Software Download

A major requirement of a software-defined/adaptable handset or terminal will be the ability to reprogram the device, via download of new software and/or parameter data to the terminal. This will permit for example:

- download of a new *user application*;
- download of a new *graphical user interface* (GUI) to change or improve the 'look and feel';
- download of a protocol stack, physical-layer configuration software, and control software to implement a *different air-interface* standard;
- incremental download of new software and/or parameters to *improve performance* (for example, a modified source codec);
- download of *software bug-fixes* (both applications and physical-layer/control software)

This feature is a key differentiator of software defined handsets from traditional single-standard implementations, and offers significant advantages of flexibility to manufacturers, service providers and users.

Methods by which software may be downloaded include:

- installation of new software from a new SIM card;
- from another computer, via for example a PC-card (PCMCIA) link;
- from a networked terminal;
- software download over-the-air.

Each download method raises issues to be addressed in compiling standardization recommendations. For example:

- security of downloaded code;
- integrity of downloaded code;
- standard API for establishing a download link to the handheld terminal;
- billing .

More general standards issues relating to 'application and configuration' software download might be:

- Choice of terminal-independent language for 'programming' the terminal (e.g. A language such as JAVA may be used for higher-level applications which are sufficiently abstracted from specific hardware features, but would be less suited to re-configuring the radio link, which may employ specific proprietary hardware features);
- Ownership and licensing of downloaded software;
- Type approval of both terminals and associated software applications making use of operators' resources;
- Matching new features and applications to the 'capabilities' of the terminal at which they are targeted. This could lead to classification of handheld terminals and

applications, such that an application may be downloaded and executed *only if* the underlying terminal capabilities can guarantee that the application can be supported (e.g. processing power, memory, deterministic task execution)

Software-defined reconfigurable terminals can potentially reduce the requirements for *de jure* standardization within the terminal, allowing functionality to develop in unison with terminal technology developments. This can be the case only if the means of programming the terminal and of ensuring its compliance subsequent to programming, can be precisely defined and managed: this will be a major work area for MMITS in producing standardization recommendations.

Table 3.2.1-1 provides examples of the decomposition of each of the modules in the handheld architecture. The breakdown is intended to provide a reasonable, comprehensive list of functions and subfunctions that are typically associated with each of the modules.

Table 3.2.1-1 Example Functions in Handheld Functional Model Subsystems

Category	Function	Sub Function	Notes
Antenna			
	Transducer		
RF			
	Frequency conversion		
	Linearization		Predistortion
	Amplification/ Attenuation		
	Frequency selection		
	Frequency de/spreading		
	Pulse shaping		Equalizer, Filter
	Diversity processing		Rake receiver
	Modulator / Demodulator		
	Energy measurement		
	Antenna control		
	Spur management		
Baseband			
	Frequency conversion		
	Frequency selection		
	Frequency de/spreading		
	Pulse shaping		Equalizer, Filter
	Diversity processing		
	Modulation / Demodulation		
	Energy measurement		
	Antenna control		
	Spur management		
	Media Access Coding		Walsh Coding
	Channel coding		
		Forward Error Correction	
		Framing	
		Multiplexing	
		Interleaving	

Category	Function	Sub Function	Notes
	Channel estimation		
	Acquisition		
	Tracking		Freq./Phase/Code, Time
	Linearization		Predistortion
	Source Coding		
		Speech	
Baseband		Voice Activity Detection	
		Data in Voice	
		Still Image	slow & full motion
		Video	
		Data	
		Audio	
		Telephony Signaling	
Controller			
	Network Adaptation		
		Bridging	
		Routing	
		Repeating	
	Network Control		
		Spectrum Sharing Management	
		Registration	
		Mobility Management	
		Media Access Control	
		Link Control	
		Service Switcher	Service Detection, Service Selection, Cross Service Handoff
	Information Security		
		User Authentication	
		Traffic Encryption	payload
		Network Encryption	preamble, ...
		Transmission Security	Transec
		Key Management	
		Node Authentication	
User I/O			
	MMI		
		Speech Recognition	
		Handwriting Recognition	
		Image recognition	
		Biometric recognition (Speech, eyeball, handwriting, keyboard, pointer)	
		Image scanning	
		Speech synthesis	
		Display management	
		Audio management	

3.2.2 Mobile Models

Information Transfer Systems

Historically, mobile systems have been called "radios," and were used primarily for voice communication. With increasing need for both voice and data, and with the greatly increased capability brought about by the use of digital data services the term radio has become overly limited. In this context we will refer to them as "information transfer systems" to reflect this additional capability.

The essence of mobile information transfer systems is their use of radio frequency circuits to permit operation from other than a fixed location, independent of a ground based infrastructure. They may be capable of being transported from one operational site to another, or they may be capable of operation while in motion. They do not have permanent connections to land line networks or power grids, but may take advantage of those support resources when the resources are available.

Mobile information transfer systems are differentiated from fixed systems by their ability to move. They are differentiated from subscriber handheld units by their scale. They are physically larger and heavier, and function with more extensive capability, approaching that of permanent sites. Typical requirements have more extensive network interconnection than handheld units, and may offer more RF channels. For example, a typical cellular PCS handset supports one standard at a time where a mobile unit will encompass supporting multiple simultaneous services.

Critical Factors for Mobile Radios

This section describes factors that are especially important for mobile radio systems but which are not particularly important for hand-held radios. Many of these factors also apply to fixed base station implementations.

Scaleability. Mobile implementations will span a wide array of possible platforms. Maritime requirements range from one or two circuits per platform to as many as tens of circuits per platform; cargo ships require one or two simultaneous channels, passenger ships require support of multiple simultaneous telephone calls, and aircraft carriers or other naval command ships require several tens of simultaneous circuits or services. Extensibility implies modular software implementations that allow replication of functionality to support multiple simultaneous instantiations of services; to at least a few hundred replicas, and perhaps to numbers limited only by word lengths, memory size, or other hardware factors. It implies hardware modules that can be replicated as needed on a supporting bus structure. It implies chassis design that can be flexible—designed for few modules where few are needed, but capable of implementation in larger configurations for more demanding applications. It implies an I/O structure that can be sized to meet platform needs without modifying the basic architecture or implementation concept.

Upgradeable. It should be possible to upgrade the mobile radio without replacing the entire radio. This of course includes software upgrades, which are a central feature of "software" radios.

For mobile units, it applies to the hardware as well. This means the potential to replace modules with new, more capable modules. It may mean in some way expanding the chassis to accommodate additional modules. Hardware upgrade for the mobile radio is in contrast to highly integrated and compact hand-held units where hardware upgrades are largely a matter of 100% replacement.

Higher-level Control Interface. In larger installations, control of the radio system may not be self-contained. That is, radios may be considered part of a larger electromagnetic systems suite, with control of the entire suite residing outside the confines or domain of the "radio" system. In a military shipboard environment, radio systems must co-exist with radar systems, electronic countermeasures systems, identification systems, and others. In the US Navy, these systems are under cognizance of a Command Control Warfare Commander, who has his own set of management tools. The modular software radio must provide an interface to allow control interaction (control acceptance, status reporting) with some higher-level control system.

Co-site Operation. The mobile radio system must be able to support multiple services, ranging from a few to a few hundred simultaneous circuits, very many of which may be physically distinct (as opposed to virtual) circuits. Naval ship installations often include 100 or more antennas, with perhaps a dozen or more individual channels (frequencies) multicoupled onto a single antenna. Radio systems must operate in proximity to very high power radars, with instrument landing systems and TACAN, with IFF systems, with navigation receivers, and numerous other electronic systems. Aircraft and land vehicles may have fewer simultaneous operating electromagnetic requirements but also have much less space for antennas and other equipment. The modular software radio must be able to operate in, and in fact be designed to mitigate, difficult co-site interference environments.

Form Factor (Affordability). The form factor selected for the mobile modular software radio must balance performance and cost. Production volume is a major cost factor. Is it possible to identify a form factor that is suitable for high-volume, minimum cost commercial applications, while being adaptable to the more environmentally stressing and lower volume military applications? Can the adaptation also be accomplished without dramatically increasing costs?

Backfittable. In some cases, particularly for aircraft radios, the space available for a new radio is the space occupied by the old radio. This constrains the selection of physical module form factors. The selected implementation for the mobile modular software radio should be implementable within the constraints of existing overall aircraft radio sizes.

Distributed Implementation. Radios for mobile applications will frequently be implemented in a distributed fashion, with user interfaces conveniently placed for the user(s), with antenna(s) located on the outside surface of a vehicle, and with other parts of the radio located to meet other criteria such as available space, environmental conditions, or transmission line losses. Modules, chassis design, and other form factor issues will need to accommodate desired distributed implementation flexibility.

Figure 3.2.2-1 shows a generalized information transfer thread. It shows how an information transfer system connects an information source to an information sink with a transformation in the center. The normal functionality is an RF channel on the left side and either a handset or a network connection on the right side.

Anticipated future MMITS mobile systems tend to be differentiated from handheld systems by their availability to support multiple simultaneous information transfer threads. These simultaneous information threads may be multiple functional instantiations on a single physical platform or with multiple physical platforms for each function.

Figure 3.2.2-2 shows the configuration of information transfer threads in a typical mobile information transfer system.

The left side has one or more air standards, each utilizing resources assigned to that standard. Each channel has an independent operation and each standard may have more than one instantiation. The right side has one or more internetworking connections that serve to deliver voice, data, video, or facsimile to a local or remote information user. The internal processing and transfer function provides the detailed actions of baseband, RF and ontrol services. The control services set up connections between these elements, and operates under direction from the user interface. Bridging and routing is accomplished by connecting two or more left side or right side elements to each other.

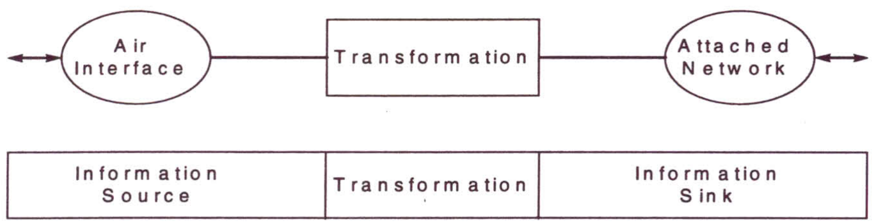


Figure 3.2.2-1 Information Transfer Thread

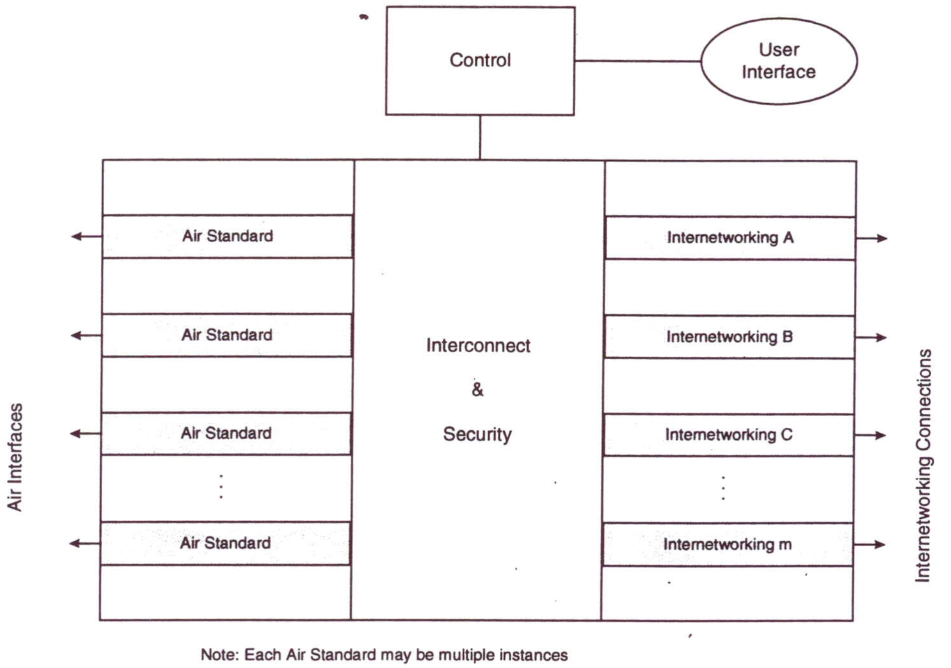


Figure 3.2.2-2 Mobile Information Transfer System Logical Structure

Mobile systems typically require modular, multimode, simultaneous operation. As shown in Figure 3.2.2-3, this implies multiple instantiations of each function within the context of a multiple input, multiple output system. These multiple functions may occur as physical replications of the function or simply as multiple software instantiations operating on a single processing platform. The information flow among the functional modules is under the control of the distributed control environment.

The modular nature of a mobile MMITS radio allows individual functions to be accomplished internal or external to the MMITS structure. For example, routing and COMSEC functions can be performed external to the MMITS without loss of generality. In other cases functions may be replicated, such as information security which may be included as part of the message process flow between routing and a user interface. The intention of the MMITS Forum standards recommendations is that all modules have defined interfaces and control processes so that "plug and play" of the employed modules operates effectively.

Figure 3.2.2-4 relates the US Navy's Joint Maritime Communications Strategy (JMCOMS) architecture to the MMITS high level functional model as an example of a mobile information transfer system structure with external functional access.

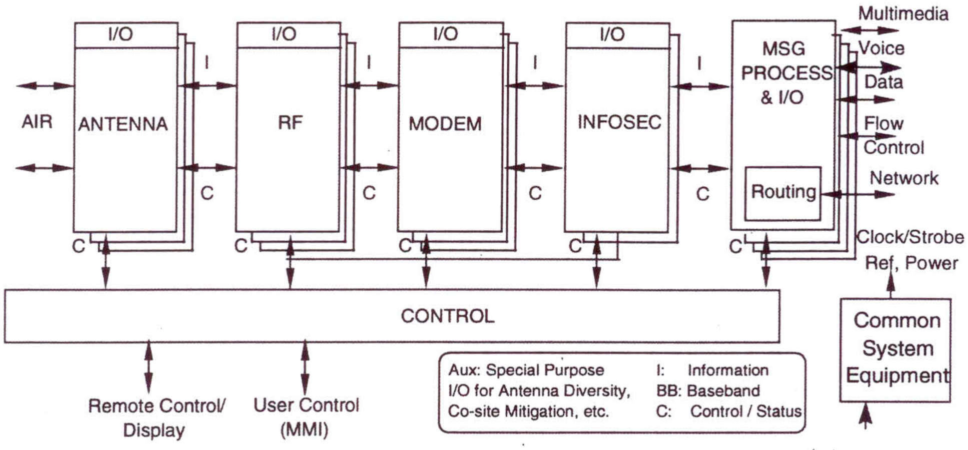


Figure 3.2.2-3 Multiple Instantiations of Each Function of Modular, Multimode Operation

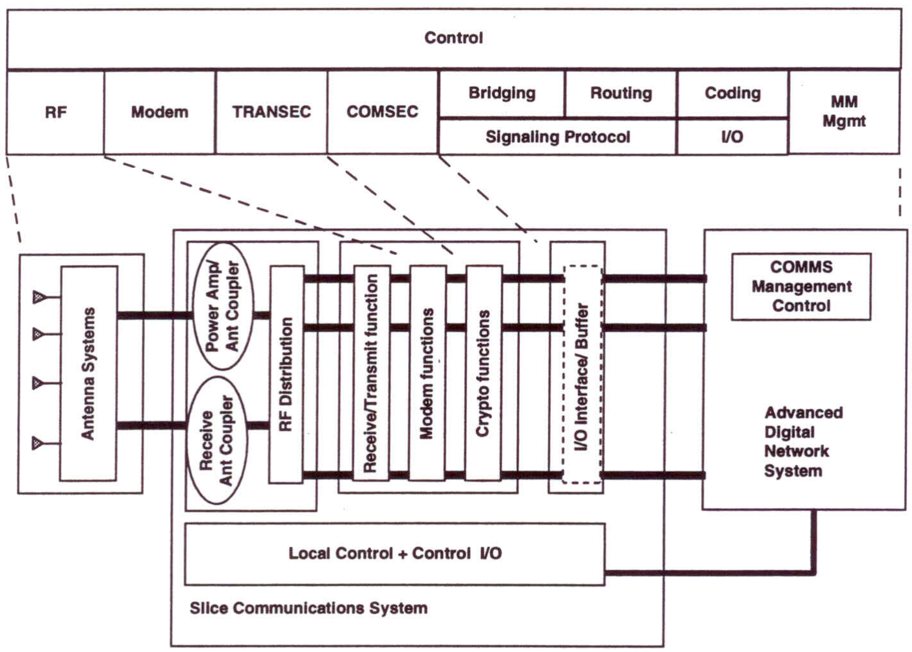


Figure 3.2.2-4 MMITS Functional Model Mapped into a Joint Maritime Communication Strategy (JMCOMS) application

3.2.3 Cross-Standard Extensions

Modular, mutimode terminals can be fielded in a totally terminal-centric fashion in which the network has no knowledge of the fact that the terminal can change from one configuration to another. The terminal can initiate a session with network type A. When it comes to the border of that network technology, the handset can take down the session with network A and initiate a session with network B. It is also possible to have some intelligence outside the terminal to help coordinate this process. But to achieve the full functional advantages inherent in MMITS mechanisms, facilities are needed for cooperation and hand-off between terminals and networks using different modes and different bands. These mechanisms should support terminal directed hand-offs, network directed hand-offs and combinations of the two.

Other standards bodies are responsible for maintaining the standards that govern each specific service (single mode/band). It is MMITS intention to work in cooperation with these other bodies to develop an umbrella model and recommendations for message types and protocol extensions that these other bodies can use, each in their own domain that will result in the ability of terminals and networks to cooperate across modes and bands. This section will present some examples of the requirements from several perspectives and an approach to meeting them.

Commercial cellular/ PCS users need hand-offs between service types and service providers. This requirement is derived from a combination of economic factors, limited spectral resources, legacy systems, geopolitical forces, etc. Examples include CDMA/TDMA/AMPS hand-offs as well as cordless, wireless LANs, CSMA, etc.

Military users require interoperability among systems. Both within a sovereign service branch and within multinational, multiservice branch operations, peace keeping policy and direct assistance type operations, there is a requirement for secure use of commercial infrastructures. Interworking and translation are required, especially for legacy systems. Defense users typically are confronted with many different radio systems.

Civilian/aviation needs simultaneous operation across several modes / bands. For example, interoperability requirements among different branches/standards include the provision of different aviation services for an analog voice, MSK, TDMA, CSMA, etc. Today, hand-offs are often done by voice command.

Emergency service coordination requires the support of many standards with significant interworking/translation requirements.

An example of one approach to addressing these requirements to support handoffs between CDMA cellular/PCS and TDMA cellular/PCS in a US standards environment is using AMPS as a bridge. In US cellular standards environments, CDMA and TDMA handsets are required to also support AMPS mode. Figure 3.2.3-1 shows how AMPS can be used to carry signaling information between the mobile unit and the infrastructure.

Another approach is to provide extensions to the message formats in both environments that allow the mobile unit and the infrastructure to negotiate the desired service type to use for the session or session continuation. Figures 3.2.3-1 and 3.2.3-2 illustrate this approach.

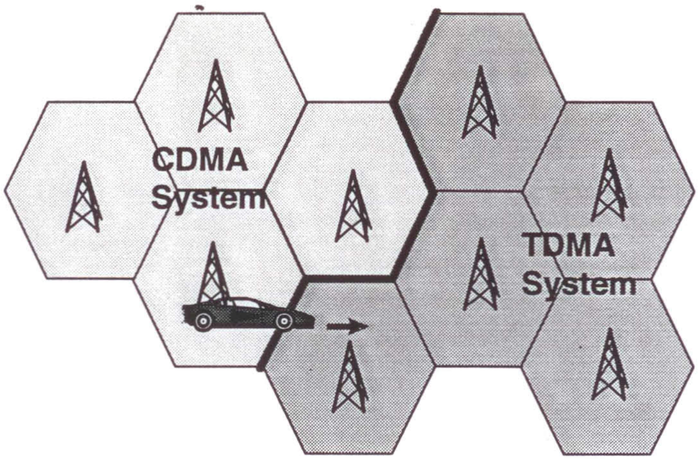
For a fully capable MMITS implementation, there should also be message formats to trigger and deliver from the infrastructure, if necessary, software modules to allow the mobile unit to configure itself to support the negotiated service.

Similar scenarios can be constructed for GSM/DECT, PDC/PHS, terrestrial cellular/LEOs, etc. Furthermore, third generation standards that are emerging are pointing to multiple, non-compatible services with similar handoff requirements. There is also consideration of support for legacy services within third generation systems which also would encompass similar handoff requirements.

In general, consideration for extensions to each of the other services standards need to take into account the following protocol groups, as applicable:

Handoff protocol extensions,
Signaling protocol extensions,
Key Distribution protocol extensions,
Channel Selection protocol extensions,
Routing protocol extensions,
Configuration protocol extensions,
Timing protocol extensions,
Billing protocol extensions, and
Administration protocol extensions

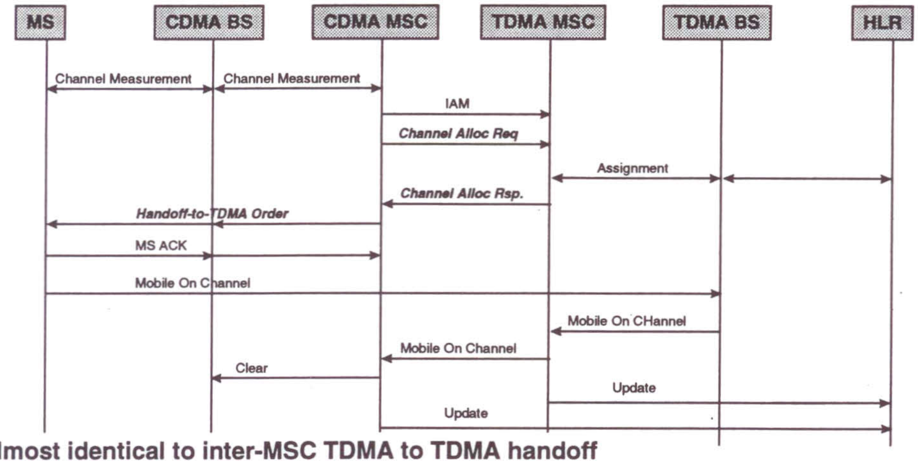
This list will necessarily be expanded as each service type is analyzed in light of the MMITS open architecture.



Signaling Strategy:
CDMA DS/MSC notify TDMA MSC of hand-off
CDMA and TDMA MSCs notify HLR
CDMA BS notifies MS of change in mode after hand-off
Alternately: MS switches to AMPS after crossing, then negotiate for TDMA

Figure 3.2.3-1 Signaling Strategy

MSC: mobile switching center
HLR: home location register
BS: base station
AMPS: Advanced Mobile Phone System



Almost identical to inter-MSC TDMA to TDMA handoff
Hand-off will be "hard" hand-off
Requires *new signals*
May have interference problems at boundary

Figure 3.2.3-2 Cross Standards Handoff

4.0 Form Factor

4.1 Handheld Form Factor

Specific physical interfaces that could be candidates for handheld form factor recommendations will be compliant with the guidelines for functional interfaces and physical modularity as defined by MMITS approach to open system standards recommendations.

Handheld devices are continuously being aggressively driven towards higher levels of integration and hence smaller form factors by the highly competitive commercial marketplace.

The physical modularity is continuously varying across functional interfaces internal to the handheld device. Physical modularity is most stable at the external interfaces and the following interfaces have been identified as potential candidates for form factor recommendations:

- Antenna to RF

- RF to Modem

- User I/O to Locally attached machine

- Battery Connection

- SIM Connection

4.2 Mobile Form Factor

Specific recommendation for form factor and interconnects are still under development and will be included in a later revision to this document

4.3 Interconnect Options

Appendix F provides examples of common interconnect standards that are appropriate for consideration in establishing an open architecture for MMITS. Then, based on requirements in the hand held and mobile areas, a subset will be recommended. A process and criteria for selecting this subset will be developed and published.

5.0 Standards Recommendations

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5.1 Recommendations (Other Organizations)

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5.2 Recommendations (MMITS)

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6.0 Plan for Future Work

It is the intention of MMITS in the process of developing standards recommendations to start with a very broad approach to describing the general architecture of the solution set, the modularization of the solution, and the identification of those items that will be standardized as well as those that will not be standardized. Successive iterations will refine those definitions and will become more focused. Figure 6.0-1 provides a view of the focusing of the standards recommendations development process.

Work plans, in terms of milestones, were developed by the working groups. The intention is to actively pursue the goals outlined in the schedules. The aim is to publish standards recommendations revisions at six month intervals.

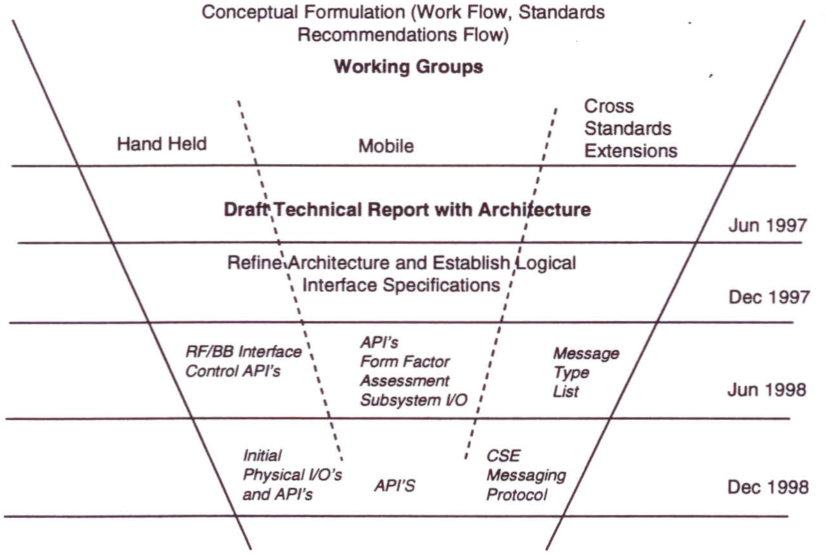


Figure 6.0-1 Standards Recommendations Development Objectives Overview

Handheld WG Work Plan

The handheld working group has developed a set of milestones to accomplish the drafting of proposed standards recommendations by the end of calendar year 1997. Figure 6.0-2 illustrates the milestones established by the working group.

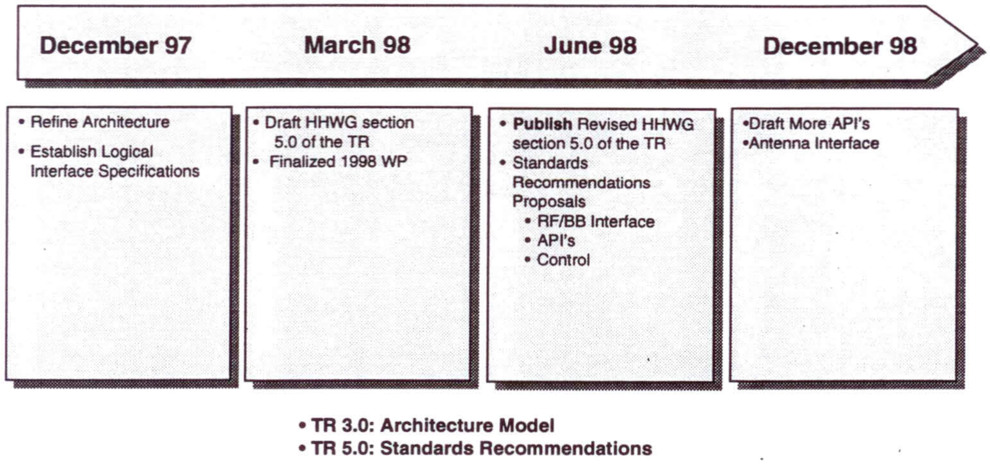


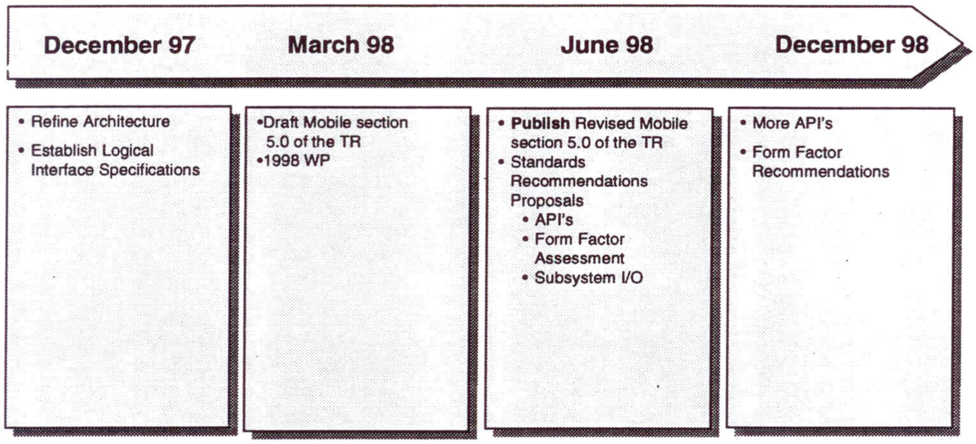
Figure 6.0-2 Handheld Working Group Work Plan

Mobile Work Plan

The mobile working group is establishing a general approach to developing the standard proposal as illustrated in the milestones shown in Figure 6.0-3.

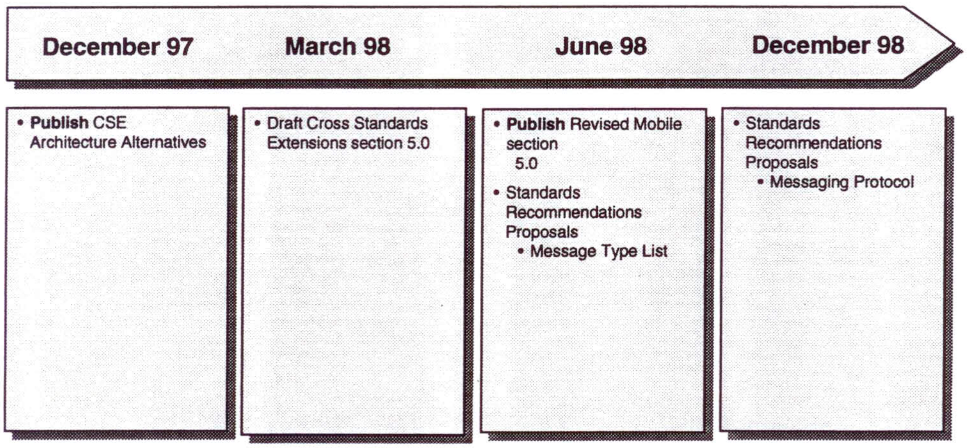
Cross Standards Extensions Work Plan

The cross standards work plan is displayed in Figure 6.0-4.



TR 3.0: Architecture Model
TR 5.0: Standards Recommendations

Figure 6.0-3 Mobile Working Group Work Plan



TR 3.0: Architecture Model
TR 5.0: Standards Recommendations

Figure 6.0-4 Cross Standards Extensions Working Group Work Plan

7.0 Glossary

DEFINITIONS

Applets	An applet is a small program that is not intended to be run on its own, but to be embedded inside another application.
Architecture	The design principles, physical configuration, functional organization, operational procedures, and data formats used as the bases for the design, construction, modification and the operation of a product, process, or element.
Economies of Scale	1) Decreasing unit costs when the scale of operation is increased; and 2) decreasing costs associated with joint production.
Extensibility	The ability to readily permit an addition of a new element, function, control, or capability within the existing framework. In MMITS, this may be new, evolving wireless services.
Feature	A specific element of a service that provides a desirable result. Examples are encryption and authentication.
Function	An operation or algorithm. Examples are down conversion and demodulation.
Functional Partitioning	A logical grouping of functions into identifiable functional blocks for the purpose of implementing a service or mode within an architecture comprised of these functional blocks.
Mode	A specific implementation type of a service. Examples are AMPS, GSM or GPS.
Module	1. An interchangeable subassembly that constitutes part of, i.e., is integrated into, a larger device or system. 2. In computer programming, a program unit that is discrete and identifiable with respect to compiling, combining with other modules, and loading.
Multi-Function/Service	Functions or Services Supported Cellular PCS
Multimode	Support multiple modulation formats and modulation bandwidths QAM, PSK, FSK,MSK, DSSS various bit rates and symbol rates
Multiband	Support Multiple frequency Bands of Operation Cellular 800 MHz PCS 1.9 GHz ISM .9, 2.4, 5.8 GHz Private Land Mobile Radio(PLMR) Multiple bands: 30- 900 MHz
Multi-Standard	Specific Standard Supported Cellular AMPS, IS-54, IS-95 PCS APCO - 25 (Public Safety) MIL-STD-188-XYZ
Open system	A system with characteristics that comply with specified, publicly maintained, readily available standards and that therefore can be connected to other systems that comply with these same standards. (Open Architecture)
Paging	A one-way communications service from a base station to mobile or fixed receivers that provide signaling or information transfer by such means as tone, tone-voice, tactile, optical readout, etc.
Refarming	The process of moving incumbent authorized users out of one frequency band into another. It is likely to be extended to the process of moving users from one mode to another mode.
Scalability	The ability to extend the functionality of the MMITS device to include multiple channels and networking or additional local connectivity and processing.
SDR	Software Defined Radio uses adaptable software and flexible hardware platforms to alter or change its functional characteristics.

Service (OSI)	In the Open Systems Interconnection--Reference Model (OSI--RM), a capability of a given layer, and the layers below it, that (a) is provided to the entities of the next higher layer and (b) for a given layer, is provided at the interface between the given layer and the next higher layer.
Service (MMITS)	Capability or a defined and interrelated set of capabilities structured to meet a specific requirement.
Service Access	In personal communications service (PCS), the ability for the network to provide user access to features and to accept user service requests specifying the type of bearer services or supplementary service that the users want to receive from the PCS network.
Service Domain	Association of a service to a particular implementation domain. Examples are cellular and satellite voice.
Upgradeability	The ability to get more or better work from the MMITS device through the insertion of improved hardware and software technologies.
User Service	Service designed to meet a user requirement. Examples are voice and data user services.

ACRONYMS

AAW	Anti-Air Warfare
ACELP	Algebraic Code Excited Linear Prediction
ADNS	Automated Digital Network System
ADPCM	Adaptive differential pulse-code modulation: a method of digitally encoding speech signals
AGC	Automatic Gain Control
ALE	Automatic Link Establishment
ALOHA	A simple multiple access protocol invented at the University of Hawaii in which users transmit whenever they have something to send. A variant that offers greater throughput is "slotted" ALOHA, in which transmissions are synchronized to a universal clock.
AMPS	Advanced mobile phone system: the American analog cellular telephone system
ANSI	American National Standards Institute
APCO	Associated Public Safety Communications Officers, Inc
API	Application Program Interface
ARDIS	Motorola wireless two-way data network
ASuW	Anti-Surface Warfare
ASW	Anti-Submarine Warfare
ATM	Asynchronous transfer mode: a packetized digital transfer system, adopted for the B-ISDN. (Beware: the same abbreviation is used for automated teller machines, i.e., "hole-in-the-wall" bank cash machines.)
BB	Base Band
BER	Bit error ratio
B-ISDN	Broadband integrated services digital network
BPSK	Binary phase shift keying
C/I	Carrier-to-interference ratio, usually expressed in dB
CCITT	Comite' Consultatif International de Radio: formerly the ITU body responsible for radio standards (now the responsibility of ITU-R). Comite' Consultatif International Telegraphique et Telephonique: formerly the ITU body responsible for nonradio standards (now the responsibility of ITU-T).
CDCS	Continuous dynamic channel selection: a channel management technique used in DECT
CDF	Cumulative distribution function: the integral of the PDF
CDMA	Code Division Multiple Access
CDPD	Cellular Digital Packet Data
CELP	Code-excited linear prediction
CISC	Complex Instruction Set Computer
CNI	Communication, Navigation and Identification (CNI)
COMSEC	Communication Security
COTS	Commercial off the shelf Systems (Software)

CSE	Cross Standards Extensions
CSMA	Carrier sense multiple access: a multiple-access protocol that offers improved performance over ALOHA, users being required to listen for a quiet channel before transmitting.
CT2	Second-generation cordless telephone
CT3	Third-generation cordless telephone
CT0, CT1	Early cordless telephone standards
CTR	Common technical regulations: the basis for type-approval of, for example, GSM handsets
CUG	Closed user group
CW	Carrier wave, that is, a constant, unmodulated radio carrier
DAMA	Demand Assignment Multiple Access
DAMPS	Digital AMPS: a digital cellular system having some compatibility with the (analog) AMPS system (U.S.).
DARPA	Defense Advanced Research Project Agency
DCS1800	Digital communication system: a variant of the GSM standard providing for operation in the 1800-MHz band, initially required by the United Kingdom for its PCN service.
DECT	Digital European Cordless Telecommunications: the second-generation cordless system standardized by ETSI.
DIN	Deutsche Industrie-Norm(enaussxhuss) (German Industrial Standards Authority, equivalent of EIA, BSA etc)
DLC	Data link control (layer)
DOD	Department of Defense
DQPSK	Differential Quadrature Phase Shift Keying
DS	Direct sequence: a form of spread-spectrum system, using a pseudorandom binary stream to spread the signal
DTMF	Dual-tone multi-frequency: system of low-speed signaling in telephone systems, for example, for dialing, using paired audio tones.
DWTS	Defense Wide Transmission Systems
EISA	Enhanced Industry Standard Architecture
EPLRS	Enhanced Position Location Reporting System
ES	Emergency Service
ESMR	Enhanced Specialized Mobile Radio
ETS	European Telecommunications Standard
ETSI	European Telecommunications Standards Institute
EU	European Union
EW	Electronic Warfare
FCC	Federal Communications Commission: U.S. Government regulatory body
FD	Full Duplex
FDD	Frequency Division Duplexing
FDDI	Fiber distributed data interface: a U.S. standard for high-rate fiber optic token-ring LAN systems
FDMA	Frequency Division Multiple Access
FEC	Forward Error Correction
FH	Frequency hopping: a form of spread-spectrum system
FPLMTS	Future public land mobile telecommunication system: the ITU name for third-generation systems. Since this name is neither memorable nor pronounceable in any language, the name IMT-2000 has been proposed.
FSK	Frequency Shift Keying
GFSK	Gaussian-minimum Frequency Shift Keying
GHz	Gigahertz
GMSK	Gaussian minimum shift keying: a form of constant-envelope binary digital modulation
GoS	Grade of service: in telephony, the probability that a call will not succeed. Note that a high GoS is worse than a low one. Also used loosely to mean service quality.
GPS	Global Positioning System

GSM	Groupe Special Mobile: originally, the CEPT (later, ETSI) committee responsible for the pan-European digital cellular standard. Also, used as the name of the system and the service. Global System for Mobile (Communication): the name for the GSM system and service, invented by a group of European operators, to fit the abbreviation "GSM."
HD	Half Duplex
HMI	Human-Machine Interface
HMMWV	High Mobility Multi-purpose Wheeled Vehicle
I/O	Input / Output
IBCN	Integrated broadband communications network
IEEE	Institute of Electrical and Electronic Engineers (U.S.). IEEE-802 is a committee responsible for developing standards for LANs.
IF	Intermediate Frequency
IFF	Identification Friend or Foe
IMT-2000	International mobile telecommunications-2000: a name proposed within ITU for their third-generation concept, otherwise known as FPLMTS
IN	intelligent network
INFOSEC	Information Security
IPR	Intellectual property rights, including patents, trademarks, copyrights
ISA	Industry Standard Architecture
ISDN	Integrated services digital network
ISM	Industrial, Scientific, Medical
ISO	International Standards Organization
ITU	International Telecommunication Union
JMCOMS	Joint Maritime Communications Strategy
JTIDS	Joint Tactical Information Distribution System
kHz	Kilohertz
LAN	Local area network
LED	Light-emitting diode
LEO	Low earth (satellite) orbit
LOS	Line of sight (radio path)
LPD	Low Probability of detection
LPI	Low probability of intercept: a property of spread-spectrum systems
MAC	Medium access control (protocol layer)
MAN	Metropolitan area network
MAP	Mobile application part: an extension of signaling system number 7, providing support of mobile systems.
MBLT	Multiplexed Block Transfer
MCM	Mine Countermeasure
MCN	Microcellular network
MEO	Medium earth (satellite) orbit
MHz	Megahertz
MMI	Man-Machine Interface
MMITS	Modular, Multifunction Information Transfer Systems
MPMLQ	Multipulse maximum likelihood quantized
MSK	Minimum Shift Keying
NATO	North Atlantic Treaty Organization
NET	Norme Europeenne de Telecommunications: formerly, the specification for type-approval, produced by CEPT, later replaced by CTRs. Thus, NET-10 was the type-approval spec for GSM, now replaced by CTR-5 and CTR-9.
NMT	Nordic mobile telephone (system): cellular telephone system prevalent in the Nordic countries.
NOS	Network Operating System
NPRM	Notice of Proposed Rule Making: an official pronouncement by the FCC (U.S.)
NTDR	Near-Term Digital Radio

NTT	Nippon Telegraph and Telephone Corporation (Japan)
OFTEL	Office of Telecommunications: U.K. official body created to protect the interests of consumers of telecommunication services.
OKQPSK	Offset-keyed quadrature phase-shift keying: digital modulation system in which in-phase and quadrature components carry bit-streams offset by half a bit, resulting in desirable spectral and envelope characteristics.
OS	Operating System
OSI	Open systems interconnection: the ISO layered protocol model
OSS	Operating Support System
PABX	Private automatic branch exchange
PACS	Personal Access Communications System, Licensed Band
PAD	Packet assembler/disassembler: device used to interface with a packet network
PBX	Private Branch Exchange
PCI	Peripheral Component Interconnect
PCIA	Personal Communications Industry Association (U.S.).
PCMCIA	Personal Computer Memory Card Industry Association
PCN	Personal communications network: used as a general term for such networks, and specifically for the U.K. systems licensed for operation in the 1800-MHz band and using the DCS 1800 standards
PCS	Personal Communication System
PDA	Personal digital assistant: a name coined to describe a portable, screenbased communication-oriented data terminal or organizer.
PDC	Personal Digital Cellular
PDF	Probability distribution function
PDH	Plesiochronous digital hierarchy: transmission system standard (plesiochronous = near-synchronous)
PHS	Personal handy phone system: a RCR standard for cordless telephony
PICMG	PCI Industrial Manufacturers Group
PIN	Personal identification number: a (typically four-digit) secret number to be input by the user to obtain service
PLMN	Public Land Mobile Network
PMR	Private mobile radio
POCSAG	Post Office Code Standardization Advisory Group
POTS	Plain old telephone service
PSI-CELP	Pitch Synchronous Innovation Code Excited Linear Prediction
PSK	Phase-shift keying
PSPDN	Packet-switched public data network
PSTN	Public-switched telephone network
PTO	Public telecommunications operator
PTT	Post, telephone and telegraph (authorities): an old name for the (usually state-monopoly) operators of telecommunication and postal services
QAM	Quadrature amplitude modulation
QCELP	Qualcomm proprietary CELP
QoS	Quality of service: an ill-defined term covering various measures of "quality" in telecommunication systems
QPSK	Quadrature phase-shift keying
RAM	A wireless mobile data system
RES	Radio equipment and systems: a technical committee of ETSI, responsible for terrestrial radio standards other than GSM
RF	Radio Frequency
RP-CELP	Regular pulse-code excited linear prediction
RPE-LTP	Regular-Pulse Excitation Long-Term Prediction
RTK	Real-Time Kernel
SCI	Scaleable Coherent Interconnect

SCSA	Signal Computing System Architecture
SCSI	Small Computer System Interface
SDH	Synchronous digital hierarchy: a transmission system standard
SEM-E	Standard Electronic Module, Defined by Mil Std 1389 Appendix E
SFH	Slow frequency hopping
SIM	Subscriber Identification Module - derived from GSM
SINCGARS	Single-Channel Ground and Airborne Radio System
SMG	Special Mobile Group: the name adopted by ETSI for the (former) GSM committee, for consistency with other ETSI Technical Committees, which all had English names. There are numerous subgroups: SMGI, SMG2, etc. The SMG5 subgroup has responsibility for work on third-generation systems.
SNR	Signal-to-noise ratio, usually expressed in dB
S-PCN	Satellite personal communications system
SS7	Signaling system number 7: an ITU standard for telecommunications network signaling
T1	U.S. standards committee, active in personal communications area
TACAN	Tactical air navigation
TACS	Total access communication system: an analog cellular phone system based on AMPS, used in the United Kingdom and elsewhere. Technical basis for regulation.
TCM	Trellis coded modulation
TCP/IP	Transmission Control Protocol / Internet Protocol
TDD	Time-division duplex: two-way communication using synchronized alternate transmission on a single carrier
TDHS	Time domain harmonic scaling
TDMA	Time Division Multiple Access
TEMPEST	Transient Electromagnetic Pulse Standard
TETRA	Trans-European trunked radio: second-generation digital PMR system standardized by ETSI
TGMS	Third-generation mobile systems
TIA	Telecommunications Industry Association (U.S.)
TRANSEC	Transmission Security
TTM	Time to Market
UAV	unmanned aerial vehicle
UHF	Ultra high frequency: usually defined as 0.3 to 3 GHz
UMTS	Universal mobile telecommunication system (or service): the concept of third-generation systems developed in Europe, particularly by the RACE program.
UPT	Universal personal telecommunication
VA	Voice activation
VERSA	Motorola defined micro-computer bus (1979)
VLF	Very Low Frequency
VME	VERSA Module Eurocard
VRC-99	Packet Radio
VSB	VME Subsystem Bus
VSELP	Vector Sum Excited Linear Prediction
WAN	Wide area network
WARC	World Administrative Radio Conference
WLLAN	Wireless local area network
WSS	Wide-sense stationary

Appendix A. The MMITS Charter

The following is the MMITS charter. It is also available on the MMITS web site: URL http://www.mmitsforum.org

Version 1.0 5/6/96

MMITS Vision

The MMITS vision is to provide high quality, ubiquitous, competitively priced wireless networking systems equipment and services with advanced capabilities. This vision includes a view of seamlessness across diverse networks and integration of capabilities in an environment of multiple standards and solutions.

Ease of use, mobility, enhanced productivity, and support for lifestyle choices are all wanted by the communications systems users. Convergence among wireless and wired services such as educational, entertainment and information services requires improved interworking and interoperability.

Consequently, consumers of communications services, communications service providers, equipment suppliers and maintainers can benefit from open architecture coupled with the software definable networking radio systems developments espoused within MMITS. This community of interest not only includes the needs of the general public, but also includes governments, and their requirements for defense, law enforcement and emergency services, including National Security and Emergency Preparedness.

MMITS Definition

The Modular Multifunction Information Transfer System (MMITS) presents an open architecture for wireless networking systems. Major considerations in networking systems include software defined radio waveform hardware and software, security, source coding, and networking protocols.

Software defined radios use adaptable software and flexible hardware platforms to address the problems that arise from the constant evolution and technical innovation in the wireless industry particularly as waveforms, modulation techniques, protocols, services, and standards change.

A software defined radio in the MMITS context goes beyond the bounds of traditional radio and extends from the radio terminal of the subscriber or user, through and beyond the network infrastructures and supporting sub-systems and systems. MMITS is a concept that spans numerous radio network technologies and services, such as cellular, PCS, mobile data, emergency services, messaging, paging, and military and government communications.

MMITS Forum Mission

The mission of the Open Architecture Modular Multifunction Information Transfer System (MMITS) Forum is to accelerate development, deployment and use of software definable radio systems consistent with the objectives of the above wireless vision.

The MMITS Forum will work toward the adoption of an open architecture for advanced wireless systems that includes the requisite functionality in terminals, networks, and systems to provide "multiple capability and multiple mission" flexibility for voice, data, messaging, image, multimedia and future needs.

The MMITS Forum shall establish requirements related to the definition of internal and external system interfaces, modules, software, and functionality that the industry can use as guidelines in building modules, products and systems.

Further, the MMITS Forum will promote the development of standards for MMITS, including those focused on MMITS equipment and those in supporting service application areas, in areas of interoperability and performance, and in underpinning core technologies, either directly or through appropriate liaison to other industry associations and standards bodies. The MMITS Forum will pursue industry wide acceptance of these standards.

To assist the wireless and supporting industries in understanding the value and benefit of software definable radio and in particular the MMITS vision, the MMITS Forum will also address market requirements, quantify the market, and develop timelines relative to the use of multi-mode, multi-band, and multi-application wireless communications systems.

The MMITS Forum membership shall include telecommunications users, equipment suppliers, and developers of technology, products, systems, hardware, and software as well as service providers and system operators or any other individual, organization, or entity who has interest in furthering the objective of MMITS.

Appendix B. Document List

MMITS Forum 1996 Document List
(March, June, September, and December Meetings)

Document No. MMITS-yy.mm.dd-nnn	Title	Author(s) & Organization	Available on the MMITS Web Site
MMITS-96.03.13-001	MMITS Meeting Agenda, 13 March 1996	W. Bonser - Rome Laboratory	
MMITS-96.03.13-002	Introductory Remarks	W. Bonser - Rome Laboratory	X
MMITS-96.03.13-003	Opens Systems for Weapon Systems Electronics	H. Leonard Burke -Defense Open Systems Joint Task Force	X
MMITS-96.03.13-004	VSO Overview	R. McKee - Mitre	X
MMITS-96.03.13-005	SpeakEasy II Briefing	B. Fette - Motorola	X
MMITS-96.03.13-006	Draft MMITS Vision and Mission Statements	W. Bonser - Rome Laboratory A. Margulies - Mitre	
MMITS-96.03.13-007	Bylaws of the VITA/VSO MMITS Task Group	W. Bonser - Rome Laboratory A. Margulies - Mitre	
MMITS-96.03.13-008	Biographies of candidates for interim MMITS Chair	A. Margulies - Mitre	
MMITS-96.03.13-009	MMITS March Meeting Report	A. Margulies - Mitre	X
MMITS-96.03.13-010	Organization Attendance, Individual Attendees	A. Margulies - Mitre	X
MMITS-96.03.13-011	Scope Committee Meeting Minutes	A. Margulies - Mitre	X
MMITS-96.06.11-001	June MMITS Forum Meeting Agenda		
MMITS-96.06.11-002	Introductory Remarks of Forum Chair	J. Mitola - Mitre	
MMITS-96.06.11-003	MMITS Steering Committee Report	M. Cummings - enVia	X
MMITS-96.06.11-004	MMITS-Defense	W. Bonser - Rome Laboratory	X
MMITS-96.06.11-005	Software Radio - A UK Military Perspective	J. Thorlby - DRA	X
MMITS-96.06.11-006	Aviation Air Ground Communications	D. Weed - FAA	X
MMITS-96.06.11-007	Commercial Wireless View and Vision	S. Blust - BWI	X
MMITS-96.06.11-008	SpeakEasy Phase II	B. Fette - Motorola	X
MMITS-96.06.11-009	Advances in Programmable Radio Technology	P. Tilley - Hazeltine	
MMITS-96.06.11-010	Open Architecture Radio Design	S. Griswold - ITT	X
MMITS-96.06.11-011	Programmable Digital Radio	C. Hilterbrick - GEC Marconi	X

MMITS-96.06.11-012	Commercial Wireless Applications	J. Kahn - Airnet	X
MMITS-96.06.11-013	New Technology Alternatives	M. Cummings - enVia	X
MMITS-96.06.11-014	Potential Host/Parent for Wireless MMITS Forum	J. Hoffmeyer - NTIA/ITS	X
MMITS-96.06.11-015	PCCA as Host for MMITS Forum	B. Fette - Motorola	X
MMITS-96.06.11-016	Broadband PCS Alliance	S. Blust - BWI	
MMITS-96.06.11-017	June Meeting Report	A. Margulies - Mitre	X
MMITS-96.06.11-018	June Meeting Attendees	A. Margulies - Mitre	X
MMITS-96.06.11-019	The Software Defined Radio: Technology and Marketplace (DRAFT)	J. Mitola - Mitre	
MMITS-96.06.11-020	Cryptographic Reduced Instruction Set Microprocessor (CYPRIS)	Lockheed-Martin	
MMITS-96.06.11-021	Strawman MMITS VITA/VSO Workplan	J. Hoffmeyer - NTIA/ITS	
MMITS-96.06.11-022	Flexible Integrated Radio System Technology (FIRST) (6/12/96)	N. Drew - Motorola Semiconductor, UK	
MMITS-96.09.10-001	September MMITS Forum Meeting Agenda		
MMITS-96.09.10-002	Opening Remarks of the Forum Chair	J. Mitola - Mitre	
MMITS-96.09.10-003	MMITS Motivation	M. Cummings - enVia	X
MMITS-96.09.10-004	Open Architectures and Defense Information Systems Programs	T. Lawrence - DARPA	X
MMITS-96.09.10-005	The Power of Open Architecture	S. Blust - BWI	X
MMITS-96.09.10-006	National Security/Emergency Preparedness Recommendations for Wireless Systems and Services	D. Bodson - National Communications System	X
MMITS-96.09.10-007	Technical Committee Overview	M. Cummings - enVia	X
MMITS-96.09.10-008	Marketing Committee Report & Draft Work Plan for the Markteing Committee	S. Blust - BWI	X
MMITS-96.09.10-009	Operations Committee	A. Margulies - Mitre	X
MMITS-96.09.10-010	Suggested Work Activities for the Operations Committee	J. Hoffmeyer - NTIA/ITS	
MMITS-96.09.10-011	Information Relative to the Incorporation of Affiliation Issue	M. Cummings - enVia J. Hoffmeyer - NTIA/ITS	X
MMITS-96.09.10-012	Position Descriptions of MMITS Forum Chairperson and Vice-Chairperson		
MMITS-96.09.10-013	Biography of J. Hoffmeyer	J. Hoffmeyer - NTIA-ITS	
MMITS-96.09.10-014	Biography of S. Blust	S. Blust - BWI	
MMITS-96.09.10-015	US Wireless Industry's Vision for IMT-2000/FPLMTS (DRAFT)	K. Buchanan - BWI	
MMITS-96.09.10-016	Commercial Wireless Subscriber Terminals: MMITS Device Potential	L. Brannan - BWI	X
MMITS-96.09.10-017	Federal Wireless Requirements	J. Hoffmeyer - NTIA/ITS	
MMITS-96.09.10-018	Direct Digitization of the RF in Radio Receivers - How Close are We?	J. Wepman - NTIA/ITS	

MMITS-96.09.10-019	Software Radio API Issues	M. Cummings - EnVia	X
MMITS-96.09.10-020	Applications Subcommittee Report	Roger Hammonds - Hughes	X
MMITS-96.09.10-021	MMITS Architecture Subcommittee	R. Vidano - Motorola P. Tilley - Hazeltine	X
MMITS-96.09.10-022	Structurally Embedded Reconfigurable Antennas: New Technologies for Multiband Radios	D. Murotake - Lockheed Sanders	
MMITS-96.09.10-023	MMITS Market Survey - Summary Results	J. Wald - Honeywell	
MMITS-96.09.10-024	Software Radios & Standards - A Cellular Baseline Perspective	H. Babbitt - Tellabs	X
MMITS-96.09.10-025	Arch. Comm. Draft Mtg. Report	R. Vidano - Motorola P. Tilley - Hazeltine	
MMITS-96.09.10-026	Applications Subcommittee Draft MTG Report	J. Mitola - Mitre	X
MMITS-96.09.10-027	Form Factor Committee Draft Mtg. Report	J. Koser R. Yan - AT&T	
MMITS-96.09.10-028	Markteing Committee Report	S. Blust - BWI	
MMITS-96.09.10-029	September Meeting Report	A. Margulies - Mitre	X
MMITS-96.09.10-030	September Meeting Attendees	A. Margulies	X
MMITS-96.12.03-001	MMITS Meeting Announcement		
MMITS-96.12.03-002	MMITS Forum December Meeting Announcement		
MMITS-96.12.03-003	MMITS - A Top Down View	M. Cummings - EnVia	
MMITS-96.12.03-004	Opening Remarks of the General Chair	J. Hoffmeyer - NTIA/ITS	
MMITS-96.12.03-005	Flexible Integrated Radio Systems Technology	M. Swinburne - Orange PCS	
MMITS-96.12.03-006	Technical Committee Overview	M. Cummings	X
MMITS-96.12.03-007	Applications Subcommittee Report		
MMITS-96.12.03-008	MMITS Applications Subcommittee Statement of applications Recommendations		
MMITS-96.12.03-009	Ltr from Rafael to Applications Subcommittee		
MMITS-96.12.03-010	Packaging Requirements Survey		
MMITS-96.12.03-011	Comparison of PCI Form Factors		
MMITS-96.12.03-012	Introducing PC/104-Plus - Why PC/104-Briefing Charts		
MMITS-96.12.03-013	Introducing PC/104-Plus: Text		
MMITS-96.12.03-014	IEEE Project 1996: HiRelPCI		
MMITS-96.12.03-015	Markteing Committee Agenda	S. Blust - BWI	
MMITS-96.12.03-016	MMITS Market Survey	S. Blust - BWI	
MMITS-96.12.03-017	Operations Committee	A. Margulies	X

MMITS-96.12.03-018	MMITS Forum Bylaws	A. Margulies	X
MMITS-96.12.03-019	Qualifications of M. Cummings for position of Technical Committee Chair	M. Cummings	
MMITS-96.12.03-020	Qualifications of D. Murotake for position of Technical Committee Vice Chair	D. Murotake	
MMITS-96.12.03-021	Proposed Documentation Process	N. King, - Siemens	
MMITS-96.12.03-022	Closing remarks of Forum Chair and Vice Chair	J. Hoffmeyer - NTIA/ITS S. Blust - BWI	
MMITS-96.12.03-023	MMITS Forum Plan (DRAFT)	J. Hoffmeyer - NTIA/ITS S. Blust - BWI	
MMITS-96.12.03-024	Technical Comm. Draft Chart Handouts	Technical Committee	
MMITS-96.12.03-025	Arch. Subcommittee Draft Mtg. Report	R. Vidano - Motorola	
MMITS-96.12.03-026	MMITS Market Survey Results	L. Brannan - BWI	
MMITS-96.12.03-027	List of attendees	A. Margulies - Mitre	
MMITS-96.12.03-028	Civil avionics work group	D. Ellingson - Honeywell Tech. Center	
MMITS-96.12.03-029	Surrogate Digital Radio (SDR) MMITS Partitioning	P. Tilley - GEC-Marconi-Hazeltine	
MMITS-96.12.03-030	Mapping SLICE Radio to the MMITS Architecture	C. Fuzak - NRAD	
MMITS-96.12.03-031	Integrated Communications, Navigation, Identification Avionics (ICNIA) Basic Architecture (12/96)	S. Ogi - TRW	

MMITS Forum 1997 Document List

Document No. MMITS-XX-yy.mm.dd-nnn	Title	Author(s) & Organization	Available on the MMITS Web Site
MMITS-GN-97.03.11-001	List of MMITS Forum 1996 documents	Hoffmeyer -NTIA/ITS	
MMITS-GN-97.03.11-002R1	List of MMITS Forum 1997 documents	Hoffmeyer -NTIA/ITS	
MMITS-GN-97.03.11-003	MMITS Forum March Meeting Agenda	Hoffmeyer -NTIA/ITS	
MMITS-GN-97.03.11-004	MMITS Corporate Briefing	Hoffmeyer -NTIA/ITS	
MMITS-GN-97.03.11-005	Policies and Procedures for Contributions, Meeting Reports, and Working Documents	Hoffmeyer -NTIA/ITS	
MMITS-GN-97.03.11-006	IPR Amendment	Margulies- MITRE	
MMITS-GN-97.03.11-007	Antitrust warning	Hoffmeyer- NTIA/ITS	
MMITS-GN-97.03.11-008	Role of MMITS in Industry	Cummings- enVia	
MMITS-GN-97.03.11-009	Vision and Objectives	Hoffmeyer- NTIA/ITS	
MMITS-GN-97.03.11-010	MMITS Forum June Meeting Announcement	Hoffmeyer-NTIA/ITS	
MMITS-GN-97.03.11-011	MMITS 2001	Stephen Blust-BellSouth	
MMITS-GN-97.03.11-012	Schedule for Completion of MMITS Work Plan	Stephen Blust-BellSouth	

MMITS-GN-97.03.11-013	Anti-trust Compliance Statement	MMITS Forum Chair	
MMITS-GN-97.06.xxxx	MMITS FORUM PROSPECTUS Version 1.0 6/13/97	Steering Committee	
MMITS/WD-01-R2	Goals, Objectives, and Plans of the MMITS Forum	MMITS Leadership	
MMITS/WD-02	MMITS Technical Report	MMITS Technical Committee	
MMITS/WD-03	Market Forecast Report	MMITS Markteing Committee	
MMITS/WD-04	MMITS Forum Plans and Procedures	MMITS Operations Committee	
MMITS/TE-97.03.11-001	Attendees	MMITS Technical Committee	
MMITS/TE-97.03.11-002	Info flow for handsets	D. Varn	
MMITS/TE-97.03.11-003	Handheld WG summary and agenda	Technical Committee	
MMITS/TE-97.03.11-004	Mobile WG status	P. Tilley	
MMITS/TE-97.03.11-005M	Application recommendations	R. Berezdivin	
MMITS/TE-97.03.11-006	Modular avionics	R. Dyer	
MMITS/TE-97.03.11-007	Handheld WG report	M. Nuotio	
MMITS/TE-97.03.11-008	Cross technology	J. Yen	
MMITS/TE-97.03.11-009	NxN Matrix	N. King	
MMITS/TE-97.03.11-010	Signaling strategy	J. Yeh	
MMITS/TE-97.03.11-011	Technical Committee Functional Table	Technical Committee	
MMITS/TE-97.03.11-012	Logical/Physical Model	Technical Committee	
MMITS/TE- 97.02.04M	Meeting report		
MMITS/OP-97.03.11-001	MMITS Forum Membership Form	A. Margulies-Mitre	
MMITS/OP-97.03.11-002	Bylaws of the MMITS Forum	Steering Committee	

Appendix C. List of Chairs and Co-chairs

TECHNICAL COMMITTEE

NAME	PHONE		E-MAIL	OFFICE
Cummings, Mark	415-854-4406	enVia	cummings@radiomail.net	Technical Chair
Murotake, Dave	603-885-2737	Sanders	dmurotak@empire.net	Technical Vice chair
Gunn, Jim	972-997-5885	Texas Instruments, Inc.	gunn@msg.ti.com	Applications Chair
Berezdivin, Bob	703-876-1948	Raytheon E-Systems	rberezdivin@fallschurch.esys .com	Applications Vice chair
Yan, Ran	908-582-4477	Lucent Technologies	rhy@bell-labs.com	Form Factor Co-chair
Koser, Jim	717-938-7679	BERG Electronics	jkoser@aol.com	Form Factor Co-chair
Vidano, Ron	602-441-8331	Motorola, Inc.	vidano@email.mot.com	Architecture Chair
Tilley, Patrick	516-262-8278	GEC-Marconi Hazeltine	tilleyp@hazeltine.com	Architecture Vice Chair
Nuotio, Mika	408-428-5264	Cadence Design Systems, Inc.	mika@cadence.com	Handheld WG Co-Chair
Andrews, Scott	619-592-0334	LOGIC Devices, Inc.	scott@logicdevices.com	Handheld WG Co-Chair
Cook, Pete	602-441-1300	Motorola, Inc.	p25359@email.mot.com	Mobile WG Chair
Williams, Larry	219-487-6154	ITT A/CD	ljwillia@itt.com	Mobile WG Co-Chair
Yeh, James	908-949-4612	Lucent Technologies	hyeh@lucent.com	Cross Technologies WG Chair Cross Technologies WG Vice Chair

OTHER OFFICERS

NAME	PHONE		E-MAIL	OFFICE
Hoffmeyer, Jim	303-497-3140	NTIA/ITS	jim@ntia.its.bldrdoc.gov	Forum Chair
Blust, Stephen	404-249-5058	BellSouthCellular, Inc.	blust.stephen@bwi.bls.com	Forum Vice Chair
Cummings, Mark	415-854-4406	enVia	cummings@radiomail.net	Steering Committee Chair
Margulies, Al	315-336-4966	The MITRE Corp	asm@mitre.org	Operations Chair
Brannan, Lowie	404-249-6789	BellSouth Cellular, Inc	brannan.lowie@bwi.bls.com	Markets Co-chair
Kraemer, Bruce	407-729-5683	Harris Semiconductor	bkraemer@harris.com	Markets Co-chair
Fette, Bruce	602-441-8392	Motorola SSTG	fette@email.mot.com	Treasurer

Appendix D. Other Organizations Contacted by MMITS Forum

The following is a list of organizations, including standards bodies, that have been contacted by the MMITS Forum for the purpose of providing an introduction to the objectives of the MMTS program and to solicit cooperative participation as appropriate.

AeroSense '97

CTIA

European Commission DG XIII-B Software Radio Workshop

Federal Telecommunications Standards Committee

GloMo

GSM-MOU Association Third Generation Interest Group

IEEE - Microcomputer Workshop

Interdepartmental Radio Advisory Committee

Multiband, Multimode Terminals Workshop

National Association of Broadcasters

PCIA

T1P1/TR46

Telecommunications Industry Association Mobile Communications Systems Division

Appendix E. MMITS Attendance List

NAME	*ORGANIZATION*
Albiez, Erik	NISE East
Andrews, Scott	LOGIC Devices, Inc.
Berezdivin, Robert (Dr)	Raytheon E-Systems
Bishop, Arthur W.	U.S. Secret Service
Blanda, Frank	Sanders/Lockheed-Martin
Blust, Stephen M.	BellSouth Cellular, Inc.
Bonser, Wayne	Rome Laboratory/C3BB
Borrelli, Glenn	Allied Signal Communications Systems
Brandt, Kirk	Space Applications Corp. (SAC)
Brannan, Lowie	BellSouth Cellular, Inc.
Breinig, Robert J.	Raytheon E-Systems
Cain, Karl	NRAD
Chapman, David	Scientific Research Corp.
Chatterjee, Asok	TSC TIPI
Choi, Ginkyu	Samsung Electronics Co., Ltd.
Climek, David	MITRE
Cook, Peter G.	Motorola, Inc.
Constantinou, George	DISA/JIEO
Cummings, Mark	enVia
Davis, Bill	Hughes Aircraft
Downes, James	U.S. Treasury Department
Drew, Nigel	Motorola, Ltd.
Duncan, Bruce	Northrop Grumman Corp.
Durkin, Jim	Scientific Research Corp.
Dyer, Randy	Rockwell Collins
Edwards, Oliver	Image Systems
Ellingson, David	Honeywell, Inc.
Eng, Raymond	U.S. Army CECOM
Fette, Bruce	Motorola
Forrester, Doug	Lucent Technologies
Frazier, William	NTIA-U.S. Dept of Commerce
Fujii, Takuro	Kolusai Electric CO, Ltd.
Fuzak, Clancy	NRaD
Gerner, Adam	US Army CECOM
Gmitro, Mike	Scientific Research Corporation
Goami, Mitsuyuki	Kosusai Electric Co., Ltd.
Gratzek, Tom	Analog Devices, Inc.
Griswold, Stan	ITT
Gruensfeder, Donn	McDonnell Douglas Aerospace
Gunn, James	Texas Instruments, Inc.
Hacker, Henry	Hughes Defense Communications
Hammac, John	Orange Personal Communications
Hammons, Roger	Hughes Networks

Harrington, Ed (Dr)	GTE Government Systems
Harris, Alan	Scientific Research Corp.
Haruyama, Shinichiro	Keio University (Yagami Campus)
Hilterbrick, Chuck L.	Northrop Grumman Corp
Hinman, Richard D.	Rome Laboratory/C3BB
Hoffmeyer, Jim	NTIA/ITS
Hughes, Timothy J. (Tim)	Hughes Aircraft Co.
Inglis, Phillip	FCC
Irmen, Greg	Rockwell
Karty, Steven L.	National Communications Systems
Kazi, Sabera	Honeywell, Inc.
Keating, Jim	Hughes Defense Communications
Kelley, Ed	Hughes Communication Products
Kim, Byung Hwan	Samsung Electronics Co.
Kim, Sun Bin	Samsung Electronics Co.
Kleinschmidt, Dale	USAF/AFC4A/TNSDW
Koser, Jim	BERG Electronics
Kraemer, Bruce	Harris Semiconductor
Kriz, Jeffrey J.	Honeywell, Inc.
Kundu, Amlan	US West Advanced Technologies
Kurtz, Rick	TRW Avionics Systems Division
Lai, Jersey	Nokia Telecommunications, Inc.
Leonard, Scott R.	Nystec
Leschhorn, Dr.	Rohde & Schwarz
Lever, Stuart	Rome Lab
Mangum, Chris	Bell South Cellular
Margulies, Allan	The MITRE Corporation
Maucksch, Thomas	Rohde & Schwarz
McChesney, James R.	ITT-A/CD
McKee, Robert	The MITRE Corporation
Mendoza, Ben	LOGIC Devices, Inc.
Mennenga, Horst	Federal Office of Posts and Telecommunications
Merkel, James J.	Titan Corp.
Moton, Robert	BellSouth Cellular
Mueller, Gerd	Rohde & Schwarz
Murotake, David K. (Dr.)	Sanders
Noble, Gary	Rockwell Collins
Nuotio, Mika	Cadence Design Systems, Inc.
Ogi, Stanley K.	TRW ASD
Olson, Richard	FAA Technical Center
Parker, Bruce C.	Motorola
Penticoff, Joel	Rockwell/Collins
Perlongo, Michael	Northrop Grumman
Phillips, Mike	Motorola
Prill, Robert	GEC Marconi Hazeltine
Pugh, Larry A.	FAA - Technical Resources, Inc.
Rice, Robert Jr.	Gen Dynamics Land System
Robinson, Michael	NISE East

Santiago, Jose M.	Nokia Telecommunications
Schimmel, Eric	Telecommunications Industry Assoc
Schrenk, Frank	DARPA
Scott, Charles	Texas Instruments
Sodano, Matt	MITRE
Steele,Bob	Space Applications Corp
Swinburne, Martin	Orange Research & Technology (PCS)
Szelc, Dawn	MITRE
Tarallo, Joe	Lucent Technologies
Tilley, Patrick	GEC-Marconi Hazeltine
Upmal, Don	US Army CECOM
Vardakas, Joe	Hughes
Vadgama, Sunil	Fujitsu Europe Telecom R&D Center Ltd.
Vasudevan, Subramanian	US West Advanced Technologies
Vidano, Ron	Motorola, Inc.
Vukish, Greg	TI
Wald, Jerry	HONEYWELL
Walker, Bob	NISE EAST
Watson, John	Xilinx Inc.
Weed, Dennis	FAA
Wepman, Jeff	NTIA/ITS
Williams, James L. Col	DISA/JIEO, Center for Standards
Williams, Jerry B.	Boeing Defense/Space
Williams, Larry	ITT A/CD
Wolter, Dave	Southwestern Bell Technology
Yan, Ran Hong	Lucent Technologies
Yeh, Hsi Jen	Lucent Technologies

Appendix F. Bus/Interconnect and Form Factor Technologies

The following section will briefly discuss the technologies that have been considered for implementation in software radio architectures. There are two terms that we need to define, Backplane and Backbone. Backplane is an embedded data transfer bus where modules plug into the backplane and transfer data between the modules. The system backbone is a larger data transfer pipe and is usually connected to another blackbox or chassis within a weapons platform or in a wide area network.

The next section will discuss the backplanes that industry is using.

F.1 EISA

Enhanced Industry Standard Architecture (EISA) was generated in 1988 by nine companies, AST Research, Compaq Computer Corp., Epson, Hewlett-Packard, NEC, Olivetti, Tandy, Wyse, and Zenith Data Systems. The group was frustrated with the extent of IBM's market share of the PC industry and its attempt to capture an even greater market with its new Microchannel architecture. Compaq originally headed up the effort, however, the standard now resides with BCPR services, which officiates the EISA standard.

EISA was designed as an enhancement to the very popular AT bus standard. EISA is a 32 bit backplane bus architecture that would be the successor to the ISA 16 bit standard. EISA features included new advanced data transfer modes that would trim the number of required clock cycles needed to move each byte of data. The theoretical maximum that the 32 bit bus can reach with a defined 8.2 MHz clock is 33MB/sec. This was a 50 percent increase in the proposed Microchannel backplane bus throughput. EISA, Microchannel, and specific processor local bus structures make up the very large and dynamic PC industry.

F.2 PCI Local Bus

The Peripheral Component Interconnect (PCI) local bus could be called the bus of tomorrow. This was designed by Intel and adopted by a consortium which includes Compaq, IBM, Intel, Apple, Digital, and Motorola to name a few. Most of today's high speed processors have PCI local bus interfaces built into the silicon interface. There are a series of I/O controllers, memory controllers and memory devices that have this PCI local bus built into their silicon. PCI holds the best chance of replacing the ancient Industry Standard Architecture (ISA) bus. PCI local bus is a 32 bit, or 64 bit, bus with multiplexed address and data lines. It is intended for use as an interconnect mechanism between highly integrated peripheral controller components (i.e., Ethernet, Serial, SCSI), processor memory systems, and peripheral add-in boards. The motivation for developing this consortium standard is the new graphics-oriented operating systems such as Windows and OS/2. These new graphic user interfaces and object oriented operating systems are creating bottlenecks between the processor and its display peripherals in the standard PC architecture.

The new features and benefits of the PCI local bus include higher performance over the processor local bus (132MBps), and lower cost, because it is designed for direct silicon interconnection, requiring no glue logic or electrical drivers. The ease of use enables full auto configuration support of the PCI local bus add-in boards and components. The PCI devices contain registers with device information required for dynamic reconfiguration. Another benefit is longevity, because it is processor independent and can migrate to 64-bit architectures, and it uses the new 3.3V and old +5V signaling voltages providing a smooth transition to the new industry standard.

However, PCI as a backplane will have its limitations. Currently the PCI local bus is able to reach its high performance because it dictates what the loading on the bus can be. This means that for a backplane running at 33MHz we can have a load factor of 10 but for the same bus running at 66MHz we can only support a load factor of four. The average 64-bit processor available today has a load factor of two. There is work being done in standards bodies and trade associations that will soon provide solutions to this loading problem for a backplane solution. However, if the PCI local bus was used on the modules or boards plugging into the backplane of embedded system architecture, this would provide an additional factor of modularity and upgradability. We could then see the use of the IEEE 1396.1 PCI local bus Mezzanine Card standard. This standard can be used on Futurebus+, Multibus II, and VMEbus modules that have a PCI local bus installed on their boards.

The other problem that PCI has is that it was originally designed as a motherboard solution. Multiprocessors and multiprocessing are not clearly defined by the standard or by any implementation of the standard currently available off the shelf.

The variations of the PCI local bus are given below.

PCI

Desktop environment and is built on current EISA 12 inch by 4 inch boards (32 and 64 bit options 33MHz and 66MHz).

Compact PCI

Compact PCI was initially designed by seven companies; AMP, DEC, I-Bus, Gespac, Hybricon, Pro-Log, and Ziatech to improve PCI for industrial applications. Compact PCI combines the 3U x 160 mm and 6U x 160 mm board sizes of VMEbus with a 2 mm pin-and-socket connector and a passive backplane. The high density 2 mm connector provides good signal integrity and minimizes noise. The standard was approved by the PCI Industrial Manufacturers Group (PICMG) in November 1995, and there are now about 100 products on the market.

PC/104

The PC/104 architecture developed by Ampro became an open standard, IEEE-P996.1, in February 1992 and the PC/104 Consortium became its custodian. PC/104 is essentially a stackable PC architecture using the 5MBps Industry Standard Architecture (ISA) bus. The card dimension is 3.775" x 3.55". Its small size makes it useful for embedded applications, and it is compact and rugged.

Enhancement

PC/104-Plus is fully compliant with the PC/104 form factor, but uses the PCI bus taking the backplane throughput from 5 MBps to 133 MBps. ISA and PCI modules can stack together. Currently it is a preliminary specification in the PC/104 Consortium. There are numerous products available for both PC/104 and PC/104-Plus.

High Reliability Enhanced PCI Bus

This bus will be developed by IEEE Project 1996 for transportation, telecommunications, and process control industries to provide high availability, fault tolerant systems that support harsh environments and extended temperature ranges. The module sizes include 6SU (4.53"), 12SU (10.43"), 18SU (16.34"), and 24SU (22.24") in height, and 225mm depth preferred for 6SU and 300mm depth preferred for 12SU as well as 175mm and 250mm. It is a 32 bit and 64 bit bus that accommodates Hot Swap and is self configurable.

CardBus

CardBus, also known as PC Card 32, started out as the PCMCIA card (see section F.3) which became popular for adding peripheral I/O and memory to mobile computers. The PCMCIA card is known as PC Card 16 (or R2, for revision 2), and PC Card 32 is the enhanced version. CardBus adds PCI bus performance to the PC Card 16. The PC Card Standard 95 replaces versions 2.0 and 2.1 of the earlier PCMCIA standard and covers both PC Card 16 and PC Card 32. The standard specifies a 68-pin interface between cards and socket host. There are three different form factors, Type I, Type II, and Type III. The only difference between them is the thickness of the cards with Type I being the thinnest. They all plug into the same socket. Three different pin assignments use the same 68-pin interface: PC Card 16, PC Card 32, and zoomed video (ZV). ZV is a recent addition which allows mobile PCs to deliver full-screen, broadcast quality video directly from a PC Card to a system's VGA controller without using the PCI bus. The PC Card Standard also specifies PCMCIA software interfaces. The software architecture specifies Socket Services (SS) and Card Services (CS) modules.

Small PCI

Small PCI was developed as a small-form-factor implementation of the PCI bus. It implements the same performance and electrical characteristics as standard PCI but only the 32 bit option. Small PCI has the same physical form factor as PC Card and CardBus and connects parallel to the system board via a 108-pin header mounted on the system board. See the chart below for a comparison of the Small PCI and the PC Card bus.

Table F-1

Description	Small PCI	Card bus
Form Factor	PCMCIA type II and III	PCMCIA type I, II, III plus RF extensions
Socket Keying	3.3v, 5v Universal and will reject JEIDA, DRAM and PCMCIA cards	Rejects all PCI & Japanese Electronic Industry Association (JEIDA) DRAM cards
Applications (Market Place)	low profile desk top	SAME
Environment	Under system PnP compatible	External PnP for Dynamic insertion & removal
Market	Built to order PCI only	Dynamic expansion & reconfiguration - bus independent
Cost	Low, direct attached to PCI	Higher cost - PCMCIA/CardBus controller required
Card Cover	Not required	Encapsulated
Connector	108 pin	68 pin
Connector Reliability	100 cycle (tested higher)	10,000 cycles
Performance	33MHz	33 MHz
Topology	Bus oriented	Point to Point
Voltage	3.3V, 5V	3.3V
Power	2.5, 5, 10 Watts	

Table F-2 Comparison of Example PCI Options

	Desktop PCI	Passive Backplane PCI	PMC	Compact PCI	Card Bus	Small-PCI	PC/104-Plus
Dimensions (in.)	Long: 12.3 x 3.9 Short: 6.9 x 3.9	12.3 x 3.9	5.9 x 2.9	6.3 x 3.9	3.4 x 2.1	3.4 x 2.1	3.8 x 3.6
Area (sq in)	Long: 48 Short: 24	48	17	25	7	7	13
Bus Connector	Edge-Card	Edge-Card	Pin & Socket	Pin & Socket	Pin & Socket	Pin & Socket	Pin & Socket
Includes ISA Bus	No	Yes	No	No	No	No	Yes
Installation Plane	Perpendicular	Perpendicular	Parallel	Perpendicular	Parallel	Parallel	Parallel
Expands Without Additional Slots (Self Stacking)	No	No	No	No	No	No	Yes
Positive Retention	No	No	Yes	Yes	No	No	Yes
Standards Body	PCI-SIG	PICMG	IEEE	PICMG	PCMCIA	PCI-SIG	PC/104
Primary Application Area	Desktop: motherboard expansion	Industrial: backplane expansion	Industrial: VME mezzanine	Industrial: backplane expansion	Laptop: end user additions	Laptop: factory options	Embedded: SBC expansion

F.3 PERSONAL COMPUTER MEMORY CARD INDUSTRY ASSOCIATION (PCMCIA)

PCMCIA was driven by the new PC market demands for smaller personal computers. These markets are laptops, Notebooks, and Palmtop computers. Since the late 1980s there have been many attempts to reduce the size and power requirements of Random Access Memory (RAM). In 1987 Mitsubishi had a popular memory card the size of a credit card. However, it used a proprietary 60 pin package. Fujitsu also had a memory card with a proprietary 68 pin package. POQUET, a new company investing in memory cards as an alternative to disk drives, was driving the market for a standard. In June 1988 the PCMCIA was established and work began on a standard memory card. In September 1990 the first release was accepted and products were available to users. In September 1991 release two was accepted as a standard and backwardly compatible to release one. This standard identifies both mechanical and electrical interfaces. It deals with file formats, data structures, and methods through which the card can convey its configuration and capabilities to the host.

PCMCIA type II or release two provide the user with 5.0 mm spacing for the case, a printed circuit card and all the components. This is the price we pay for the convenience of a credit card size memory board. However, PCMCIA has not been limited to memory board applications. PCMCIA is becoming the de facto expansion standard for mobile communications. However, component height, component footprint, component power, and data conversion are still issues that have to be solved when designing a PCMCIA card.

F.4 The VMEBUS Backplane

History

In 1979 Motorola defined a micro-computer bus called the VERSAbus. This bus was designed to build multiprocessing systems using the new Motorola 68000 32 bit processor. In 1981, Motorola, working with Mostek and Signetics modified the VERSAbus specification and called it VERSA Module Eurocard (VME), named from the location of the labs where the specification was modified. These companies released the specification to the world calling it the VMEbus. In 1987, the Institute of Electrical and Electronics Engineers (IEEE) published ANSI (American National Standards Institute) and IEEE 1014-1987, the standard that defined both the electrical and mechanical characteristics of the VMEbus backplane and module.

The VMEbus is defined by ANSI/IEEE 1014-1987 which defines both the electrical and mechanical characteristics of backplane and module. There are two acceptable board sizes 3U x 160mm (3.9 inches x 6.2 inches) with one connector and 6U x 160mm (9.2 inches x 6.2 inches) with two connectors (P1, P2). The standard defines a convection or forced air cooling method of the modules. The theoretical transfer rate of a module over the backplane bus is 40 Megabytes (MBps) per second at 32-bit wide transfers. It is a multiprocessor, asynchronous parallel bus architecture.

There are a number of military and commercial users who have developed their products based on the VMEbus. They range from military avionics and industrial control systems, to medical imaging systems. The spectrum of VMEbus products available today covers a wide variety of environments. Today's military programs will require equipment to meet programmatic concerns as well as performance requirements. The programmatic concerns deal with cost, performance, development time, proof of concept, and development of the application software. There are five equipment styles into which today's VMEbus products can be categorized. These styles are applicable to 90 percent of military application platforms and include commercial, ruggedized air cooled, ruggedized conduction cooled, military air cooled, and military conduction cooled. These equipment styles cover environmental and programmatic requirements from commercial systems to mission-critical applications.

The VMEbus migration with technology

Since 1980 the VMEbus has found its way into many commercial, industrial, and military applications. The VMEbus has become many corporations' internal research and development backplane bus which evolved to actual commercial products based on the VMEbus. The VMEbus is in a wide variety of commercial applications, from billing and controlling systems for the telecommunication industry to medical imaging and manufacturing floor applications. VMEbus technology follows the PC market advances in silicon and Input/Output (I/O) application techniques.

The VMEbus has migrated from single boards acting as processor, memory, and I/O control to single boards containing all three elements. Recently the backplane industry has seen a new trend in multiprocessor technology. Specialty processors like the Intel I860, the Texas Instruments TSM320C040 digital signal processor, and Transputers are showing up 2, 4, 8 processors to a VMEbus board. These processors in combination with the new 32 bit and 64 bit Complex Instruction Set Computer (CISC)- based processors from Intel, Motorola, Hewlett Packard, and Digital provide an unique modular capability for embedded applications.

To meet the data throughput demands of these new processors and I/O controllers, the VMEbus has added new high speed data bus structures to its current VME Subsystem Bus (VSB) P2 alternate data bus. Raceway, SkyChannel, and Signal Computing System Architecture (SCSA) all provide unique solutions to moving data from processor to processor to memory or I/O controller.

With new technologies emerging like Personal Computer Memory Card Industry Association (PCMCIA), Peripheral Component Interconnect (PCI) local bus, and Scaleable Coherent Interconnect (SCI) the VMEbus is providing solutions for these technologies. There are PCMCIA type three memory expansion boards, PCI local bus processors and even mezzanine bus cards, as well as Scaleable Coherent Interconnect I/O controllers.

Despite its age the VMEbus has been able to adapt to the changing commercial marketplace expanding the role it plays in development, research, and production. It is also expanding its market industry by addressing Fault Tolerance, Live Insertion, High Availability, and Testability.

Below are sections that discuss some of the enhancements to the VMEbus since 1980.

F.5 VME64

VME64 is an ANSI standard, ANSI/VITA-1 1995, and increases the VMEbus throughput to 80 Mbps from the 32-bit version of 40. VME64 is 100 percent backward compatible to ANSI/IEEE 1014 (32-bit VMEbus). VME64 provides 64/32/24/16/08 data it transfers with 16/32/64 bit addressing. VMEbus 6U x 160mm boards will be capable of 80 Mbytes/sec. 3U x 160mm boards will provide their users with 40 Mbytes/sec. VME64 adds new capabilities such as:

- Rescinding DTACK
- Lock commands
- Retry signal
- Auto slot ID
- Auto system controller
- Control and Status registers

Rescinding DTACK provides users and integrators with quicker and cleaner data transfers. LOCK commands aid the integrator and user in sectioning off specific system resources. The RETRY signal provides a mechanism to retry a data or address transfer if an error or read modify write cycle is in process. Auto Slot ID provides the system integrator with board identification and location in the VMEbus system configuration. Along with the Auto system controller the VMEbus system can now, on power up, identify who the slot one controller is and what other resources are in the system configuration. The Control and Status registers will provide faster access to faults and health monitoring capabilities.

Products Availability

Currently there are four manufacturers of VMEbus Silicon that have VME64 compliant silicon. Newbridge Technology, Force Computers, Motorola, and Cypress Semiconductor. The majority of products that are available with VME64 enhancements are processor boards. I/O and memory boards are still in development with the VME64 enhancements. To find what company is supporting VME64, check the VITA World Wide Web site for their on-line product catalog (http://www.vita.com).

Integration Techniques

The VMEbus boards that do support VME64 enhancements may have little or no effect on the throughput of a system when the new Multiplexed Block Transfer (MBLT) of VME64 is integrated. The reason for this is simply that many I/O and memory boards are still transferring 32 bit data instead of the MBLT 64 bit data transfers. Also some of the processors that offer MBLT 64-bit transfers still have 32-bit local bus structures requiring two local bus accesses for every one VMEbus MBLT 64 bit data transfer. Therefore if you have a VME64 processor who will transfer 32 bit data over the VMEbus at a rate of 10 MBytes a second (BLT) you may find that same processor transferring 64 bit data over the VMEbus at a slower rate of 7 MBps. This is because to the processor's local bus is 32 bits wide and the processor has to move the data into or out of the VMEbus interface chip's internal File In, File Out (FIFO) or register. Look to the 64-bit processors and their 64-bit local bus structures for maximizing the MBLT feature of the VMEbus. PCI local bus is still currently only 32-bits wide. However it can move data at a very high rate (130MBps). Thirty-two-bit processors like the Power PC may not have the MBLT slow down with this combination local bus and VMEbus interface.

F.6 VME64 Extensions

The VME64 Extensions are a group of optional capabilities or enhancements that will help the integrator tailor a VMEbus-configured system to meet specific needs of his or her application. VME64 Extensions have sought solutions to providing the VMEbus user with additional I/O through the P1 and P2 connectors. They have looked at ways to improve signal integrity and provide higher availability of the configured system through fault management and testability techniques.

Enhancements

The VME64 Extensions provide VMEbus users and system integrators with the hardware and software tools to meet the new generation of applications. VME64 Extensions provide new voltage pins like 3.3V and 48V with additional ground signals to improve signal integrity. VME64 Extensions provides the user with a new high speed serial bus designed to be an alternate data path for the VMEbus. There is a new test and maintenance bus (IEEE 1149.5) defined for use with the VME64 Extensions. Live Insertion pins have been defined to allow hot swap of boards. There are also additional I/O pins on the new connectors and a space defined for an optional P0 connector. The VME64 Extension also defines a new EMI protection front panel, that will reduce the emissions of VMEbus processor boards so that they can meet UL and CE (European) standards.

Products Availability

Currently this standard is in a working committee and has not been released for ANSI accreditation. Therefore, there are no products available with all of the features described in the paragraphs above. However, there are boards that have been produced by major VMEbus board manufactures and Backplane vendors have tested the new connector and backplane solutions.

Integration Techniques

When these products do become available in the VMEbus market, care should be given to configuring systems with VME64 Extension products. Because these enhancements are options within the document not all companies will produce all options. This could cause a problem with interoperability.

F.7 VME320

Enhancements

At a recent press conference, Bustronic Corporation and Arizona Digital announced their development of a new enhancement to the VMEbus, VME320. This is a new type of VME backplane that transfers data at 320 Mbytes/sec. This is 4 times faster than the existing VME64 and unlike the VME64 Extensions, will be completely backwardly compatible with all existing VMEbus boards. It uses the existing 96-pin DIN connectors and is also available in a 160 MBps version, VME160.

Products Availability

Currently this standard is in a working committee and has not been released for ANSI accreditation.

Integration Techniques

Because this new technique provides cleaner transitions than traditional VMEbus backplanes, the integration of products into new or existing systems should provide no change in performance or an improvement in electrical performance as well as data transfer rate.

F.8 SEM-E on VME

Enhancements

SEM-E has been a popular form factor used in the military for a number of years. It is based on conduction cooled technology, a small form factor, and a blade-and-fork style connector that provides high reliability in high shock and vibration environments. This technology under standardization uses the SEM-E form factor with the VMEbus backplane and protocol.

Products Availability

Currently this standard is in a working committee and has not been released for ANSI accreditation.

Integration Techniques

Once products become available using this form factor/backplane combination the utility of SEM-E will be greatly enhanced by the inclusion of a standardized protocol.

F.9 VMEbus P2 Sub-bus Data Transfer Architectures

This section will discuss a sub-bus or sub-backplane data transfer bus. These buses have been added to meet the rising need to move larger amounts of data in greater speeds.

F.9.1 RACEway

The ANSI Board of Standards Review officially approved the VITA 5-1994, RACEway Interlink as a standard on July 31, 1995. RACEway is a crossbar-switch technology integrated onto a P2 backplane for the VMEbus. RACEway provides the VMEbus user with up to six bi-directional data paths with a maximum throughput of 160 MBps.

Enhancements

The development of RACEway Interlink was motivated by the desire to provide high bandwidth communication while maintaining compatibility with the VMEbus. RACEway Interlink is a scaleable interconnection fabric based on a network of crossbar-switch devices that provide 1.6 gigabytes per second (Gbps) throughput. The RACEway Interlink specification was brought to the VSO for standardization by Mercury Computer Systems, Inc..

The RACEway Interlink standard is targeted at multiprocessor and high-speed I/O applications. I/O devices such as A/D, D/A, frame stores, graphic displays, LAN/WAN connections, and storage devices. RACEway Interlink enhances VMEbus performance in existing VMEbus systems by enabling concurrent communication between multiple processors.

Product Availability

Numerous RACEway Interlink design projects are underway in the VMEbus community with developers using the new standard to link I/O subsystems with off-the-shelf VME boards. Also underway is the design of chip-level products to support this standard. Mercury and Cypress Semiconductor Corporation will be working together to develop semiconductors that will help proliferate RACEway technology.

F.9.2 VSB

The VME Subsystem Bus (VSB) is the son of VMX and VMX32 memory expansion buses that were developed by Motorola to move data to and from the processor board's local bus. VMX and VMX32 were local bus expansions in the days when only 256K and 512K DRAM or SRAM fit onto a single board computer. The VME community saw that a separate data transfer bus would increase the system throughput and expanded the VMX concept to include arbitration and interrupts.

Enhancements

The VSB uses all the user defined pins of the VMEbus P2 connector. It defines a complete asynchronous backplane data transfer bus. The VSB is a full 32-bit address, data bus with a single level arbiter and single level interrupt. The VSB supports dynamic bus sizing, read-modify write cycles, and block transfers as does the VMEbus. The throughput of the VSB is currently 30-40 MBps. There is work going on at VITA/VSO that is exploring how to increase the speed and data size of the current VSB standard.

Products

The VSB has been available off-the-shelf since 1987. There are many processors, I/O controllers, and memory cards that support this P2 bus. There are even processors that are available in five environmental build standards that support this 32 bit subsystem bus.

F.9.3 Skychannel

SKYchannel is a 200 MBps packet bus architecture developed by SKY computers. This architecture provides the VMEbus user a higher throughput and alternate data transfer path from the standard VMEbus backplane architecture. SKYchannel connects multiple single board computers on the VMEbus through an active P2 backplane connection. This concept is similar to the RACEway crossbar P2 active backplane solution.

Enhancements

The SKYchannel packet bus architecture provides yet another P2 backplane communications path. This new packet mode architecture uses a series of FIFOs, DMA controllers and packet controllers at each SKYchannel interface to ensure that packets are built continuously and data pipelines are filled. SKYchannel can be a backplane or a point to point connection. The current proposed specification allows the user up to ten ports and five simultaneous 320Mbps per level for an aggregated data bandwidth of 1600Mbps (200MBps).

Products Availability

SKYchannel is still in working group draft. Products are available from SKY, but they do not meet the current configuration of the draft standard.

F.9.4 SCSA

The ANSI Board of Standards Review officially approved the VITA 6-1994, SCSA as a standard on July 24, 1995.

Enhancements

SCSA is a comprehensive, open software and hardware architecture that streamlines the process of building computer telephony systems.

SCSA offers a standard way of dealing with the many levels and inter relationships that come into play when developing and building computer telephony systems. It provides standard interfaces that satisfy the demands of application program developers, hardware component developers, software algorithm developers, platform developers, and end users.

This new ANSI/VITA 6-1994 SCSA standard allows the VMEbus architecture to move firmly into telephony. SCSA enables VMEbus manufacturers to develop products that bring SCSA's high signal capacity and VME performance and robust packaging to a growing, global CTI market.

Product Availability

Currently there are no board level products available with VMEbus and SCSA. However, there are many turnkey systems that integrate VMEbus and SCSA in digital switching systems.

F.10 Backbone or System Bus Structures

In this section we will be discussing current system backbone structures and how they are implemented or going to be implemented in the software radio and to the software radio system architectures.

F.10.1 MIL-STD-1553B

During the late 1960's the military aircraft industry reached a level of performance complexity such that simple point-to-point interconnection was no longer cost effective. Nor did it meet the requirements of the applications. The need to share information and resources grew as size, weight, and space requirements became critical in smaller faster aircraft. In 1968 the SAE A2K Committee in cooperation with the TRI-Services was formed to generate military standard for multiplexing. The Military Standard Aircraft Internal Time Division Command, Response Multiplexed Data Bus was issued in 1973. The current MIL-STD-1553B standard was adopted in 1978. This serial bus had a transfer rate of 1 Mbps in 20-bit frames. However, with the processor overhead and response required throughputs of 7.125 Kbps is what is seen on today's MIL-STD-1553B backbone bus standards. The data bus travels a shielded twisted pair cable. The data bus transmissions are serial time division multiplex messages in pulse code modulation form. The data bus traffic is half duplex, hence it travels in one direction at a time over one of the dual redundant cables. The MIL-STD-1553B data bus network functions in a command, response sequence. Access to the data bus is provided only when a command is received and acknowledged by the data bus controller. The MIL-STD-1553B data bus is found in many commercial and military Avionics system architectures as well as in the military Vetronics industry. We have seen a great push to have the black box chassis connect to this standard serial bus to provide a cost effective mechanism to pass data within our system application.

F.10.2 MIL-STD-1773A

The MIL-STD-1773A is the optical equivalent of the MIL-STD-1553 bus. The MIL-STD-1773 was developed to realize the optical technology advantages for the Avionics community. Optics provide solutions with higher bandwidth, lighter weight, and reduced space. Optics also provides immunity to electromagnetic interference. MIL-STD-1773 is implemented to replace MIL-STD-1553 and therefore the standard is implemented at the same speed of 1 Mbps. Since MIL-STD-1773 deals with optical rather than electrical signals there were changes required in the Manchester II coding. A logical one begins with optical energy present and a logical zero begins with no optical energy present.

F.10.3 FDDI

Fiber Distributed Data Interface (FDDI) is a 100 Mbps Local Area Network (LAN) standard. The topology of the FDDI is a point to point connection of links connected in a logical ring. There are two such rings that circle each other connecting to the same links in the ring. To govern who will be in control the FDDI bus a token is passed between all the nodes on the FDDI bus. This topology lends itself to fault tolerance. In a dual attached LAN a break in the ring will automatically switch the data to the other ring. There can be up to 500 links or stations with the maximum size of the rings or LAN as 200 kilometers. The maximum distance between each link or station can be up to 2 kilometers squared. The Open System Interconnect reference model identifies FDDI as a physical layer or layer one and part of the data link layer two. FDDI and Ethernet (IEEE 802.3) are considered very similar. However, FDDI is more related to the (IEEE 802.5) token ring. The first FDDI standard was available from ANSI X3T9 committee in early 1983. It officially was completed in the year 1988 as the ANSI standard X3.148-1988

F.10.4 N-ISDN

Narrowband Integrated Services Digital Network (N-ISDN) provides end-to-end digital connectivity with access to voice and data services over the same digital transmission and switching facilities. N-ISDN provides two core interfaces Basic Rate Interface (BRI) and Primary Rate Interface (PRI). N-ISDN also provides the user with three channel types B, D,and H. BRI is a set of two bearer channels (B) which carry data or voice. Each B channel is a 64K bits per second (bps) pipe. This pipe or channel can carry any type of digitized voice, data, and video information. BRI also carries one D channel for signaling and switching data. The D channel is a 16 Kbps digital channel that carries the information for the network switches to set up, connect, monitor, and tear down connections or calls. PRI is a larger set of channels that includes 23 B channels at 64 Kbps and one D channel. The D channel in the PRI mode is different than BRI. The difference is the amount of data required in the D channel for the switching information. This channel is 64 Kbps. In Europe, primarily, the H channel is used to carry user information relating to video teleconferencing, high speed data, and high audio or sound programs and images. The H channel has variable throughput capabilities at 384 Kbps, 1.536 Mbps, or 1.920 Mbps. These throughput capabilities allow video teleconferencing, high-quality audio and images to be passed between users. It is the signaling channel that allows N-ISDN to carry multiple integrated digital services over a switched circuit.

F.10.5 ATM

Asynchronous Transfer Mode (ATM) is the formal International Telecommunication Union (ITU) standard for cell based voice, data, and multimedia communication in a public network. ATM is a high bandwidth, low delay switching and multiplexing technology that uses a 53 byte cell (one byte is eight bits) for transmitting information. Each cell consists of an information field that is transported transparently by the network (Similar to the signal channel D of N-ISDN) and a header containing routing information. The obvious benefits of ATM include high speed, low latency, and increased network availability through automatic and guaranteed assignment of network bandwidth. This is ideal for time sensitive data like voice and video. For the military it could carry synchronous channels with cryptographic data. Current ATM data rates are 45Mbps, 51Mbps, 100Mbps, 155Mbps, and 622Mbps. ATM is a connection oriented process, although it is designed for either connectionless and connections-oriented services. ATM supports a number of applications using the ATM Adaptation Layers (AAL). ATM is an evolving standard and there are currently three AALs presently defined with a fourth AAL2 under development.

AAL1: Timing required, constant bit rate, connection oriented. This ATM Adaptation Layer provides the details for connection oriented circuit emulation of a point to point line. T1, E1 or T3, E3 leased circuits could be emulated with the use of this AAL.

AAL2: Designed to support variable bit rate applications such as compressed motion video traffic generated by the MPEG, MPEG2 algorithms.

AAL3/4: Timing not required, variable bit rate, connectionless. This supports fast packet services such as Switched Multi-megabit Data Service (SMDS).

AAL 5: Unrestricted (variable bit rate, connection oriented or connectionless), also known as "Class X." This AAL supports a fast packet service such as cell-relay. This AAL is being implemented in the Local Area Network emulation for ATM

ATM information is sent between two points over a media comprised of virtual channels. Each channel can be transmitted over the network in a manner consistent with the needs of the data or subscriber. The user's data is associated with a specified virtual channel. In ATM the virtual channel is used to describe unidirectional transport of ATM cells associated by a common unique identifier value called a virtual channel identifier. A virtual path is used to describe unidirectional transport of ATM cells belonging to virtual channels that are associated by a common identifier value called virtual path identifier. The ATM switch reads the virtual channel identifier and virtual path information from an incoming cell and based on the information makes a routing decision and sends the cell out through the proper switch port.

F.10.6 FIBREChannel

In 1988 the ANSI standards body, X3T9.3 committee, formed a FibreChannel working group to develop a practical, inexpensive yet expandable method for achieving high speed data transfers among workstations, mainframes, supercomputers, desktop computers, storage devices, and display devices. FibreChannel was started to address the need for fast transfers of large volumes of data while at the same time relieving system manufacturers from the burden of supporting the variety of channels and networks currently in place throughout the Information Technology market.

In 1994 ANSI X3.230-1994 was approved for optimizing large volumes of data, not for low-latency dynamic interactive usage. The throughput of the standard allows for multiple architectures, point-to-point and Local Area Network configurations at 265,531 and 1062 MBps to 2 and possibly 4 GBps.

The current market that the FibreChannel solutions appear to be addressing is in the area of mass storage devices. SCSI-3 is a FibreChannel-like serial connection.

F.10.7 FireWire

FireWire, IEEE Std. 1394-1995, was originally intended as an interconnection method between PC peripherals and consumer electronic devices. The throughput speeds are 100 Mbps and 200 Mbps with 400 Mbps in development. The distance over which it operates is bounded at 10s of meters. Some FireWire products are available, and Microsoft has announced its intention to support it in future versions of Windows.FireWire, IEEE Std. 1394-1995, was originally intended as an interconnection method between PC peripherals and consumer electronic devices. The throughput speeds are 100 Mbps and 200 Mbps with 400 Mbps in development. The distance over which it operates is bounded at 10s of meters. Some FireWire products are available, and Microsoft has announced its intention to support it in future versions of Windows.FireWire, IEEE Std. 1394-1995, was originally intended as an interconnection method between PC peripherals and consumer electronic devices. The throughput speeds are 100 Mbps and 200 Mbps with 400 Mbps in development. The distance over which it operates is bounded at 10s of meters. Some FireWire products are available, and Microsoft has announced its intention to support it in future versions of Windows.