [C]

This is the reference access point for services directed to or from the subscriber unit.

5.6.5 Intra RF Subsystem interfaces

The interfaces between functional blocks within the RF subsystem are not specified, but where elements of the system are located on geographically separate sites, signalling formats must be compatible with standard transmission facilities, in accordance with the North American transmission standards as defined by Bellcore TR-TSY-00333 for Switched and Special Access Services.

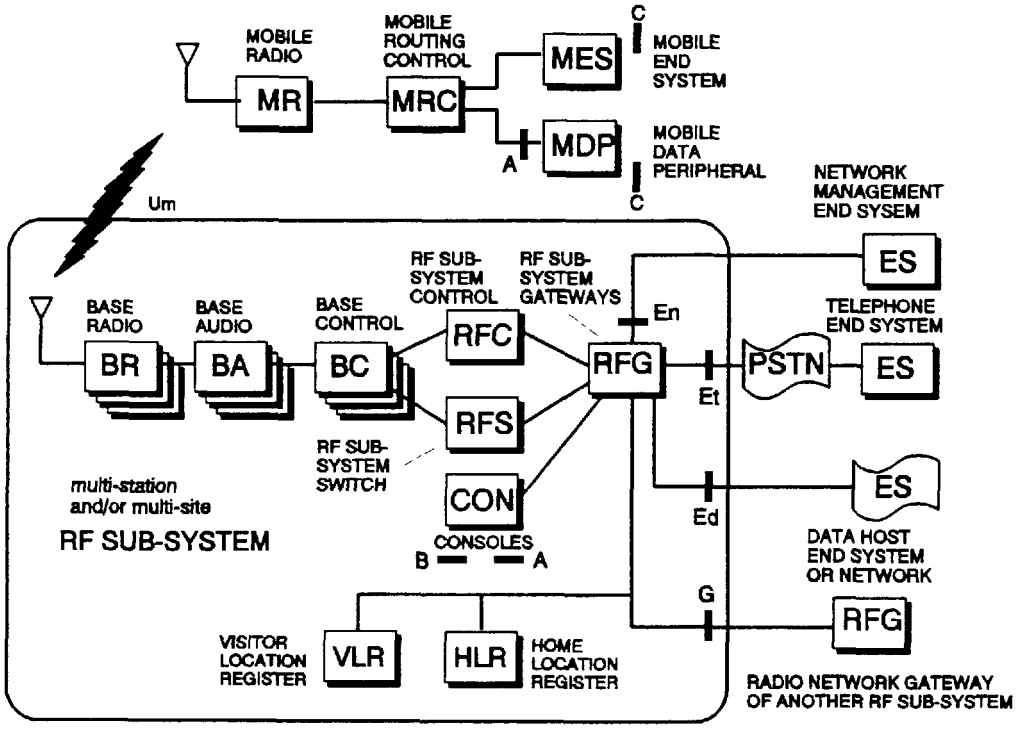

Figure 5-1 Repeater (example) Reference Configuration

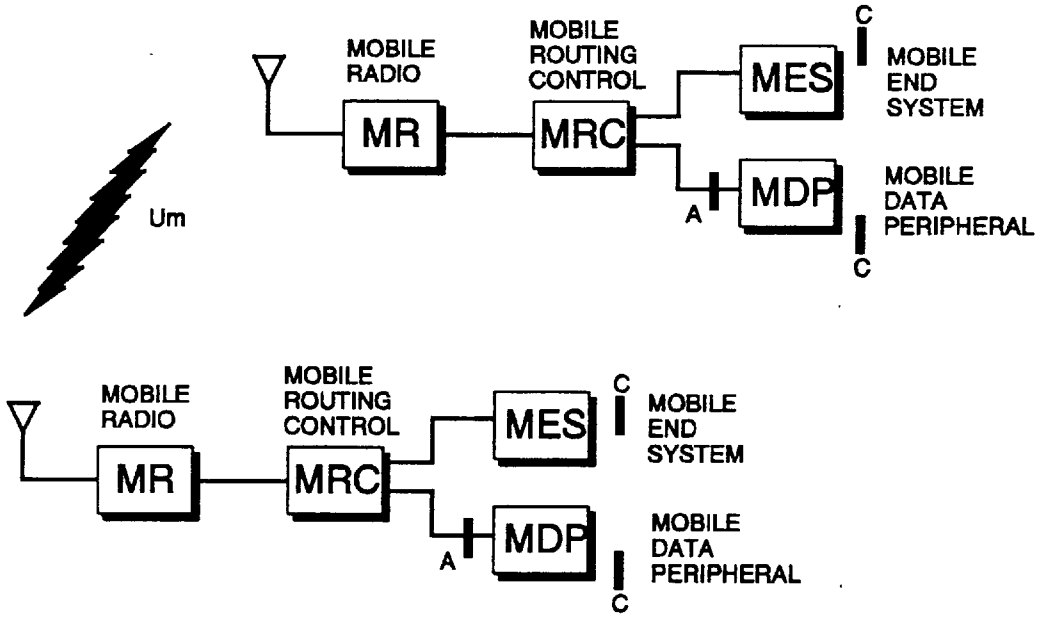

Figure 5-2 Non-repeater Reference Configuration

5.7 Performance

The system shall, as a minimum, meet all of the performance requirements of APCO 16A. Where those of APCO 16a and APCO 25 conflict, APCO 25 requirements shall supersede. The Project 16-A (900MHz Trunked Communications System Functional Requirements Development) documents are available from APCO Institute, Inc.

5.7.1 System Characteristics

- The system shall allow for single-station sites without loss of control, voice, or text capability.
- The system shall allow direct mobile-to-mobile communication at any time without degrading the normal system performance.
- Direct communication, while in range of the fixed equipment, shall do no more than temporarily capture receivers from possible outbound messages.
- Direct communication shall be possible at any time while out of range of the fixed equipment with no degradation in system performance or capacity.
- The system shall minimally be equally adaptive to all public safety mobile radio frequency bands and blocks of spectrum, without precluding its adaption to other land mobile bands.
- The system shall conform to the performance specifications of all standards detailed under "Conformance Testing" (Chapter 5.10).

The system shall allow for expansion via a building block approach. The number of sites shall be upgradeable for expansion/problem solving without requiring existing equipment changeout. The basic RF subsystem or site shall have a minimum of one channel, and no specified maximum.

5.7.2 Channel Utilization

The system shall give immediate channel utilization 2 times as spectrum efficient as current analog systems, representing a move from one 25kHz to two 12.5kHz channels.

5.7.3 PSTN Interconnection

Interconnection to public switched telephone networks shall be equal to or superior to the performance of current analog systems.

5.7.4 Range

System range shall be equal to or superior to current analog clear-voice systems when operating in either clear or encrypted voice mode. Satisfactory range must be achieved with no increased risk to health and safety of operators from high-power transmitters.

RF emissions from base radios (BRs) shall meet ANSI Standard [TBD]. RF coverage requirements shall be explicitly stated, and shall apply equally to mobile and handheld units, as well as to clear and encrypted transmissions. The coverage model for RF coverage measurement shall be [TBD].

5.7.5 Resilience

5.7.5.1 Resilience to Interference

The system shall be designed to be resistant to interference from co-channel, adjacent channel and intermodulation effects to at least the standard of Continuous Tone Coded Squelch Systems (CTCSS).

5.7.5.2 Graceful system degradation

It is vital that a communications system for a public-safety organization be reliable. The system must provide for a basic level of service that encompasses the majority of the communications traffic even in the presence of equipment or facilities failure.

Resilience in this context implies and requires a design concept that provides those essential communications in the presence of degrees of equipment/facility failure.

Resilience is provided in a design by supporting the basic modes of communications through the simplest, most reliable paths. Lesser used features and functions may be supported by higher levels of switching, for example. Thus, failures in more complex areas of the system will result in the reduction of features rather than the loss of a basic mode of communication.

5.7.5.3 Alarms

As an additional aid to resilience, the system shall provide a high level of error reporting and alarming, especially of those functions which cannot be recovered automatically in the event of a failure. The alarms and reports should contain sufficient information to aid the system operator in the repair of the condition.

5.7.6 Encrypted Mode

System performance in encrypted mode (either voice or data) shall not be lower than when operating in the clear.

5.7.7 Compatibility

The system shall be able to co-exist with older analog systems, share the same segments of allocated RF spectrum and provide little interference to existing adjacent channel analog systems while working correctly within its specified performance parameters.

5.7.8 Voice Quality

Voice quality for both clear and encrypted communication shall be equal to or superior to current clear-voice analog systems. The measure of quality shall include examples of both male and female voices.

5.7.9 Call Delays

Throughput delay is the propagation delay of audio through a system.
Throughput delays shall be less than :

- 250 msec for direct radio-to-radio communications.
- 350 msec for direct radio-to-radio communications through a single repeater station.
- 500 msec for direct radio-to-radio communications within an RF subsystem.

The requirement for ½ second access delay is in the specification of 900 MHz TRUNKED COMMUNICATIONS SYSTEM FUNCTIONAL REQUIREMENTS DEVELOPMENT (APCO 16 section 2/6/9)

5.7.10 Gross Bit Rate

Data transmission over the RF link shall be allowed by the system at a minimum gross bit rate of 9600 BPS with minimal re-transmissions. The net BIT rate that is available after deduction of overhead for error correction and re-transmission is 5.8 kBPS.

5.7.11 Control Channel Loading

The trunking control channel shall accommodate an average loading of [TBD] calls per second with no call delays, and shall accommodate an impulsive load of [TBD] calls per second, without becoming unstable. The recovery time after experiencing such an impulsive load shall be no greater than two seconds.

5.7.12 Registration and Authentication Times

Systems may require a radio entering the coverage area of an RF subsystem to be validated before the radio is allowed to operate on the system. This can require authentication or registration procedures. Registration procedures shall be completed within [TBD] seconds; authentication procedures shall be completed within [TBD] seconds.

5.7.13 Number Ranges

5.7.13.1 Radio Subsystems

The system, in conventional and trunked mode, shall be able to uniquely identify at least 64,000 radio subsystems.

5.7.13.2 Talk Groups and Radios

The system, in conventional and trunked mode, shall allow each radio subsystem to uniquely identify at least 65,000 talk groups and at least 16,000,000 radio unit IDs.

5.7.14 Battery Performance

5.7.14.1 Battery Life

Portable radio batteries shall be capable of powering the radio units for at least 8 hours with a 5,5,90 duty cycle.

5.7.14.2 Battery Size

Batteries shall provide the specified performance while having minimal size and weight. Maximum dimensions shall be less than or equal to existing public safety equipment.

5.7.15 RF Performance

Performance requirements for base station, mobile and portable transceivers are specified in document TSB102.CAAB.

5.7.16 Environmental Performance

Performance requirements for base station, mobile and portable transceivers are specified in document TSB102.CAAB.

5.8 Man-Machine Interfaces

5.8.1 Man-machine Interface of the Subscriber Unit

5.8.1.1 Optional Keyboard

Call talk group, unit ID, and user-accessible data interfacing shall be provided with the use of a 16-key keypad, if a keypad is fitted to the subscriber unit. The keys shall be of a size to allow user-friendly operation. The identity of the keys shall be as follows: numbers 0 through 9, *, #, and four additional special function keys.

Table 5-4 Typical Keypad

1	2	3	FN1
4	5	6	FN2
7	8	9	FN3
*	0	#	FN4

5.8.1.2 Control Knobs

As a minimum, there shall be control knobs for volume and for quick access for unit/channel entry. The knobs should be of an ergonomic design.

5.8.1.3 Input/Output Connector

The input/output connectors shall be of uniform pin-function assignment. Connector form and general location shall be at the manufacturer's discretion.

5.8.1.3.1 Electrical Specification

Voltage levels for subscriber unit data interfaces shall be consistent with CCITT V.24 and EIA-232-E specifications. The minimum subset (if a data port is fitted) should be as shown in Table 5-5.

Table 5-5 Data Interface Lines

V.24	EIA-232-E	Description	Direction
102	AB	Common	Both
103	BA	Transmitted Data	DCE Input
104	BB	Received Data	DCE Output
107	CC	Data Set Ready	DCE Output
133	CJ	Ready for Receiving	DCE Input
106	DB	Clear to Send	DCE Output

Note that Ready for Receiving (RFR) is used in place of Ready to Send (RTS), and appears on the same connector pin.
If the data port is to support synchronous data transmissions, Signal Element Timing circuits CCITT V24, 114 and 115 (DB and DD) should also be supported.

5.8.1.3.2 Recommended Input/Output Connectors

An ELCO EQR-R-B-07-P5-H28-E3 or equivalent connector is recommended for dedicated connectors. However, the connector functions may be combined with the use of an ELCO EQR-R-B-19-P5-H28-E3 connecter.

5.8.1.3.2.1 Programming Connector.

The recommended pin requirements for the programming functions are as follows:

a. DATA
b. WE (Read Write Enable)
c. RTS (Request To Send)
d. CTS (Clear To Send)
e. CLK (Clock)
f. DD (Data Detect)

5.8.1.3.2.2 Key Load Connector.

The recommended pin requirements for the Key Loading Functions are as follows:

DES Key Fill

a. WE (Read Write Enable)
b. KID (Key ID)
c. B-
d. Key Data
e. Shield Ground

DS-102 Type 1 Key Fill

a. REF
b. CFD Sense
c. CTS
d. DATA (Clock)
e. CLK

5.8.1.3.2.3 Surveillance Harness.

The recommended pin requirements for the surveillance harness functions are as follows:

a. External Mic
b. External Speaker
c. External PTT

5.8.1.3.2.4 Antenna Connector.

The recommended antenna connector is a Female TNC compliant to MIL C-39012.

5.8.1.3.2.5 Data Port Connector.

The recommended pin requirements for the data port functions are as follows:

a. Protective Ground Shield
b. Transmit Data
c. Receive Data
d. Ready for Receiving/Ready to Send
e. Clear To Send
f. Data Set Ready
g. Signal Ground
h. Transmit Clock (Synchronous
i. Receive Clock Only)

5.8.1.3.2.6 Combined I/O Connector.

The above mentioned connectors may be combined to minimize the number of required pins. The recommended combined pin assignments are as follows:

a. Protective Ground, Shield
b. Transmit Data, DATA, Key Data
c. Receive Data
d. Ready for Receiving, RTS, CFD Sense, WE
e. Clear To Send, CTS
f. Data Set Ready
g. Signal Ground, B-
h. Data Detect
i. CLK, Clock, Transmit Clock
j. Receive Clock
k. External Mic
l. External Speaker
m. External PTT

5.9 Security

The APCO Project 25 radio system provides bearer services and telecommunications services for user traffic (ie. voice, data, packet etc.) as defined within section 5.4 of this TRS.

Section 5.9.1 defines the requirements for encryption of the user traffic in relation to the bearer and telecommunications services provided.

Section 5.9.2 defines the additional requirements for encryption of control channel signalling for call set-up and clear down.

Further sections may be added to Section 5.9 as a result of ongoing committee activities.

5.9.1 Traffic Channel Security

5.9.1.1 User Security Requirements

The system shall provide up to four levels of encryption with compatible modes of operation and shall provide the same functions associated with clear (unencrypted digital) operation. Radios shall be capable of zero, one or two types of operation, as required.

Type 1 Classified national government communications
Type 2 Unclassified national security related communications
Type 3 Unclassified sensitive government communications (eg. Public Safety)
Type 4 Exportable

The security requirement for APCO Project 25 is clearly defined as the provision of identical services and facilities in the encrypted mode of operation compared to digital clear, both for conventional and trunked modes of operation.

APCO Project 25 shall fully define the Type 3 encryption standard; Type 1 and 4 algorithms shall not be defined within APCO Project 25, but must conform to the standard Common Air Interface (CAI). No Type 2 implementation is proposed for the APCO Project 25 system.

APCO Project 25 shall provide the user with an end-to-end encrypted service for digital voice and data traffic, using a non-encrypted control channel. The system design shall allow for the optional encryption of certain control channel functions, but shall not require the provision of encryption devices in any of the RF subsystem bearer equipments.

The system design shall be transparent to the actual type of encryption employed and shall provide for multiple types of encryption to be employed simultaneously on the same RF-subsystem.

Certain radios may be provided with multiple levels of encryption (eg. Type 1 & Type 3) within the same radio, selectable by the operator. The APCO Project 25 system design shall not preclude this means of operation.

5.9.1.2 Bearer Services

The bearer services of APCO Project 25, as defined in Section 5.4 of this TRS, and listed below, shall be optionally provided as encrypted bearer services.

Circuit switched reliable data
Packet switched confirmed delivery data
Packet switched unconfirmed delivery data

Circuit switched unreliable data shall not be provided as an encrypted service.

5.9.1.3 Teleservices

The security requirements for the teleservices of APCO Project 25, as defined in Section 5.4 of this TRS, are listed below.

5.9.1.3.1 Broadcast, Group and Individual Voice Calls

All voice calls shall be provided with a user-selectable voice encryption facility to meet the traffic security requirements defined in 5.9.1.1.

APCO Project 25 shall provide facilities for call addressing to be supported in either clear or encrypted form, allowing source, destination and talkgroup IDs to be cryptographically protected if required.

Note that when using encrypted IDs, all signalling shall be carried out on an end-to-end basis. This precludes the system from providing such functions as call routing, mobile registration, etc. for this mode of operation.

In addition, this mode shall support the following features for both clear and secure traffic:

a) ANI/Emergency signalling,
b) Scanning,
c) Radio Unit Monitor facilities.

5.9.1.3.2 Circuit Switched and Packet Switched Data Network Access

These services may optionally be encrypted using an encryption device at the data interface point Ed.

The data transmission system, including data headers, terminator blocks, acknowledgements and source and destination addresses, shall not be encrypted, whether the service itself is encrypted or not.

5.9.1.3.3 Pre-programmed Data Messaging

This teleservice shall not be provided as an encrypted service.

5.9.1.4 Encryption Performance Requirements

The APCO Project 25 encryption system shall offer the following performance levels:

i) A voice quality equal to or superior to clear-voice analog systems,
ii) A range performance equal to or superior to clear-voice analog systems,
iii) A synchronization system commensurate with the above requirements and offering both initial and late entry capabilities.

5.9.1.4.1 Algorithm Performance

The algorithm performance shall be as defined for the FIPS 46 DES standard for Type 3 systems, and as defined for the [TBD] for Federal Government Type 1 systems.

The APCO Project 25 Common Air Interface shall not degrade the encryption performance through the use of repeated predictive plain-text traffic.

5.9.1.4.2 Sync Performance

The system shall provide a mechanism for both initial and late entry synchronization under limit range conditions of Rayleigh fading and 5% mean BER.

Initial sync shall provide better than 98% probability of correct operation under limit range conditions.

Late-entry sync shall provide better than 95% probability of no more than 1 second loss of message for radios which try to late enter to a net under limit range conditions.

Initial sync, together with the RF sub-system signalling and vocoder system, shall provide throughput delays of no more than those specified in paragraph B.21 of the Statement of Requirements (i.e. 250 ms maximum for direct mode operation). In this context, throughput delay shall be defined as the time taken from push-to-talk operation of the transmitting radio and the provision of decrypted audio at the receiving radio.

5.9.1.5 Key Requirements

The encryption system shall provide for at least 8 crypto keys within each encrypted equipment and shall provide for a minimum of 4 active-traffic keys. The allocation of the remaining key stores to "active" or "next" keys shall not be defined within the standard.

The Common Air Interface shall be capable of transporting key variables of up to 72 bits in length, although some systems may require fewer bits for this purpose.

5.9.1.6 Physical Security requirements

All APCO Project 25 encrypted services shall be provided as end-to-end functions between communicating handheld or mobile radios, consoles or compatible RF subsystem gateway interfaces (see General System Model).

All encrypted equipments shall be designed such that the encryption device can be physically secured when unattended or not in use. Note this may be achieved by securing the entire equipment containing the encryption device.

As a consequence of the physical security requirements, no system function shall be designed to require encryption facilities within unattended RF subsystem components (i.e. infrastructure). Consequently, all functions related to infrastructure signalling shall be carried out in the unencrypted mode.

5.9.1.7 TEMPEST Requirements

All APCO Project 25 encrypted equipments shall be designed to meet the TEMPEST requirements appropriate to the level of algorithm employed.

TEMPEST requirements for Type 1 systems shall be separately specified by the Federal Government. No TEMPEST precautions shall be required for Type 3 systems.

5.9.1.8 Key Management

5.9.1.8.1 Physical

All encrypted radios shall be provided with a common key-fill interface, desirably using the connector recommended in 5.8.1.3.2.2. All equipments using the same encryption device shall use a common key-fill device.

Encrypted radios shall be provided with a zeroize facility to allow the user to erase encryption keys in an emergency.

Mobile radios may be provided with a "Crypto Ignition Key" (CIK) to allow a user to secure an unattended radio by removal of this key.

Manual fill, zeroize and CIK facilities may be provided remotely to a mobile radio for ease of access.

5.9.1.8.2 Cloning

It shall not be possible for key variables to be extracted from an encrypted radio for use in cloning an unfilled equipment.

5.9.1.8.3 Over-The-Air Rekeying (OTAR)

The system design shall provide support for over-the-air rekeying of encryption devices. OTAR messages shall be encrypted before transmission and shall not be required to provide the RF subsystem with unencrypted address or user ID information. The OTAR functional entity is defined in Ref. [TBD].

5.9.2 Control Channel Signalling

The control channel shall be optionally encrypted. This shall be a standard option, and carried out on a packet by packet basis. A marker will be transmitted in the clear section of the message packet to indicate an encrypted packet to all radio units active on the control channel.

The control channel encryption mechanism is detailed is Ref. [TBD]. The trunked control channel shall not degrade the encryption performance through the use of repeated plain-text control channel signalling.

The requirements of sections 5.9.1.4.2, 5.9.1.6, and 5.9.1.8 relating to sync performance, physical security, and key management also apply to encryption of the control channel.

To comply with physical security , no control channel encryption device shall be located at a remote unattended base station location. Authentication and synchronization mechanisms shall allow for possible delays between base station and RF sub-system control.

Drafters Note: Is this requirement consistent with the present proposal for synchronization of an encrypted control channel?

It is recommended that the system be resistant to control and traffic channel jamming due to co-channel and adjacent channel interference as well as deliberate jamming. The system should detect and alert the system operator of the occurrence of jamming, and should have the ability to change control channel either automatically or manually from a network management terminal.

5.9.3 Network Management

Network management encompasses the control functions associated with the provision of the network services, and is not directly concerned with the control of user radio equipments. Network management therefore excludes such functions as mobile registration, OTAR services, etc.

The network management function is defined in section 5.5.5.4 of this TRS as comprising:

a) Configuration management,
b) Fault management,
c) Performance management,
d) Accounting management
e) Security management.

The security management function is responsible for controlling access to network elements and all of the associated management information.

Physical security requirements preclude the use of encryption devices within the network infrastructure, preventing the incorporation of an encrypted service for network management functions.

All of these aspects shall be fully defined, but shall be independent of the encryption service offered for end-to-end digital traffic. This shall allow the provision of a protected, but not fully encrypted, service for those systems where provision of encryption devices within the network infrastructure is precluded.

The minimum security requirements for network management shall be:

a) Protection against unauthorized access via recording and replay of network management messages (spoofing),
b) Authentication between source and destination equipments prior to any configuration or accounting management actions,
c) Protection of mobile registration data against unauthorized eavesdropping.

5.9.4 Electronic Serial Number

A radio unit shall have an Electronic Serial Number (ESN) embedded into the radio, and the radio shall respond to ESN enquiries, using the procedures specified in the relevant operational procedures. The system may, or may not, make use of this ESN security check.

5.10 Conformance Testing

Conformance testing is intended to ensure that equipment conforms to definitional specifications. Interoperability should be facilitated by conformance testing. Interoperabiliy testing is the purpose of Lock Down; see Section 4.2.2.13. Performance measurements are a different and complementary test. Performance testing is covered by section 5.7.15.

Conformance testing is meant to be conducted by manufacturers. The major interfaces of the system are subject to conformance testing.

5.10.1 Radio Aspects

The major interface of the radio units is the Common Air Interface. There is a Common Air Interface Conformance Test Specification, TSB102.BAAB.

This includes a section that applies to the conformance of the transmitter. This ensures the proper modulation and tests for formatted code words. The tests shall verify that word encoders and message interleaving works properly.

There is a section that specifies that a receiver should de-interleave and decode the words in the proper manner. The receiver section does not specify the level of bit error rate versus RF signal level, but forward error correction mechanisms are tested. This portion is a performance issue and is covered by the performance tests specifications.

5.10.2 Standards Conformance

The mobile and portable equipment shall meet requirements based on MIL-STD 810 "Environmental Test Methods and Engineering Guide". These are specified in detail in TSB102.CAAB.

5.10.3 Additional System Interfaces

There are four additional major interfaces for a APCO Project 25 system. Each of these interfaces will have a conformance test specification or the interface shall conform to regulatory requirements. As each of the interfaces becomes fully defined, conformance tests for the interface shall be created.

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Appendix A APCO Project 25 NAMING DEFINITIONS

NEW TECHNOLOGY STANDARDS PROJECT
DIGITAL RADIO TECHNICAL STANDARDS
APCO Project 25 NAMING DEFINITIONS - VERSION 2.5
Thursday July 6, 1995
Approved by the APCO Project 25 Steering Committee on August 12, 1995

1 Scope

The intent of this appendix is to provide definitions to describe fixed network equipment (FNE) configurations and macro components thereof for APCO Project 25 usage. This shall detail the basic characteristics of the FNE configurations and components as they apply to APCO Project 25.

These definitions are specifically intended to cover only the APCO Project 25 infrastructure, and do not define subscriber R.F. units (e.g., mobiles or portables), etc.

1.1 Revision history

Version 1.0	6/17/94	first review by the subcommittee
Version 1.1	7/15/94	changes from subcommittee
Version 2.0	1/10/95	first review by total UNTG
Version 2.1	3/8/95	incorporate changes from UNTG
Version 2.2	3/27/95	incorporate changes from UNTG
Version 2.3	5/31/95	incorporate changes from UNTG
Version 2.4	6/8/95	changes from subcommittee
Version 2.5	7/6/95	changes from subcommittee

1.2 References

1) *General System Model* , (part of) TSB-102
2) *Technical Requirements Specification* , (part of) TSB-102
3) *Network Management Interface Definition* , TSB-102.BAFA

2 Introduction

There are two (2) main APCO Project 25 communication configurations, the System, and the Network.

The System is the basic configuration for all communication offerings. The System shall refer to the communications infrastructure equipment necessary to provide the desired customer functionality in the coverage area to be addressed for this communications functionality. In this manner, a System may span infrastructure configurations from a single base station or repeater providing a single coverage area, to a multiplicity of base stations or repeaters combined into geographic clusters to provide wide area coverage areas.
The System can also be decomposed into one or more RF Subsystems. The RF Subsystem (RFSS) shall be considered to consist of infrastructure components necessary to provide the communication coverage for some portion of the System. There may be a single RFSS (providing all the necessary coverage for the System) or many RFSS (each providing some portion of the System coverage, possibly overlapping) composing the System. The interconnection of these RF Subsystems constitutes the System proper.

The Network is defined as a plurality of Systems logically connected to provide a greater communication offering.

These definitions of communication configurations must be considered as being flexible to fit all communication needs, small or large, conventional or trunked, standalone or networked.

Interconnection of elements within a System, and the interconnection between Systems themselves to afford a greater communication offering, needs to be accomplished through an appropriate interface. This interface may be either open (e.g., defined in the "standard") or closed (e.g., proprietary). When such interface is open, equipment of any manufacture (compliant with the Standard interface) may be interconnected. When such interface is closed, the ability to combine infrastructure components of different manufacturers may be severely limited, or may not exist. (In general this will require explicit agreements of sharing between the different manufacturers.)

The current scope of APCO Project 25 offers a standard interface between elements of the System, and between Systems, in the form of the Inter-RF Subsystem Interface (ISI). *There is currently "no" standard interface for the interconnection of the basic infrastructure components (i.e., base stations, controllers, switches, etc.) composing a System.*

3 Infrastructure

The infrastructure is considered as consisting of Systems in various configurations. Groupings of Systems into Networks allows for greater communication offering than can be individually offered by the System components separately.

3.1 System

This is the basis for the APCO Project 25 communication configurations. The System is defined to support some set of communication services and functions (i.e., roaming, group dispatch, telephone interconnect, etc.) across a defined coverage area, at some first grade of service for a defined set of communication users.

The set of communication services and functions supported by a System is defined to include the capability of supporting those services and functions designated as mandatory in the TRS [ref.2]. In addition, other optional services or functions may be supported across the System. This set of services will be available throughout the coverage area of the System.

The first grade of service shall indicate the attributes of the service offerings (e.g., access time) which are to be expected for service performance within the confines of this coverage area.

In general, grade of service in this document shall refer to the general availability of a service, and the particular attributes defining the service (e.g., expected access time).

The defined set of communication users are those which are allowed access to this System and the services and functions afforded by this System.

A System itself is composed of one or more elements known as RF Subsystems (RFSS). Multiple RFSS are interconnected via a standard defined interface complying with the ISI ("G" of the Standard Model). This interconnection may be accomplished for example by utilizing a Private/Public switch network, or utilizing dedicated circuits in a mesh configuration.

The RFSS of different manufactures may be combined into a single System. The System control is provided in a distributed, peer-to-peer fashion across the RFSS elements of the System.

The System may optionally maintain a database of all communication users assigned to this System. This maintains the attributes for these communication users. This also provide mobility management for these communication units (e.g., track the current routable location of the communication unit).

Communication users may freely roam within the coverage area of the System and receive seamless communication service for the defined set of communication services for this System.

Network management of the System (composed of multiple RFSSs) shall consist of coordinating distributed managing entities for unique System entities (i.e., RFSS) at a System level.

3.1.1 RF Subsystem

The System is composed of RF Subsystems. The RFSS is the smallest portion of the infrastructure bounded by the standard APCO interfaces (namely the Common Air, Data Peripheral, Intersystem, Telephone, and Network Management interfaces). *[The standard definitions of the components and interfaces internal to the RFSS are currently outside the scope of the APCO Project 25 standard.]*

The RFSS shall provide the System set of services across some portion of the System coverage area with at least a first grade of service. (It is conceivable that a service offering completely within the domain of a single RFSS of the System could provide a better grade of service than is guaranteed for the entire System. For example, there may be an optional service which the RFSS is capable of supporting but which is not generally available across the entire System, and thereby is not considered one of the System service offerings.)

The components of the RFSS which are not established as standard open interfaces in APCO Project 25 activities shall be provided by a common manufacturer.

The RFSS may optionally assume the task of tracking and managing the communication users currently associated with its particular RFSS.

Communication users may freely roam across the coverage area of the RFSS and receive seamless communication service across the coverage area of the RFSS.

3.1.2 Interfaces

The RFSS shall have the capability to be configured with the following APCO Project 25 interfaces:

Common Air Interface ("U_m" of the Standard Model))

The RFSS optionally may be configured as required with the following APCO Project 25 interfaces:

Data Host Interface ("E_d" of the Standard Model)
Network Management Interface ("E_n" of the Standard Model))
Telephone Interface ("E_t" of the Standard Model)
Inter-RF Subsystem Interface ("G" of the Standard Model)

Note: The RFSS optionally may be configured for other interfaces as future APCO Project 25 activities may develop.

3.2 Network

This is a "logical" grouping of Systems to typically increase the coverage area to support some portion (possibly all) of the set of communication services (i.e., roaming, group dispatch, telephone interconnect, etc.), <u>across</u> an increased coverage area, at some second grade of service for a defined set of communication users.

The Network will have the capability of supporting all the designated mandatory services and functions [ref 2].

(It is conceivable that some services will not span the Network. Such services would not be considered as part of the set of services for the Network. The Network will provide such services to the roaming communication user only on a specific System basis, where the particular System is capable of supporting the service.)

(NOTE: It is not to be implied that the second grade of service is necessarily inferior to the first grade of service. The second grade of service may be at least equal to the first grade of service.)

The Systems of different manufactures may be combined into a single Network. The Network control is provided in a distributed, peer-to-peer fashion across all the Systems of the Network.

Communication users of this set may freely roam within the coverage area of the Network.

Roaming between Networks shall be coordinated by the (Network) managing entities of the roaming (visiting Network) and the roamed (hosting Network) elements.

3.2.1 System

Each System of the Network shall support at least the set of communication services defined for this Network for the set of communication users. [It is conceivable that for a communication service totally within the domain of a single System of the Network, the grade of service for this communication service may exceed that of the general Network.]

3.2.2 Interfaces

In a network configuration, System elements shall be interconnected via the standard ISI ("G" of the Standard Model).

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Appendix B GLOSSARY OF TERMS, ACRONYMS, AND ABBREVIATIONS

Introduction

This glossary has been developed to clarify terms used by APCO Project 25, in establishing standards and bulletins for digital radio for Public Safety. They have been designed to coincide with, or complement, Federal Standard 1037B and the IEEE Standard Dictionary of Electrical and Electronic Terms, where identical terms are used. They may or may not be identical to the same or similar terms described elsewhere.

4-ary FM signaling
The transmission of digital data such that each signaling symbol can take on any of 4, rather than two, states. This multilevel (or multiple decision threshold) system implies three or more transmitted conditions.

A Interface
The label given to the Radio Data Peripheral Interface for mobile and portable subscriber units.

Access
A performance measure of systems. It is measured from the time a data packet is sent from one of the units using the channel to the time the packet is received and processed by the receiving unit.

Access Method
The ability and means necessary to store data, retrieve data, or communicate with a system. FDMA, TDMA and CDMA are examples.

ACIPR
Abbreviation for "Adjacent-Channel Interference Protection Ratio."

ADCCP
Abbreviation for "Advanced Data Communication Control Procedure." American version of HDLC.

ADPCM
Abbreviation for "Adaptive Differential Pulse Coded Modulation." A form of differential pulse code modulation in which the prediction algorithm is adaptive to the incoming signal.

ALGID
Abbreviation for the eight BITs which identify the encryption algorithm in systems with multiple encryption algorithms.

Algorithm
A finite set of well defined rules for the solution of a problem, in a finite number of steps.

ALOHA
See Pure "ALOHA"

ALPC
Abbreviation for a "Adaptive Linear Predictive Coding" technique.

Amplitude Droop
Of a captured burst occurs when the overall amplitude of the transmitted signal varies over the burst as a function of time.

APCO
Abbreviation for "Associated Public-Safety Communication Officers, Inc."

APCO Project 16A
A suite of operational requirements developed by APCO for Public Safety trunked radio systems. It is titled "900 MHz Trunked Communications System Functional Requirements Development, Dated March 1979."

Application layer
Layer 7 of the OSI model. The highest layer. This layer interfaces directly to, and performs common application services for, the application processes; it also issues requests to the Presentation Layer. The common application services provide semantic conversion between associated application processes. Note: examples of common application services of general interest include the virtual file, virtual terminal, and job transfer and manipulation protocols

ARPAnet
A computer network developed by the Advanced Research Projects Agency of the U.S. Department of Defense.

ARQ
Automatic Retry Request to retry corrupted data packets

ASCII
Abbreviation for "American Standard Code for Information Interchange" - A seven-BIT code that defines 128 characters, including control characters, letters,numbers, and symbols.

Audio throughput delay
Waiting time delay from audio input at sending unit until audio output at receiving unit.

Backward Compatibility
Ability of new units to operate within an "old" system infrastructure or to directly intercommunicate with an "old" unit.

Bandwidth
The difference between the limiting frequencies of a continuous frequency band. Typically measured in kilohertz. May be considered the amount in kilohertz required for a single communications channel.

BCH
Abbreviation for "Bose-Chaudhuri-Hocquenghem," a binary coding scheme.

BER
Abbreviation for "BIT Error Rate"

BER Threshold
The level at which the BIT error rate exceeds the error correction capability and communication fails in a digital system.

Binary Backoff Procedure
A procedure used to adjust the retransmission time in the CSMA/CD random access technique. It doubles the retransmission interval each time a collision is detected.

BIT
Acronym for binary digit.

BIT Rate
In a BIT stream, the number of BIT occurring per unit time, usually expressed as BITs per second or BPS.

BIT Stuffing
A method used for synchronizing BIT streams that do not necessarily have the same or rationally related BIT rates, by adding non-information ("stuffing") BITs.

Blocking IPR
An Intellectual Property Right, patent, copyright or other right proprietary to an individual, group or company, which precludes someone else from making, using or selling that invention.

Blocking Probability
The probability that customers are turned away in a queue or other service system.

BPS
Abbreviation for BITs Per Second, a data rate measure.

BR
Base Radio, a reference designating a base station radio.

C4FM
The acronym for a 4-ary FM transmitter which uses QPSK-C modulation to work with a CFDD compatible receiver.

CAI
Abbreviation for Common Air Interface.

Call Congestion
The ratio of calls lost due to a lack of system resources to the total number of calls over a long interval of time.

Call Delay
The delay experienced when a call arriving at an automatic switching device finds no idle channel of facility available to process the call immediately.

Call Set-up Time
The overall length of time required to establish a circuit switched call between users or terminals.

Capture Effect
An effect associated with the reception of frequency modulated signals in which if two signals are received on or near the same frequency, only the stronger of the two will appear in the output.

Carrier Noise Level
The noise level resulting from undesired variations of a carrier in the absence of any intended modulation.

Carrier Squelch
A radio receive mode of operation that causes the receiver to unmute in the presence of a received signal.

CCITT
Abbreviation for "International Telegraph and Telephone Consultative Committee."

CDMA
Abbreviation for Code Division Multiple Access. A coding scheme in which digital information is encoded in an expanded bandwidth format. An access method that allocates each user a coded set of channels on which to send outgoing information frames.

CELP
Abbreviation for a "Code Excited Linear Predictive" voice coding technique (analog to digital voice conversion).

CEPT
Abbreviation for a "European Committee of Post and Telegraphs" (Telephone - Telecommunications)

CFB
Abbreviation for a "Cipher Feedback" an encryption synchronization method

CFDD
The acronym for a receiver which uses QPSK-C compatible modulation. CCFD stands for Compatible Frequency Discriminator Detection.

Channel
A single unidirectional or bidirectional path for transmitting or receiving, or both, of electrical or electromagnetic signals.

Channel Rate
The data rate at which information is transmitted through the channel, typically stated in BITs per second (BPS).

Channel Spacing
Typically measured in kilohertz from the center of one channel to the center of the next-adjacent-channel. May, or may not, be identical to bandwidth.

C/I
Abbreviation for "Carrier to Interference" signal ratio.

CM
Abbreviation for a "Circuit Merit" A delivered voice quality test and rating strategy

CODEC
A COder-DECoder device (analog to digital voice conversion).

CODE Type 1
An encryption code definition.

CODE Type 2
An encryption code definition.

CODE Type 3
An encryption code definition.

CODE Type 4
An encryption code definition.

Common Air Interface (CAI)
A radio to radio signal path defined in terms of Access Method, Modulation Scheme, Vocoding Method, Channel Data Rate and Channel Data Format.

Common channel signaling (CCS)
A signalling method using one of the channels on a multichannel network for the control, accounting and management of traffic on all of the channels of the network.

Connectionless Data Service
Service at a given layer of the OSI Reference Model in which there is no connection setup phase.

Conventional Systems

Type-A Systems: A non-infrastructure dependent technique where communications resources of independent logical channels are shared amongst system users by means of subscriber discipline without automatic system intervention. Each logical channel may only support the function channel type of digital voice. (e.g. simple talk-listen operation)

Type-B Systems: An infrastructure dependent technique where communications resources of independent logical channels are shared amongst system users by means of subscriber discipline without automatic system intervention. Each logical channel may support both digital voice and digital data functional channel types. Where hybrid voice and data usage is provided, automatic control over the data resource is provided to effectively manage data transmissions and to manage voice/data traffic conflicts.

Composite Conventional Systems: An infrastructure dependent technique where communications resources are comprised of one or more mutually exclusive logical channels. Subscribers are permanently assigned to a specific logical channel. No subscriber traffic load allocation between logical channels is provided. All users assigned to a particular logical channel share that channels resource by means of an automatic resource allocation management technique based upon statistical queuing theory. Typically usage requests follow a Poisson arrival process and the resource allocator assigns communications resources in response to requests from system users. Each of these mutually exclusive logical channels employ Composite Control.

Console

A subsystem comprised of one or more elements from a single manufacturer that is the device(s) which allows a person(s) to effectively and efficiently use and control the capabilities and the functions of the radio system(s) to which it is attached.

Covert

Adjective used to describe undercover operations by government agents. "Covert" communications are generally encrypted.

CQPSK

The acronym for a QPSK AM transmitter which uses QPSK-C modulation to work with a CFDD compatible receiver.

CRC

Cyclic Redundancy Checksum for data error detection.

CSMA/CD

Abbreviation for "Carrier Sense, Multiple Access" with "Collision Detection." It is a multiaccess technique in which stations listen before transmitting. A transmitting station detecting a collision aborts its transmission.

CTCSS

Abbreviation for "Continuous Tone-Controlled Squelch System."

CVSD
Abbreviation for "Continuously Variable Slope Delta" modulation technique. A type of delta modulation in which the size of the steps of the approximated signal is progressively increased or decreased as required to make the approximated signal closely match the input analog signal.

DAM
Abbreviation for a "Diagnostic Acceptance Measure." An audio acceptability test.

Data Link Layer
Layer 2 of the OSI model. This layer responds to service requests from the Network Layer and issues service requests to the Physical Layer. The Data Link Layer provides the functions and procedural means to transfer data between network entities and to detect and possibly correct errors that may occur in the Physical Layer. Note: examples of data link protocols are HDLC and ADCCP for point-to-point or packet-switched networks and LLC for local area networks.

Datagram Service
Service at the network layer in which successive packets may be routed independently from end to end. There is no call setup phase. Datagrams may arrive out of order.

DCA
Abbreviation for "Defense Communications Agency"

DCE
Abbreviation for "Data Circuit terminating Equipment" through which the DTE is connected to a network.

DCPSK
Abbreviation for the "Differential Coherent Phase Shift Keying" modulation technique. A method of encoding information in terms of phase changes, rather than absolute phases, and detected by comparing phases of adjacent BITs.

DCT
Abbreviation for "Discrete Cosine Transform" a technique used in vocoding.

Deadlock
A situation in which traffic ceases to flow and throughput drops to Zero.

De-Key
Turn the transmitter off (release the Push-to-Talk switch).

Delay Time
The sum of waiting time and service time in a queue.

DES
Abbreviation for "Digital Encryption Standard"

Dibit
Two BITs grouped together to represent a 4-level symbol

Differential Manchester Encoding
A modified version of Manchester coding. In this scheme, the phase of successive binary intervals is switched.

Differential Modulation
A type of modulation in which the choice of the significant condition for any signal element is dependent on the choice for the previous signal element.

DNA
Abbreviation for DEC's "Digital Network Architecture".

DPA
Abbreviation for "Demand Protocol Architecture"

DPSK
Abbreviation for "Differential Phase Shift Keying" modulation technique. A method of encoding information for digital transmission. In DPSK, each signal element is encoded as a change in the phase of the carrier with respect to its previous phase angle.

DQPSK
Abbreviation for "Differential Quadrature Phase Shift Keying" modulation technique.

DRT
Abbreviation for a "Diagnostic Rhyme Test" An audio intelligibility test

DS0
Abbreviation for a 64 kBPS telephone service

DS1
Abbreviation for a 1.544 MBPS telephone service.

DSP
Abbreviation for "Digital Signal Processor" a specialized microcomputer.

DTE
Abbreviation for "Data Transmission Equipment" (user systems).

DTMF
Abbreviation for "Dual-Tone Multi-Frequency" - a signalling scheme used by the telephone system in which two voice band tones are generated for each keypad key press.

Dual Mode Equipment
Equipment which will transmit and receive information using either the APCO Project 25 standard digital signals or current analog standard signals without modification or interfacing devices.

DVP
Abbreviation for "Digital Voice Protection" - one of several encryption algorithms used to provide secure voice radio transmissions.

EA
Abbreviation for "Enhanced Address."

EASAP
Abbreviation for "Enhanced Address Service Access Point."

EBCDIC
Abbreviation for "Enhanced Binary Code for Digital Information Communication" - An eight-BIT code that defines characters, including control characters, letters,numbers, and symbols.

ECC
Abbreviation for "Error Correction Code" See Error Correction.

ECMA
Abbreviation for "European Computer Manufacturers Association."

Ed Interface
The label given to the Host and Data Interface in the General System Model.

En Interface
The label given to the Network Management Interface in the General System Model.

Encryption
A coding of plain text (or clear voice) into unintelligible forms for secure transmission.

erlang
An international, dimensionless unit of the average traffic intensity (occupancy) of a facility during a period of time, normally a busy hour. The number of erlangs is the ratio of time during which a facility is occupied to the time the facility is available for occupancy.

erlang-B Distribution
Erlang distribution of the first kind, or erlang loss formula.

Error Correction
Digital coding technique for detecting and correcting information transmission errors.

Error Vector Magnitude (EVM)
Is a modulation quality measure for digitally modulated transmitters. It is measured by computing the RMS average of the magnitudes of the error vectors which describe the difference between the ideal symbol vector and the transmitted symbol vector at the decision (time) points. This measurement can also report individually, the AMPLITUDE ERROR in percent and the PHASE ERROR in RMS degrees. This measurement is typically done with Digital Signal Processing on a captured data burst.

ES
Encryption Synchronization information embedded in a voice data frame

Et Interface
The label given to the Telephone Interconnect Interface in the General System Model.

EVM
Error Vector Magnitude

ETSI
Abbreviation for "European Telecommunications Standards Institute."

FAX
Abbreviation for "Facsimile"

FCC
Abbreviation for "Federal Communications Commission"

FCFS (FIFO)
A service discipline of queuing systems, based on the First Come, First Served rule.

FDDI
Abbreviation for "Fiber Distribution Data Interface"

FDMA (Frequency Division Multiple Access)
Access method that divides a communication channel into two or more individual channels.

FEC
Abbreviation for "Forward Error Correction"

FIFO(FCFS)
A service discipline of queuing systems, based on the First In, First Out rule.

FIPS
Abbreviation for "Federal Information Processing Standard."

Firmware
Software that is permanently stored in a hardware device which allows reading and executing the software, but not writing or modifying the software.

Flow Control
In data communications systems, a device function that controls the rate at which data may be transmitted from one terminal so that it is equal to the rate at which it can be received by another terminal.

FNE
Abbreviation for "Fixed Network Equipment."

Format
In data transmission, the arrangement of contiguous BITs or Frame sequences which make a group, word, message or language.

Frame
In data transmission, the sequence of contiguous BITs bracketed by and including beginning and ending flag sequences. Unit of data of the data link layer.

FS
Frame Synchronization to mark the first information BIT

FSxxxx
Federal Standard number.

FSK
Frequency Shift Keying A form of frequency modulation in which the modulating signal shifts the output frequency between predetermined values.

FSNF
Abbreviation for "Fragment Sequence Number Field" in the Common Air Interface.

FTP
Abbreviation for "File Transfer Protocol."

Full-Duplex
An operating method in which transmission is permitted, simultaneously, in both directions of a telecommunications channel.

G Interface
The label given to the Inter-RF-Subsystem Interface in the General System Model.

Galois Field (GF)
A data field used to calculate parity checks for a Reed-Solomon code.

Gateway
An interface that provides the necessary protocol translation between disparate networks.

GF
Galois Field to calculate parity checks for a Reed-Solomon code

GMSK
Abbreviation for "Gaussian Minimum Shift Keying" A form of frequency modulation in which the modulating signal shifts the output frequency between predetermined values. A form of MSK which uses gaussian low pass filtering of the binary data to reduce sideband energy.

Golay
Name of a standard error correction code

GOSIP
Abbreviation for "Government Open Systems Interconnection Profile"

GPS
Abbreviation for "Global Positioning System"

Graceful Close
Method used to terminate a connection at the transport layer with no loss of data.

GSM
Abbreviation for "Group Specialized Mobile" radio service

Half-Duplex
That mode of operation in which communications occurs between two terminals in either direction, but only one direction at a time. May occur on a half-duplex or duplex circuit but not on a simplex circuit.

HDLC
Abbreviation for "Highlevel Data Link Control." The international standard for data link control developed by ISO.

Hex BIT
6 BITs grouped together to represent a Reed-Solomon code symbol

Hierarchial Numbering
Multiple level numbering. An example is the telephone number made up of levels such as "Country Code," "Area Code," "Exchange Number" and "Line Number."

Hierarchical Routing
Multiple level routing. Used both in packet switching and circuit switching.

Hub Polling
One of the polling techniques. Permission to transmit is passed sequentially from one designated user to another.

I/O
Abbreviation for "Input and/or Output."

IEEE
Abbreviation for "Institute of Electrical and Electronics Engineers, Inc."

ILS
Abbreviation for an "Input buffer Limiting Scheme." A flow control scheme that blocks overload locally generated arrivals by limiting their number at a buffer.

IMBE
Abbreviation for "Improved Multi Band Excitation" A voice coding technique based on Sinusoidal Transform Coding (analog to digital voice conversion).

Inband Signaling
Signalling that uses frequencies or time slots within the bandwidth of the information channel.

Incarnation Number
A unique name or number sent within a data unit to avoid duplicate data unit acceptance.

IP
Abbreviation for "Internetwork Protocol" in the ISO activities, as well as Internet Protocol in ARPA protocol activities.

IPR
Abbreviation for "Intellectual Property Rights" Patents, Copyrights or similar rights which are proprietary to an individual, group or company.

IQ Origin Offset
Is a measurement that shows how well balanced the IQ modulators in the transmitter are and if there is excessive leakage around them.

IRAC
Abbreviation for the Federal Government "Interdepartment Radio Advisory Committee."

ISDN
Abbreviation for "Integrated Services Digital Network" All-digital network handling a multiplicity of services with standard interfaces for user access. An integrated digital network in which the same time-division switches and digital transmission paths are used to establish connections for different services.

ISO
Abbreviation for "International Standards Organization"

kBPS
Abbreviation for BITs per second in thousands.

Key
The parameter defining an encryption code or method.

Key Tag
The parameter defining one of several encryption codes or methods.

KID
Sixteen BITs which identify the encryption key in systems with multiple encryption keys.

LAN
Abbreviation for "Local Area Network."

LAPB
Abbreviation for "Balanced link access procedure." The data link level of X.25. Same as a subset of the asychronous balanced mode of HDLC.

LC
Link Control information embedded in digital voice

Linear Amplifier
A radio final amplifier in which the output is linearly proportional to the input. Usually a class A amplifier.

Linearized Amplifier
A radio final amplifier in which the output is mostly linearly proportional to the input. Usually a class AB amplifier.

LLC
Logical Link Control sublayer of the OSI Data Link Layer

LMR
Abbreviation for "Land Mobile Radio"

Local Area Network (LAN)
A network covering small geographic areas .

LSB
Abbreviation for "Least Significant BIT."

LSD
Low Speed Data embedded in digital voice

LU
Abbreviation for "Logical Unit."

MAC
Media Access Control sublayer of the OSI Data Link Layer

Managed Conventional
Systems with enriched feature sets in which information about subscriber operational capability and availability are centrally (within a sub-system) managed. OTAR/OTAC functions are examples of system functionality requiring management.

Manchester Encoding
A way of encoding to get a zero-DC binary waveform. In this encoding scheme, half of the BIT interval is transmitted with a positive signal and the other half is transmitted with a negative signal.

M-ary Signaling
The transmission of digital data such that each signaling symbol can take on any of M, rather than two, states. This multilevel (or multiple decision threshold) system implies three or more transmitted conditions.

MDT
Abbreviation for "Mobile Data Terminal"

Mean Frequency Offset
A measurement over the captured burst that is a measure of the FREQUENCY ERROR from the EVM measurement

MFID
Abbreviation for "Manufacturer's Identity." An eight-BIT field identifying manufacturer of the radio equipment.

MI
Message Indicator to initialize encryption

MIB
Abbreviation for "Management Information BITs."

MIL-STD
Abbreviation for "Military Standard".

MODEM
An acronym for MOdulator/DEModulator. A device for converting digital signals into quasi-analog signals for transmission over analog communications channels and for reconverting the quasi-analog signals into digital signals.

Modulation
A controlled variation of any property of a carrier wave for the purpose of transferring information.

MOS
Abbreviation for "Mean Opinion Score." An audio quality test.

MR
Mobile Radio, a reference designating a mobile or portable subscriber unit

MSB
Abbreviation for "Most Significant BIT."

MSK
Abbreviation for "Minimum Shift Keying." A form of frequency modulation in which the modulating signal shifts the output frequency between predetermined values. Sometimes called fast frequency shift keying.

Network layer
Layer 3 of the OSI model. This layer responds to service requests from the Transport Layer and issues service requests to the Data Link Layer The Network Layer provides the functional and procedural means of transferring variable length data sequences from a source to a destination via one or more networks while maintaining the quality of service requested by the Transport Layer. The Network Layer performs network routing, flow control, segmentation/desegmentation, and error control functions.

NASTD
Abbreviation for "National Association of State Telecommunications Directors."

NCS
Abbreviation for "National Communications Systems group" a Federal agency.

NID
Network Identifier code word following the frame sync

NIST
Abbreviation for "National Institute of Standards and Technology" a Federal agency.

NPSPAC
Abbreviation for "National Public Safety Planning Advisory Committee" A user/industry advisory committee established by the Federal Communications Commission to develop a plan for the use of the 800 MHz Public Safety spectrum.

NSA
Abbreviation for the Federal Government "National Security Agency."

NTIA
Abbreviation for "National Telecommunications and Information Administration". a Federal agency.

Octal
Base 8 notation for numbers, also called radix 8

Octet
Eight BITs grouped together, also called a byte

OFB
Abbreviation for a "Output Feedback." An encryption synchronization method.

On-Premise Extension
An extension telephone, PBX station, or key system station located on property that is contiguous with that on which the main telephone, PBX, Or key system is located. See also extension facility, off-premises extension, on-line.

On-Premises Wiring
Customer-owned metallic or optical-fiber communications transmission lines, installed within or between buildings. Note: On-Premises Wiring comprises horizontal wiring and backbone wiring, and extends from the external network interface to the user work station areas. It includes the total communications wiring to transport current or future data, voice, LAN, and image information.

Open Network Architecture (ONA)
In the context of the FCCs Computer inquiry III, the overall design of a communication carrier's basic network facilities end services to permit all users of the basic network to interconnect to specific basic network functions and interfaces on an unbundled, equal-access basis. Note: the ONA concept consists of three integral components (a) basic service arrangements (BSAs), (b) basic service elements (BSEs), and (c) complementary network services.

Open System
A system whose characteristics comply with specified standards and that therefore can be connected to other systems that comply with these same standards. Note: contrast with closed system (FP) (ISO).

Open Systems Interconnection (OSI)
A logical structure for network operations standardized within the ISO; a seven-layer network architecture being used for the definition of network protocol standards to enable any OSI-compliant computer or device to communicate with any other OSI-compliant computer or device for a meaningful exchange of information

Open System Interconnection (OSI) Architecture Network
Architecture that adheres to that particular set of ISO standards that relates to Open Systems Architecture

Open Systems Interconnection (OSI) Protocol Specification
The lowest level of abstraction within the OSI standards scheme Each OSI-Protocol Specification operates at a single layer. Each defines the primitive operations and permissible responses required to exchange information between peer processes in communicating systems to carry out all or a subset of the services defined within the OSI-Service Definitions for that layer.

Open System Interconnection--Reference Model (OSI/RM)
An abstract description of the digital communication between application processes running in distinct systems. The model employs a hierarchical structure of seven layers. Each layer performs value-added service at the request of the adjacent higher layer and, in turn, requests more basic services from the adjacent lower layer.
-Physical Layer: Layer 1
-Data Link Layer: Layer 2
-Network Layer: Layer 3
-Transport Layer: Layer 4
-Session Layer: Layer 5
-Presentation Layer:Layer 6
-Application Layer: Layer 7

Open Systems Interconnection (OSI)-Service Definitions
The next lower level of abstraction below that of the OSI-Reference Model The OSI Service-Definitions for each layer define the layer's abstract interface and the facilities provided to the user of the service independent of the mechanism used to accomplish the service .

Open Systems Interconnection (OSI)--Systems Management
Functions in the Application Layer related to the management of various OSI resources and their status across all layers of the OSI architecture .

Operating System
An integrated collection of routines that service the sequencing and processing of programs by a computer. Includes such functions as memory allocation, file management, input and output operations, communications and interfacing to other application software.

OSI
Abbreviation for "Open System Interconnection."

OTAC
Abbreviation for "Over-The-Air-Control."

OTAP
Abbreviation for "Over-The-Air-Programming."

OTAR
Abbreviation for "Over-The-Air-Rekeying."

Packet
A sequence of binary digits, including data and control signals, that is transmitted and switched as a composite whole. The data, control signals and possibly error control information, are arranged in a specific format.

Packet Switching
The process of routing and transferring data by means of addressed packets so that a channel is occupied during the transmission of the packet only, and upon completion of the transmission the channel is made available for the transfer of other traffic.

PBX
Abbreviation for "Private Branch Exchange." A privately owned switch, generally of relatively small size, connected via output trunks to the public switched telephone network.

PCM
Abbreviation for "Pulse Coded Modulation." That form of modulation in which the modulating signal is sequentially sampled, quantized, and coded into a binary form for transmission over a digital link.

PDT
Abbreviation for "Portable Data Terminal"

PDU
Abbreviation for "Protocol Data Unit", the unit of data in the OSI Reference Model containing both protocol-control information and user data from the layer above.

Physical Layer
Layer 1 of the OSI model the lowest of seven hierarchical layers. The Physical layer performs services requested by the Data Link Layer. The major functions and services performed by the physical layer are: (a) establishment and termination of a connection to a communications medium; (b) participation in the process whereby the communication resources are effectively shared among multiple users, e.g., contention resolution and flow control; and, (c) conversion between the representation of digital data in user equipment and the corresponding signals transmitted over a communications channel.

$\pi/4$ DQPSK
Abbreviation for "Differential Quadrature Phase Shift Keying" modulation technique. $\pi/4$ indicates 90° phase angles.

$\pi/4$ QPSK
Abbreviation for "Quadrature Phase Shift Keying" modulation technique. PSK using four phase states. $\pi/4$ indicates 90° phase angles.

PN Sequence
A pseudo random BIT sequence used in vocoding.

Poisson Process
one of the most common arrival processes in queuing theory which has the memoryless property of successive arrivals.

Polling
A network control system in which a designated control station invites its tributary stations to transmit in any sequence specified by the control station.

POTS
Abbreviation for "Plain Old Telephone Service."

PPP
Abbreviation for "Point-to-Point Protocol."

Presentation Layer
Layer 6 of the OSI model. This layer responds to service requests from the Application Layer and issues service requests to the Session Layer. The Presentation Layer relieves the Application Layer of concern regarding syntactical differences in data representation within the end-user systems. Note: an example of a presentation service would be the conversion of an EBCDIC-coded text file to an ASCII-Coded file.

Primitives
Abstract representations of interactions across the service access points, indicating information is passed between the service user and service provider. There are four types of primitives in the OSI Reference Model: request, indication, response, and confirm.

Processing Delay
The time in ms required for the coding and decoding of voice or data information.

Protocol
A set of unique rules specifying a sequence of actions necessary to perform a communications function.

PSDN
Abbreviation for "Public Switched Data Network."

PSK
Abbreviation for "Phase Shift Keying." A method of modulation used for digital transmission wherein the phase of the carrier is discretely varied in relation to a reference phase, or the phase of the previous signal element, in accordance with the data to be transmitted.

PSTN
Abbreviation for "Public Switched Telephone Network."

PTT
Abbreviation for "Push-to-Talk", the switch on a subscriber unit which, when pressed, causes the subscriber unit to transmit.

PU
Abbreviation for "Physical Unit."

Pure ALOHA
A random access technique developed by the University of Hawaii in the early 1970s. In this scheme, a user wishing to transmit does so at will. Collisions are resolved by retransmitting after a random period of time.

Quadrature Modulation
Modulation of two carrier components 90° apart in phase by separate modulating functions.

QAM
Abbreviation for "Quadrature Amplitude Modulation." Quadrature modulation in which some form of amplitude modulation is used for both inputs.

QPSK
Abbreviation for "Quadrature Phase Shift Keying" modulation technique. PSK using four phase states.

QPSK-C family
A form of digital modulation which can use a C4FM FM transmitter or a CQPSK AM transmitter with a CFDD compatible receiver. This modulation method is a blend of 4-level FSK and $\pi/4$ DQPSK, which allows operation using either a transmitter with a frequency modulator using a class C power amplifier or a transmitter with an AM modulator using a linear class AB power amplifier. The CFDD compatible receiver is used for either transmitter.

Quad QAM
Abbreviation for "4 Quadrature Amplitude Modulation."

Reed-Solomon (RS)
An error correction coding scheme for binary data fields.

Reference Vocoder
The particular implementation of the APCO Project Vocoder available from Digital Voice Systems Incorporated as Model VC-20-PRJ25. This is the agreed upon reference implementation of the APCO Project 25 Vocoder.

Remote Concentrator
A remote extension of a local switch often used to concentrate or multiplex remote users via one transmission facility to the local switch to which directed.

RF
Abbreviation for "Radio Frequency."

RF-Subsystem
The RF infrastructure which is bounded by the five open APCO Project 25 interfaces and three standard computer network gateway interfaces. It is the RF equipment and related non standard peripheral equipment which provides a standardized RF communication channel. One of the APCO Project 25 interfaces is the Common Air Interface (CAI).

RS-232
An asynchronous, serial, data transmission standard that defines the required sequence, timing, and hardware interface.

RS
Reed-Solomon error correction code.

SAP
Service Access Point, where a network provides a service.

SDLC
Abbreviation for "Synchronous Data Link Control." Data link control in IBM's SNA.

Session Layer
Layer 5 of the OSI model. This layer responds to service requests from the Presentation Layer and issues service requests to the Transport Layer. The Session Layer provides the mechanism for managing the dialogue between end user application processes. It provides for either duplex or half-duplex operation and establishes checkpointing, adjournment, termination, and restart procedures.

Setup Delay
The time in ms required to actuate equipment for transmission and reception.

Signal
The detectable transmitted energy which carries information from a transmitter to a receiver.

SINAD
Abbreviation for "SIgnal plus Noise And Distortion" to "noise and distortion" ratio.

Slotted ALOHA
A random access technique extending pure ALOHA to the case in which messages may only be transmitted in slotted intervals of time.

SMPT
Abbreviation for "Simple Mail Transfer Protocol."

SMRS
Abbreviation for "Specialized Mobile Radio Service."

SNA
Abbreviation for IBM's Systems Network Architecture. This is a seven-layer communication architecture.

SNMP
Abbreviation for "Simple Network Management Protocol."

Software
A set of instructions that tells the computer what to do.

Squelch
A radio circuit that eliminates noise from the speaker when no transmitted signal is present.

STC
Abbreviation for "Sinusoidal Transform Coding" A voice coding technique (analog to digital voice conversion).

STU III
Acronym for "Secure Telephone Unit, version III (3)."

Subscriber Unit
A mobile or portable radio unit used in a radio system.

Subsystem
A defined portion of any organized assembly of resources and procedures united and regulated by interaction or interdependence to accomplish a set of specific functions.

System
Any organized assembly of resources and procedures united and regulated by interaction or interdependence to accomplish a set of specific functions.

T1 system
A digital communication system designed to handle 24 voice channels at 64 kBPS each. Digital transmission media to support 1.544 mBPS. transmission speed.

Tandem Switch
An intermediate switch connecting two other switching exchanges.

TCP
Abbreviation for "Transmission Control Protocol." ARPAnet developed transport layer protocol.

TDMA (Time Division Multiple Access)
A communications technique that uses a common channel for communication among multiple users by allocating unique time slots to different users.

Telnet
Terminal-remote host protocol developed for ARPAnet.

TGID
Abbreviation for "Talk-Group Identifier." A twelve BIT field identifying talk-group of the radio message.

Throughput Delay
The total time in ms between the initiation of a voice or data signal, ie. push-to-talk, until the reception and identification of the identical signal at the received output speaker or other device.

TIA
Abbreviation for "Telecommunications Industry Association"

Time-Out-Timer
A function that limits the transmission period to a pre-defined time. The user will automatically stop transmitting when the timer goes off after the pre-defined time and will generate an alert to notify that no transmission is taking place.

TP
Abbreviation for "Transport Protocol," OSI Reference Model.

TPDU
Abbreviation for "Transport Protocol Data Unit."

Transmission Delay
The time in ms required for transmission of a voice frame or data packet through a communication channel.

Transport Layer
Layer 4 of the OSI model. This layer responds to service requests from the Session Layer and issues service requests to the Network Layer The purpose of the Transport Layer is to provide transparent transfer of data between end users, thus relieving the upper layers from any concern with providing reliable and cost-effective data transfer.

Trellis Code
Type of error correcting code for digital modulation

TriBIT
3 BITs grouped together into a symbol for a trellis code

TRS
Technical Requirements Specification

Trunk
A single transmission channel between two points that are switching centers or nodes, or both.

Trunked (system)
Systems with full feature sets in which all aspects of radio operation, including RF channel selection and access, are centrally managed.

Trunking

An infrastructure dependent technique where communications resources, comprised of more than one logical channel (trunk) are shared amongst system users by means of an automatic resource allocation management technique based upon statistical queuing theory and resident in the systems fixed infrastructure. Typically usage requests follow a Poisson arrival process and the resource allocator assigns communications resources in response to requests from system users. As demand for service exceeds system capability at that time, service must be increasingly denied immediate access. This action is termed "blocking", with the blocked service request being queued for a later service response. The offered grade of service of the system is inversely proportional to the probability of blocking (e.g. lower probability of blocking offers a higher grade of service potential).

The dynamic resource allocation methodology of trunking results in the establishment of functional channels defining resource availability by means of dynamically allocating logical channels both to particular subscribers and for specific functions. These functional channels can be used for the conveyance of payload information, system control or a combination thereof. This results in the development of three (3) specific types of functional channels, these are: control, digital voice, and digital data.

Dedicated Control Trunking: Refers to a logical channel resource which supports only control function channel type (e.g.. resource management signaling, requests for service, etc.) between the fixed trunking system infrastructure and the subscriber and associated units.

Composite Control Trunking: Refers to a logical channel resource which supports control functional channel type as well as digital voice and/or digital data functional channel types (e.g. teleservice related payloads).

TSAP

Abbreviation for "Transport Service Access Point" in the OSI transport protocol layer.

TSDU

Abbreviation for "Transport Service Data Unit" in the OSI transport protocol layer.

Type 1

An encryption code definition.

Type 2

An encryption code definition.

Type 3

An encryption code definition.

Type 4

An encryption code definition.

UDP
Abbreviation for "User Datagram Protocol."

ULP
Abbreviation for "Upper Layer Protocol." Layer above TCP.

Um Interface
The label given to the Common Air Interface reference point in the General System Model.

Unmanaged Conventional
Limited feature set systems which possess no centralized management of subscriber operation or capability. These systems are typically simple talk listen systems, perhaps with selective calling capability, but noway to change any of the operational capabilities of a subscriber without direct, physical alteration of the radio.

User Friendly
A term used to describe a device which can be operated using the least possible amount of mental and physical interaction by the device operator.

Vertical Partitioning
A way of separating groups or units in a hierarchial manner. In the public switched telephone system, for example, telephone numbers are made up of "vertical" levels such as "Country Code," "Area Code," "Exchange Number" and "Line Number."

VOCODER
A type of voice coder. Usually consisting of a speech analyzer and a speech synthesizer which convert analog speech into digital signals for transmission and digital signals back into artificial speech sounds for reception.

VSELP
Abbreviation for a "Vector Sum code Excited Linear Predictive" voice coding technique (analog to digital voice conversion).

Voice Coder
A type of digital coder, usually consisting of a speech analyzer and a speech synthesizer which converts analog speech into digital signals for transmission and digital signals back into artificial speech sounds for reception.

WAN
Abbreviation for "Wide-area Network"

X.25
The CCITT three-layered interface architecture for packet switching connecting a DTE to a DCE.

Appendix C STATEMENT OF REQUIREMENTS

NEW TECHNOLOGY STANDARDS PROJECT
DIGITAL RADIO TECHNICAL STANDARDS
STATEMENT OF REQUIREMENTS
Thursday August 11, 1994
Adopted by APCO Project 25 Steering Committee Thursday, August 12, 1994

A INTRODUCTION

The objectives of this effort to establish a standards profile for the operations and functionality of new digital Public Safety radio systems are as follows.

1. Obtain maximum radio spectrum efficiency.

2. Ensure competition in system life cycle procurement.

3. Allow effective, efficient and reliable intra-agency and interagency communications.

4. Provide "user friendly" equipment, "user friendly" being defined as the least amount of mental and physical interaction by the operator.

B GENERAL REQUIREMENTS LIST

In order to meet the stated objectives, it is felt that a general list of requirements is needed that defines the necessary system characteristics. This general list of requirements serves as a guideline for the more comprehensive list of detailed requirements which follows. To support this, the following statements are set forth as provided by Public Safety users with some modification.

1. The system shall offer channel utilization that immediately improves spectrum efficiency by at least two (2) times[1] over current analog systems, with a goal of an increase in improvement to at least four (4) times as technology continues to develop.

2. Subscriber units shall communicate in either a conventional or trunked environment using clear (un-encrypted digital), digitally encrypted voice, or data modes regardless of the manufacturer of the equipment.

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[1] Public Safety Frequencies 821-824/866-869 MHz presently use enhanced 25 kHz channel equipment together with a 12.5 kHz / 25 kHz regional coordination plan tied to minimum spacings between base stations. In this instance,. the improvement in spectrum efficiency with 12.5 kHz digital channels will be approximately 1.3 times.

3. The system shall provide up to four levels of encryption with compatible modes of operation and shall provide the same functions associated with clear (un-encrypted digital) operation.
Subscriber units shall be capable of zero, one or two types of encryption, as required.

   Type 1 is for classified national government communication.
   Type 2 is for unclassified national security-related communications.
   Type 3 is for unclassified sensitive government communications (e.g., Public Safety).
   Type 4 is for other purposes, (e.g., exportable).

4. Multiple radio subsystems must be interconnectable into larger systems. Further, subscriber unit units must be able to roam between different radio subsystems. Up to 64,000 different radio subsystems shall be uniquely identifiable. Further, each radio subsystem shall provide for up to 2,000 uniquely identifiable functional talk-groups or vertical partitions for distinct and separate organizations, and at least 48,000 individually identifiable subscriber units. Through hierarchical numbering, individual subscriber units and talk-groups from any radio subsystem are uniquely identifiable in any radio subsystem in concert with their home subsystem identification (similar to hierarchical telephone numbers and area codes).

5. The system shall be designed around a suite of operational standards so that field systems manufactured by different vendors can operate together and offer unit-to-unit communications based on predefined activation procedures.

6. Data transmission between a public or private switched telephone network access point, standard SNA, X.25, or TCP/IP networks and mobile (or portable) Data Terminal Equipment (DTE), over the RF link, are required. Data transmission shall operate at a speed of at least 9600 bps (including overhead) with minimal error retransmissions. All host applications on SNA, X.25, or TCP/IP networks shall have the ability to identify, and transparently communicate with any subscriber unit linked DTE device.

7. All subsystems which comprise a radio system must be under control of a single network management scheme, regardless of manufacturer. The scope of the single network management scheme includes the five basic elements of network management:

    a. Configuration Management
    b. Fault Management
    c. Security Management
    d. Performance Management
    e. Accounting Management

    Implicit in the ability to manage these elements is the transfer of relevant managed object attributes which can be used for example to generate;

    Managed information reports, alarms, reconfiguration, etc.

8. Management of system components and software levels shall be able to be performed from a single point.

9. Overall system management shall be able to delegate vertical partitioning management to the organization responsible for the operation of the partition.

10. Voice quality for both clear and encrypted communication shall be equal to or superior to current clear voice analog systems and the measure of quality shall include both male and female voices.

11. System range performance for both clear and encrypted communication shall be equal to or superior to current clear voice analog systems and shall include simulcast without the need for additional site development.

12. The system shall meet all the mandatory requirements and shall offer as options the same desirable features as APCO Project 16A. In all instances where APCO Project 25 Statement of Requirements conflicts with those of APCO Project 16A, the APCO Project 25 Requirements shall supersede.

13. Equipment size shall be comparable to existing analog systems. Portable subscriber units shall be offered for covert and uniformed users (covert portable being smaller) with batteries that shall power these portables for at least 8 hours (5,5,90 duty cycle) with minimal size and weight.

14. Interconnection to public switched telephone network shall be equal to or superior to current analog systems.

15. Each manufacturer's system shall provide for backward compatibility with that manufacturer's existing analog systems to facilitate a graceful and gradual migration from the old analog to the new digital. As a minimum, this shall include mobile and portable subscriber units. In addition, subscriber units shall include the ability to select and operate on available analog mutual aid channels for communications with the fixed network equipment as well as direct unit-to-unit.

16. The system shall be able to co-exist with older analog systems, share the same segments of allocated RF spectrum and provide little interference to existing adjacent-channel analog systems as well as work properly.

17. The system shall be technically flexible to allow for single and multiple site systems, voting and simulcast designs, with variable numbers of stations per site. The system shall allow for single station sites without loss of control, voice, or text capability. The maximum number of stations at a site shall not be limited for future growth.

18. The system shall allow for continued enhancement of standardized functions and features so that the system can grow with user needs. Further, a standard method shall be specified for segmenting non-standard (or potentially future-standard), value-added features between manufacturers to safeguard from unintentional interaction between subscriber units of different manufacturers subsystems.

19. The system shall minimally be equally adaptive to all Public Safety mobile radio frequency bands and blocks of spectrum, without precluding its adapting to other land mobile bands.

20. The mobile and portable equipment shall meet the applicable sections of MIL-STD-810D "Environmental Test Methods and Engineering Guide" as follows.

    506.2 Rain, Procedure I (blowing rain)
    509.2 Salt Fog, Procedure I (aggravated screening)
    510.2 Sand and Dust, Procedure I (blowing dust)
    514.3 Vibration, Procedure I, Category 1 (3 axes)
    516.3 Shock, Procedure I (functional)

21. Throughput delay shall be as follows:

    a. Less than 250 msec in direct radio-to-radio communications.
    b. Less than 350 msec in radio-to-radio communications through a single conventional repeater.
    c. Less than 500 msec in radio-to-radio communications within an RF subsystem.

22. The system shall be designed to be resistant to interference from co-channel, adjacent-channel, and intermodulation effects similar to Continuous Tone-Controlled Squelch Systems (CTCSS) used today.

23. The system shall allow direct mobile to mobile communication at any time without degrading normal system performance. Direct communication while in range of the fixed equipment shall do no more than temporarily capture receivers from possible outbound messages. Direct communication shall be possible at any time while out of range of the fixed equipment with no degradation in system performance or capacity.

24. A dispatcher shall have the ability to interrupt any call enabled by the system that an individual may be engaged in.

25. The mobile and portable equipment shall be able to scan both conventional channels (at least 8) and trunked talk-groups (at least 8) in both clear and encrypted voice. The scan to be completed in the minimum time. The scan shall be selectable priority which means that the transmitter channel or talk-group selected by the user is the priority channel or talk-group.

26. The system shall have over-the-air-re-keying (OTAR) of encryption keys.

27. The system shall allow mobiles and portables to roam over a wide coverage area with automatic connection as the unit enters a new site coverage area within any radio subsystem. The system must provide for registration and authorization control over subscriber units roaming between radio subsystems. Manual and automatic roaming capabilities shall be provided between radio subsystems.

28. The system shall allocate channels at sites based upon subscriber units present which need to receive a given message.

29. A manufacturer of an APCO 25 software product should define the extent of the operating environment over which the product is known to work.

C DETAILED REQUIREMENTS LIST

In order to meet the above stated general requirements list, it is felt that a detailed list of requirements is needed that defines the necessary system characteristics and services. The general rule for these detailed requirements is that they stem from one or more of the general requirements. To support this, the following requirements are recommended.

1 System Requirements

a. The system shall support existing 25 kHz and 12.5 kHz channelization where already established. Within 25 kHz channelization and where permitted, the system shall support operation on 2-for-1 12.5 kHz channelization. All protocols and procedures shall be adaptable to further channel splits as technology permits.

b. Systems or subsystems shall be configured in single site, multiple site non-simulcast, or multiple site simulcast. Multiple RF subsystems shall be combinable into larger wide-area systems. Wide-area systems shall be composed of individual RF subsystems which are independently capable of single site, multiple site, or multiple site simulcast. Any individual site need only deploy as many stations as necessary except in RF simulcast subsystems.

c. Systems shall support authorized roamers from compatible digital systems for interagency assistance.

d. All calls shall be digital except compatible analog voice calls.

e. The site (or simulcast RF subsystem) location of all subscriber units, including authorized roamers, shall be maintained by the system.

f. Calls shall not require resources at sites that do not contain addressed subscriber units (except simulcast RF subsystems).

g. RF subsystems shall contain all the control intelligence to support call processing and track unit location and roamers within the RF subsystem. All RF subsystems shall support standard signalling and communications interfaces to be flexibly linked into wider-area networks via private or public networks.

h. RF subsystems from any manufacturer (as described in C.1.g.) must be interconnectable into a wide-area system.

i. Signaling format(s) must be compatible with standard transmission facilities in accordance with the North American transmission standards as defined by Bellcore TR-TSY-000333 for Switched and Special Access Services.

2 RF Subsystem Interfaces

a. An RF subsystem shall support either analog or ISDN standard fixed-network PSTN interfaces for telephone interconnect.

b. An RF subsystem shall support a fixed-network host computer interface or an X.25, SNA, or TCP/IP network interface.

c. An RF subsystem shall support standard network management interfaces to other RF subsystems of any manufacturer.

d. An RF subsystem shall support standard service signalling and bearer channel interface for interconnection with other RF subsystems by a public or private wide-area network. The standard service set between RF subsystems shall be composed of the following.

(1) group calls setup
(2) private calls setup
(3) voice encryption control
(4) RF subsystem registration (roaming)
(5) analog bearer channel
(6) digital bearer channel
(7) access control and security

3 Common Air Interface Requirements

a. One channel bit-rate, modulation, and link layer shall be utilized for all voice and data capabilities, excepted only for manufacturer-specific subsystems to provide backwards compatibility to existing manufacturer-specific systems.

b. For single channel operation, control, voice, or data, features must be integrated into a common channel.

c. A standard service set for all manufacturers composed of the following.

(1) group calls
(2) private calls
(3) interconnect calls
(4) voice encryption control
(5) data messages
(6) site registration
(7) RF subsystem registration (roaming)
(8) dynamic subscriber unit talk-group regrouping
(9) emergency alarm
(10) User ID

4 Mobile/Portable Subscriber unit Requirements

a. Support all digital communications within this system.

b. Support analog communications within this system when involved in a call from an analog unit.

c. Support analog communications on a conventional channel.

d. Support a data port to an attached MDT (mobile data terminal), portable computer or other peripheral device.

D STANDARDS SUITE PROPOSED

In order to meet the stated objectives and requirements, it is felt that a comprehensive suite of standards is necessary that defines the interface characteristics and permits the interconnection of all system components. The necessary standards components are as follows.

1 Bandwidth

Adopt 12.5 kHz bandwidth channels with future migration to 6.25 kHz bandwidth channels as technology allows.

2 FS-1024

Adopt work done under FS-1024 project (Narrowband Digital Land Mobile Radio) as much as possible to ensure vendor competition and interoperability.

3 Interface

a. Establish a Common Air Interface all-digital trunking control standard, voice and data standard, and a control standard.

b. Adopt an RF subsystem Interface Standard for the connections between all RF subsystems from international, national or industry standards as appropriate and available. Such standards sources as CCITT shall be consulted, among others.

4 Host Interface Standard

The mobile data terminal (MDT) interface must be able to present an addressable MDT data stream to a host-attached port, physically over either an RS-232 or V.35 electrical interface, using either analog or digital transmission public switched telephone network (PSTN) facilities, or a computer network. When connected to a computer network, each MDT must be individually provided with its own network address, with such network presentation conforming to layers 1 through 3 of the OSI model according to the following specifications.

a. 1984 CCITT Recommendation X.25. The physical layer must be capable of conforming with EIA RS-232-C for data rates under 19.2 kbps and CCITT V.35 for data rates above 19.2 kbps. The link layer must be compliant with High-level Data Link Control (HDLC) Link Access Procedure Balanced (LAPB).

b. IBM System Network Architecture (SNA) using Physical Unit (PU) 2 to PU 4 with Logical Unit (LU) 2 and LU 3. The physical layer is as specified in item D.1., above. The link layer must be compliant with Synchronous Data-Link Control (SDLC).

5 Encryption Standard

a. Adopt FIPS 46 DES (Data Encryption Standard) to ensure vendor competition and interoperability.

STATEMENT OF REQUIREMENTS INDEX


TELECOMMUNICATIONS
INDUSTRY ASSOCIATION