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Part 9: Peripheral Equipment Interface

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Contents

Intellectual Property Rights 5
Foreword....5
Introduction 5
Background 6
Need for a Physical Link Update 6
1 Scope 7
2 References 7
2.1 Normative references 7
2.2 Informative references....8
3 Definitions and abbreviations....8
3.1 Definitions....8
3.2 Abbreviations 9
4 Background 10
4.1 Support of High Data Rates....10
4.2 Data Reliability 10
4.3 Power Efficiency 10
4.4 Robustness....10
4.5 Ease-of-Use 10
4.6 Widely Adopted in the Information Technology World and Compatibility with Other Data Systems....10
4.7 Security 10
5 Wired Solutions - Background....11
5.1 Firewire 11
5.1.1 Technical Specification and Architecture....11
5.1.2 Power Supply....11
5.1.3 Versions and Data Rates....11
5.1.3.1 Firewire 400....11
5.1.3.2 Firewire-800....12
5.2 USB....12
5.2.1 Technical Specification and Architecture....12
5.2.2 Power Supply....12
5.2.2.1 Versions and Data Rates 12
5.2.2.1.1 USB 1.0/1.1 12
5.2.2.1.2 USB 2.0 13
5.2.3 USB Backward Compatibility 13
5.3 USB on the Go 13
5.3.1 Why USB OTG....13
5.3.2 Power Supply....14
5.3.3 USB Data Transfer Modes, Connection Configurations....14
5.3.3.1 Control transfers....14
5.3.3.2 Interrupt transfers....14
5.3.3.3 Isochronous transfers 14
5.4 EIA-485....15
5.4.1 Technical Specification and Architecture....15
5.4.2 Power Supply....15
5.5 Comparisons between Wired Solutions....16
5.5.1 Support of High Data Rates....16
5.5.2 Data Reliability....16
5.5.3 Power Efficiency 16
5.5.4 Robustness....16
5.5.5 Ease-of-Use....17
5.5.6 Widely Adopted in the Information Technology World and Compatibility with Other Data Systems 18
5.5.7 Data overhead....18
6 Wireless Solutions - Background....19
6.1 Wireless USB 19

6.1.1 Certified Wireless USB (CWUSB) ... 19
6.1.2 CWUSB Technical Specification and Architecture ... 19
6.1.3 Versions and Data Rates ... 19
6.1.4 UWB Noise ... 19
6.2 Bluetooth ... 19
6.2.1 Technical Specification and Features ... 20
6.2.2 Versions, Features and Data Rates ... 20
6.3 Infrared Data Association ... 20
6.3.1 Technical Specification and Features ... 21
6.3.2 Versions, Features and Data Rates ... 21
6.4 Comparisons between Wireless Solutions ... 21
6.4.1 Support of High Data Rates ... 21
6.4.2 Data Reliability ... 22
6.4.3 Power Efficiency ... 22
6.4.4 Robustness ... 22
6.4.5 Ease-of-Use ... 22
6.4.6 Widely Adopted in the Information Technology World and Compatibility with Other Data Systems ... 23
6.4.7 Security ... 23
7 Background Conclusions ... 25
7.1 Comparison of technologies ... 25
7.1.1 Summary of table 7.1 ... 25
7.1.2 Summary of table 7.2 ... 25
8 User Requirements for Enhancements of the TETRA Peripheral Equipment Interface standard ... 26
8.1 Introduction ... 26
8.2 Physical Link ... 26
8.2.1 USB ... 26
8.2.2 Bluetooth ... 26
8.2.3 Wireless USB ... 27
8.3 Multimedia capability ... 27
8.4 QoS negotiation ... 27
8.5 Circuit mode data, SDS, and STATUS messaging ... 27
8.6 Multiple services on PEI ... 27
8.7 Void ... 27
8.8 Multiple applications ... 27
8.9 Embedded systems ... 28
8.10 Legacy applications support (TETRA and GSM) ... 28
8.11 Standardized complete support similar by all manufacturers ... 28
8.12 Interoperable ... 28
8.13 Developing a driver from scratch ... 28
8.14 Multiple platforms ... 28
8.15 Ease of application developers ... 28
8.16 Circuit mode data, PD, SDS and STATUS messaging ... 28
8.17 Minimum cost ... 29
8.18 Time to market ... 29
8.19 Open source driver layers ... 29
8.20 Freely available drivers ... 29
8.21 IPR licensing costs - FRAND ... 29
8.22 Resilient to errors on the interface ... 29
8.23 Future upgradeability ... 29
8.24 Hot-pluggable ... 30
8.25 Easy to test and certify ... 30
8.26 Low CPU and memory overhead ... 30
8.27 Battery life concerns ... 30
8.28 Flow control ... 30
Annex A: Indicative data throughput rates for example TETRA 2 data applications. ... 31
A.1 Data rates ... 32
Annex B: Comparisons between data format, number of supported devices, maximum data speed and usage of well-known physical links ... 33
History ... 34

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Terrestrial Trunked Radio (TETRA).

The present document is part 9 of a multi-part deliverable covering the User Requirement Specification TETRA Release 2 and Release 2.1, as identified below:

Part 1: "General overview";

Part 2: "High Speed Data";

Part 3: "Codec";

Part 4: "Air Interface Enhancements";

Part 5: "Interworking and Roaming";

Part 6: "Subscriber Identity Module (SIM)";

Part 7: "Security";

Part 8: "Air - Ground - Air services";

Part 9 "Peripheral Equipment Interface";

Part 10: "Local Mode Broadband";

Part 11: "Over The Air Management".

Introduction

The Terms of Reference for TC TETRA approved at ETSI Board meeting #52, May 2005 ([ETSI/B52(05)13 rev.1]) is to produce ETSI deliverables (and maintenance thereafter) in accordance with the following requirements:

- The provision of user driven services, facilities and functionality as required by traditional Professional Mobile Radio (PMR) user organizations such as the Emergency Services, Government, Military, Transportation, Utility and Industrial organizations as well as Public Access Mobile Radio (PAMR) Operators.

- The evolution and enhancement of TETRA as required by the market with the provision of new services, facilities and functionality made possible by new technology innovations.

- Further enhancements of the TETRA air interface standard in order to provide increased benefits and optimization in terms of spectrum efficiency, network capacity, system performance, quality of service, and other relevant parameters.

- The full backward compatibility and integration of the new services, facilities and functionality with existing TETRA standards in order to future-proof the existing and future investments of TETRA users.

The TETRA Release 2 standard, incorporating the high-speed capability (TEDS) has just been published. This high-speed data capability increases the maximum data rate of the TETRA systems from 28,8 kbit/s to over 500 kbit/s, which has the capability to radically changing the range of data applications available to TETRA users. The current TETRA PEI standard, EN 300 392-5 [i.18] V1.3.1 is a narrow band interface with limited application handling capability for the Release 2 type TETRA networks. Hence, an enhanced PEI with a concurrent multimedia capability is essential to enable access to the system from a range of data terminals (such as laptops, etc.).

The present document provides the User Requirement Specifications for the TETRA Peripheral Equipment Interface enhancements.

The URS is required by WG3 and WG4 of TC TETRA to guide the enhancement of the current TETRA PEI standard.

Background

The PEI standard which was last updated on August 2007 EN 300 392-5 [i.18], defines a point-to-point configuration between a TE2 and a MT2 using a sub-set of ITU-T Recommendations V.24 [i.2] and V.28 [i.3]. The V.24 standard provides list of definitions for interchange circuits between Data Terminal Equipment (DTE) and Data Circuit-Terminating Equipment (DCE), first agreed in 1964 which is equivalent to a subset of Electronic Industries Association (EIA) Recommended Standard EIA-232. Beside large voltage swings, limitations in noise immunity and low reliability of the flow control mechanisms that this standard introduces, the achievable data rate is also a major bottleneck in wide-band capability of the TETRA release 2.

In order to propose appropriate physical links, an initial study has already been carried out by HW communications Ltd and submitted to ETSI TC TETRA WG4 as a response to the ETSI's call for STF 314 on TETRA Release 2 PEI [i.4]. The present document, recommends wired and wireless physical link candidates that should be used between a Terminal Equipment 2 (TE2) and a Mobile Termination 2 (MT2) at the TETRA reference point RT [i.1].

Need for a Physical Link Update

Before the initiation of TETRA Release 2, limited attention has been paid to the provision of IP-based wideband multimedia services in Private Mobile Radio (PMR) wireless networks, such as those used by public safety organizations in TETRA release 1. However, TETRA Release 2 has changed this by development of TEDS, which intends to broaden the spectrum of multimedia services offered to TETRA users. As TEDS offers data rates comparable to that of 2,5G/3G networks, then the using real-time multimedia applications will be feasible in TETRA.

For example, in table 1, the average required throughput for real-time video is presented. The video resolution and frame sizes are derived based on ITU-T Recommendation H.264 [i.5]. It is clear that for TETRA2, using outdated physical link technologies such as EIA-232 which supports maximum data rate of 20 kbit/s is no longer a feasible option.

Table 1: Average throughput for real-time video transmission

Multimedia service Real-time video (Resolution/frame)	Average throughput (kbit/s)
128 × 96 / 30,9 176 × 144 / 15,0	64
176 × 144 / 30,3 320 × 240 / 10,0	192

A list of applications with minimum required data rates for transmission is provided in annex A.

1 Scope

The present document provides the User Requirement Specifications (URS) for the enhancements of the TETRA Peripheral Equipment Interface.

The existing TETRA PEI standard has been available since 1998. The TETRA Release 2 standard, incorporating the high-speed data capability (TEDS) has been published. This HSD capability increases the maximum data rate of the TETRA systems from 28,8 kbit/s to over 500 kbit/s, radically changing the range of data applications available to TETRA users. The TETRA users could, from now on, use a range of multimedia applications (with video as a medium) via TEDS channels. One bottleneck to making full use of this new capability is the restrictions imposed by interfacing TETRA Release 2 systems via mobile stations only. Hence, a standard HSD PEI with a concurrent multimedia capability is essential to enable access to the system from a range of data terminals (such as laptops, etc.).

Peripheral Equipment Interface enhancements translated into terms of:

- PEI physical layer aspects;
- Multimedia capability ;
- QoS negotiation

The present document is applicable to the specification of TETRA Release 2 equipment.

The user requirements contained in the present document are described mainly in non-technical terms and are based on discussions in TC TETRA WG1.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific.

- For a specific reference, subsequent revisions do not apply.
- Non-specific reference may be made only to a complete document or a part thereof and only in the following cases:
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2.1 Normative references

The following referenced documents are indispensable for the application of the present document. For dated references, only the edition cited applies. For non-specific references, the latest edition of the referenced document (including any amendments) applies.

Not applicable.

2.2 Informative references

The following referenced documents are not essential to the use of the present document but they assist the user with regard to a particular subject area**.** For non-specific references, the latest version of the referenced document (including any amendments) applies.

[i.1] ETSI TR 102 021-1: "Terrestrial Trunked Radio (TETRA); User Requirement Specification TETRA Release 2; Part 1: General Overview".

[i.2] ITU-T Recommendation V.24: "List of definitions for interchange circuits between data terminal equipment (DTE) and data circuit-terminating equipment (DCE)".

[i.3] ITU-T Recommendation V.28: "Electrical characteristics for unbalanced double-current interchange circuits".

[i.4] Collective Letter 06-2474 (2006-06): "Preliminary Call for Experts for Specialist Task Force QH (ETSI/ TETRA WG4) on TETRA Release 2 Peripheral Equipment Interface (PEI)".

[i.5] ITU-T Recommendation H. 264: "Advanced video coding for generic audiovisual services".

[i.6] 1394 Trade Association, "1394 Standards and Specifications Summary".

[i.7] Universal Serial Bus.

NOTE: Available at http://www.usb.org.

[i.8] "On-The-Go Supplement to the USB 2.0 Specification".

NOTE: Available at http://www.usb.org/developers/onthego/.

[i.9] "Engineering Department, Electronic Industries Association, EIA Standard RS-485 Electrical Characteristics of Generators and Receivers for Use in Balanced Multipoint Systems, reprinted in Telebyte Technology "Data Communication Library" Greenlawn NY, 1985".

[i.10] http://www.bulgin.co.uk.

[i.11] "Wireless Universal Serial Bus Specification" 1.0 Revision by: Agere Systems Inc., Hewlett-Packard Company, Intel Corp., Microsoft Corp., NEC Corp., Koninklijke Philips Electronics N.V., Samsung Electronics Co. Ltd., May 2005.

[i.12] http://www.wimedia.org/en/index.asp.

[i.13] http://www.cypress.com/.

[i.14] "Specification of the Bluetooth system", Specification Version D, November 2004.

[i.15] http://www.irda.org/.

[i.16] http://www.wi-fi.org/.

[i.17] ITU-T recommendation V.250: "Serial asynchronous automatic dialling and control".

[i.18] ETSI EN 300 392-5: "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D); Part 5: Peripheral Equipment Interface (PEI)".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

function: entity, especially in USB OTG, that is responsible for responding to requests to initiate communications on the PEI

host: entity, especially in USB OTG, that is responsible for initiating the communications on the PEI

3.2 Abbreviations

For the purposes of the present document, the abbreviations apply:

ASN	Abstract Syntax Notation
BER	Bit Error Rate
COM	COMmunications (serial) port
CPU	Central Processing Unit
CWUSB	Certified Wireless USB
DSCP	DiffServ CodePoints
EIA	Electronics Industries Association (USA).
EISA	Extended ISA
FCC	Federal Communications Commission (USA)
FRAND	Fair, Reasonable And Non-Discrimatory terms.
GFSK	Gaussian Frequency Shift Keying
GPL	GNU Public License
GSM	Groupe Special Mobile
HSD	High-Speed Data
IETF	Internet Engineering Task Force
IOP	InterOPerability
IP	Internet Protocol or International Protection
IrDA	Infrared Data Association
IRQ	Interrupt ReQuest
ISA	Industry Standard Architecture
ITU-T	International Telecommunications Union - Telecommunications standardization sector
mA	milliAmpere
MIDI	Musical Instrument Digital Interface
MS	Mobile Station (which comprises both TE and MT)
MT	Mobile Terminal
OSI-RM	Open System Interconnection – Reference Model
PC	Personal Computer
PCI	Peripheral Connection Interface
PD	Packet Data
PDA	Personal Digital Assistant
PEI	Peripheral Equipment Interface
PPP	Point-to-Point Protocol
QoS	Quality of Service
RF	Radio Frequency
SCSI	Small Computer Systems Interface
SDS	Short Data Service
SNR	Signal to Noise Ratio
STATUS	When capitalized, this means TETRA 16-bit status messaging
TCP	Transport Control Protocol
TE	Terminal Equipment, which is used for hosting an application
TEDS	TETRA Enhanced Data Service
TETRA	TErrestrial Trunked RAdio
UART	Universal Asynchronous Receiver / Transmitter
UDP	User Datagram Protocol
USB OTG	USB On The Go
USB	Universal Serial Bus
UWB	Ultra WideBand
WiFi	Wireless Fidelity

4 Background

There are number of criteria to be considered for a suitable physical link. The following criteria are briefly explained.

4.1 Support of High Data Rates

This is a prime requirement that enables wideband transmission of concurrent applications including multimedia.

4.2 Data Reliability

The physical link should provide minimum acceptable data reliability. This is an important feature that almost all applications such as multimedia data rely upon. Unreliable communication does not only affect the data and data quality but also affects the throughput.

4.3 Power Efficiency

Low power physical links which results in longer battery life and connection time of a mobile unit as well as the peripheral equipment is an important factor.

NOTE: It is not straight forward to calculate power efficiency of physical links. This is because almost all chipsets have different operation modes such as "Active or Operating" and "Suspend" modes. Depending on the application"s data rate and times switching between operating and suspend mode, power consumption changes are non trivial to calculate.

It is possible to introduce a function that takes parameters based on the application and derive power consumption of chipsets. Let us consider two parameters as α and β representing percentage of the time that device is in operating or suspended mode, respectively. Then mean power consumption, P_C, of the chipset is defined as:

$$P_C = \alpha \times P_A + \beta \times P_S \qquad \text{(Eq.1)}$$

Where, P_A and P_S are power consumption of the chipset in operating and suspended modes respectively.

4.4 Robustness

The physical link should be robust in harsh environments and protect itself from ingress of hazards such as water, oil and dust. The same time connection should be stable and reliable in harsh conditions such as on-the-move, vibration intensive, scenarios.

4.5 Ease-of-Use

In emergency situations, the user should be able to setup and disconnect a physical connection fast and effectively.

4.6 Widely Adopted in the Information Technology World and Compatibility with Other Data Systems

This is to ensure cost effective, easy and efficient implementation and operations. It is important to ensure that the physical connection is supported by most peripheral equipment such as PCs, video conferencing units, telemedicine platforms and portable clinical devices.

4.7 Security

For wireless solutions, data security is an important issue. The proposed physical links would be compared together where the level of securities that they provide are rated.

5 Wired Solutions - Background

5.1 Firewire

Many computers intended for home or professional audio/video use built-in FireWire [i.6] interfaces.

The Firewire documentation defines a media, topology and protocol for a point-to-point serial cable interface.

5.1.1 Technical Specification and Architecture

The digital interface supports either asynchronous or isochronous data transfers. FireWire can connect together up to 63 peripherals in an acyclic topology (as opposed to Parallel SCSI's Electrical bus topology). It allows peer-to-peer device communication to take place without using system memory or the CPU. FireWire also supports multiple hosts per bus. It is designed to support Plug-and-play and hot swapping. Its six-wire cable is more flexible than most Parallel SCSI cables and can supply up to 45 watts of power per port at up to 30 volts, allowing moderate-consumption devices to operate without a separate power supply.

5.1.2 Power Supply

Based on the electrical specification of a chipset (µPD72852A with data sheet number: S16725EJ2V0DS), recommended operating voltage and current are presented in tables 5.1 and 5.2.

Table 5.1: Power supply voltage

Parameter	Condition	MIN.	TYP.	MAX.	Unit
Power supply voltage	Source power node	3,0	3,3	3,6	V
	Non-source power node	2,7	3,0	3,6	V

Table 5.2: Power supply currents

Parameter	Condition	TYP.	Unit
Supply Current	Transmit maximum packet (all ports transmitting maximum size isochronous packet - 4 096 bytes, sent on every isochronous interval, S400), V = 3,3 V,T_A = 25° C	68	mA
	Repeat typical packet (receiving on one port DV packets on every isochronous interval, S100, and transmitting on the other port), VDD = 3,3 V, TA = 25° C	60	mA
	Idle (one port receiving and one port transmitting cycle starts), VDD = 3,3 V, TA = 25° C	40	mA
	1 port receiving cycle start packet only, V = 3,3 V, TA=25° C	31	mA
	Suspend mode, V = 3,3 V, TA = 25° C	115	mA

NOTE: Exact power supply and power efficiency depends on the chipset and manufacturer. In the present document, we have selected one chipset for each physical link.

5.1.3 Versions and Data Rates

5.1.3.1 Firewire 400

Firewire 400 can transfer data between devices at 100 Mbit/s, 200 Mbit/s or 400 Mbit/s data rates. These different transfer modes are commonly referred to as S100, S200, and S400. Cable length is limited to 4,5 meters (about 15 feet), although up to 16 cables can be daisy chained using active repeaters, external hubs, or internal hubs often present in Firewire equipment.

5.1.3.2 Firewire-800

FireWire-800 was introduced commercially by Apple in 2003. This newer specification and corresponding products allow a transfer rate of 786,432 Mbit/s with backwards compatibility to the slower rates and 6-pin connectors of FireWire 400.

Table 5.3: FireWire-800 data rates as a function of distance

Cable type	100 Mbps	200 Mbps	400 Mbps	800 Mbps	1 600 Mbps	3 200 Mbps
9-pin shielded twisted pair copper	4,5 m	4,5 m	4,5 m	4,5 m	4,5 m	4,5 m
CAT 5 unshielded twisted-pair	100 m	-	-	-	-	-
Step-index plastic optical fibre	50 m	50 m	-	-	-	-
Polymer-clad plastic optical fibre	100 m	100 m	-	-	-	-
Glass optical fibre	100 m	100 m	100 m	100 m	100 m	100 m

5.2 USB

Universal Serial Bus (USB) [i.7] is a connectivity specification developed by Intel and other technology industry leaders. USB provides ease of use, expandability, and speed for the end user. USB is arguably the most successful interconnect in computing history. USB was designed to allow peripherals to be connected without the need to plug expansion cards into the computer's ISA, EISA, or PCI bus and to improve plug-and-play capabilities by allowing devices to be hot-swapped. When a device is first connected, the host enumerates, recognizes it, and loads the appropriate device driver as required.

5.2.1 Technical Specification and Architecture

A USB system has an asymmetric design, consisting of a host controller and multiple daisy-chained devices. Additional USB hubs may be included in the chain, allowing branching into a tree structure, subject to a limit of 5 levels of branching per controller. No more than 127 devices, including the bus devices, may be connected to a single host controller.

In USB terminology, devices (and hubs) are referred to as functions. These functions have associated pipes (logical channels) which are connections from the host controller to a logical entity on the device endpoint. The pipes are synonymous to byte streams. These endpoints (and their respective pipes) are numbered 0 to 15 in each direction, so a function can have up to 32 active pipes, 16 inward and 16 outward. (The OUT direction should be interpreted out of the host controller and the IN direction is into the host controller.) Each endpoint can transfer data in one direction only, either into or out of the device/function. Each pipe is uni-directional. Endpoint 0 is however reserved for the bus management in both directions and thus takes up two of the 32 endpoints. In these pipes, data is transferred in packets of varying length. Each pipe has a maximum packet length so a USB packet will often contain something on the order of 8, 16, 32, 64, 128, 256, 512 or 1 024 bytes.

5.2.2 Power Supply

The USB specification provides a 5 V supply and return from which connected USB devices may draw power. Initially a device is only allowed to draw 100 mA. It may request more current from the upstream device in units of 100 mA up to a maximum of 500 mA.

5.2.2.1 Versions and Data Rates

5.2.2.1.1 USB 1.0/1.1

Following are the specifications for are the specifications USB 1.0/1.1:

- 1,5 Mbps data transmission rate for 1.0.
- 12 Mbps data transmission rate for 1.1.
- Support for up to 127 devices.

- Hot Plug and Play capability.
- Both isochronous and asynchronous data transfers.
- Cable length of up to 5 meters.
- Built-in power supply/distribution for low-power devices.

5.2.2.1.2 USB 2.0

Key specifications for are the specifications USB 1.0/1.1:

- Contains all of the features of USB 1.0 and 1.1.
- Fully backward compatible with USB 1.0 and 1.1.
- Available in two versions: USB and Hi-Speed USB.
- Transmission speed of 12-Mbps for USB and 480 Mbps for Hi-Speed USB.
- All peripherals run at their highest rated speed instead of the speed of the slowest peripheral.
- Tested at a higher level than USB 1.0/1.1 so that it is more reliable.

NOTE: We have not found any information or experiment on USB data rates as a function of distance.

5.2.3 USB Backward Compatibility

Adopting the new technology and migrating towards USB physical link, is convenient for TETRA devices. Existing terminals are implemented based on the EIA Recommended Standards such as EIA-232. For the purpose of backward compatibility, it is possible to build a virtual COM port to move from a real Universal Asynchronous Receiver-Transmitter (UART) system to a UART-USB system. There is also a wide range of converter cables available in the market.

5.3 USB on the Go

USB On-The-Go [i.8] (normally abbreviated USB OTG) is a supplement to the USB 2.0 specification that allows USB devices to transfer data directly between themselves.

5.3.1 Why USB OTG

Standard USB uses client/server architecture: one device acts as a USB host and the other as a USB peripheral. Only the USB host contains the device driver and the necessary controls to transfer the data. The USB peripherals do not contain those parts, so two USB peripherals cannot exchange the data without the use of USB hosts.

USB On-The-Go was developed to overcome that shortfall. With USB On-The-Go, the USB devices are given limited ability to transfer data between themselves. If both are USB OTG, the connecting cable determines which one will initially act as host, and the devices can negotiate to swap roles if needed. USB OTG devices can also connect to plain USB devices from a target peripheral list.

USB OTG introduces one new port receptacle called AB connector. It can accept either an A plug or a B plug.

The OTG Supplement addresses the need for mobile interconnectivity by allowing a USB peripheral to have the following enhancements:

- Host capability to communicate with selected other USB peripherals.
- A small USB connector to fit the mobile form factor.
- Low power features to preserve battery life.

5.3.2 Power Supply

When an A-device is providing power to VBUS on a port, it is required to maintain an output voltage (VA_VBUS_OUT) on that port between 4,4 V and 5,25 V, under loads of 0 mA up to the rated per port output of the device's supply (IA_VBUS_OUT min = 8 mA) as long as the rated output of the A-device is less than or equal to 100 mA. If the current rating per port of the A-device is greater than 100 mA, then the voltage regulation is required to be between 4,75 V and 5,25 V, and the A-device is required to meet the USB 2.0 specification requirements for power providers. If the A-device is not capable of providing at least 100 mA on a port, it should be able to detect when VBUS falls below the value necessary for proper operation of a B-device (VA_VBUS_VLD min). In tables 5.4 and 5.5, the voltage and current specifications are presented:

Table 5.4: Power supply Voltage

Parameter	Symbol	Conditions	Min	Max	Units
A-Device Output	VA-VBUS-OUT	0 ≤ IVBUS ≤ IA_VBUS_OUT < 100 mA	4,4	5,25	V
B-Device to Dual-Role Device Output Voltage	VB_DRD_OUT		2,1	5,25	V
B-device to Host Output Voltage	VB_HST_OUT			2,0	V

Table 5.5: Power supply currents

Parameter	Symbol	Conditions	Min	Max	Units
A-Device Output Current	IA-VBUS-OUT	4,4 V ≤ VBUS ≤ 5,25 V	8		mA
B-Device to Dual-Role Un-configured Average Current	IB_DRD_UNCFG	0 V ≤ VBUS ≤ 5,25 V		150	µA
B-Device (peripheral only) Un-configured Average Current	IB_PO_UNCFG	0 V≤ VBUS ≤ 5,25 V		8	mA

The initial host is called the A-Device, and the initial peripheral is called the B-Device. Under certain conditions, the A-device will relinquish the role of host to a dual-role B-device.

5.3.3 USB Data Transfer Modes, Connection Configurations

Data directed from the host to a device is called downstream or out transfer; data directed from a device to the host is called upstream or in transfer. Data transfer occurs between the host and a particular endpoint on the USB device, and the data link between the host and the endpoint is called a pipe. A given USB device may have many endpoints, and the number of data pipes between the host and the device is the same as the number of endpoints on the device. A pipe may be uni-directional or bi-directional, and the data flow in one pipe is independent of the data flow in any other pipes. Communication on the USB network can use any one of four different data transfer types.

5.3.3.1 Control transfers

These are short data packets for device control and configuration, particularly at attach time.

Bulk transfers: These are data packets in relatively large quantities. Devices like scanners or SCSI adapters use this transfer type.

5.3.3.2 Interrupt transfers

These are data packets that are polled periodically. The host controller will automatically post an interrupt at a specified interval.

5.3.3.3 Isochronous transfers

These are data streams in real time with higher requirements for bandwidth than for reliability. Audio and video devices generally use this transfer type.

Like a serial port, each USB port on a computer is assigned a unique identification number (port ID) by the USB controller. When a USB device is attached to a USB port, this unique port ID is assigned to the device and the device descriptor is read by the USB controller. The device descriptor includes information that applies globally to the device, as well as information on the configuration of the device. A configuration defines the functionality and I/O behaviour of a USB device. A USB device may have one or more configurations, which are described by their corresponding configuration descriptors. Each configuration has one or more interfaces, which can be considered as a physical communication channel; each interface has zero or more endpoints, which can be either data providers or data consumers, or both. Interfaces are described by interface descriptors, and endpoints are described by end-point descriptors. Furthermore, a USB device might also have string descriptors to provide additional information such as vendor name, device name, or serial numbers.

5.4 EIA-485

The Electronics Industry Association (EIA) has produced standards for EIA-485, EIA-422, EIA-232, and EIA-423 that deal with data communications. As the application of EIA-232 has extended far beyond the original purpose of interconnecting a terminal with a modem, successor standards have been developed to address the limitations. Standards such as EIA-422, EIA-423 and EIA-485 are considered as successors of EIA-232, where transmission over longer distances with higher data rates becomes possible. Among these successors, we focus on EIA-485 [i.9] as it supports maximum data rates required by TETRA Release 2 as well as it meets the requirements for truly multi-point communications.

5.4.1 Technical Specification and Architecture

EIA-485 will support 32 drivers and 32 receivers (bi-directional, half duplex, multi-drop communications over a single or dual twisted pair cable). An EIA-485 network can be connected in a 2 or 4 wire mode. Maximum cable length can be as much as 4 000 feet because of the differential voltage transmission system used. The typical use for EIA-485 is a single PC connected to several addressable devices that share the same cable. In table 5.3, the main specifications of EIA-485 are listed:

Table 5.6: EIA-485 Specifications

Maximum distance @ Rate	1 200 meter / 4 000 feet @ maximum 100 kbps
Maximum Rate @ Distance	10 Mbps @ 12 meter / 50 ft
Driver Output Resistance	100 Ω
Receiver Input Resistance	4 k Ω minimum

5.4.2 Power Supply

Table 5.7 presents voltage specification of a typical EIA-485 chip.

Table 5.7: Voltage specifications for the EIA-485 based on NEC's DS16F95 chip

Parameter		Minimum	Typ.	Maximum	Units
Supply Voltage		4,75	5	5,25	V
Voltage at Any Bus Terminal	Common Mode	-7	-	12	V
	Different Input	-	-	±12	V

Table 5.8: Current specifications for the EIA-485 based on NEC's DS16F95 chip

Parameter	Mode	Minimum	Typ.	Maximum	Units
Output Current Low	Driver	-	-	-60	mA
	Receiver	-	-	-400	µA
Output Current High	Driver	-	-	60	mA
	Receiver	-	-	16	mA

5.5 Comparisons between Wired Solutions

5.5.1 Support of High Data Rates

Table 5.9 presents transfer rate comparisons between USB 1.1, USB 2.0, Firewire and EIA-485. For TETRA Release 2, both USB and Firewire meet maximum data rate requirement.

Table 5.9: Maximum burst transfer rate comparisons

Maximum Burst Transfer Rate				
USB 1.1	USB 2.0	FireWire 1394a	FireWire 1394b	EIA-485
12 Mb/s	480 Mb/s	400 Mb/s	800 Mb/s	10 Mbps @ 50 ft

USB was designed as a desktop bus, with the expectation that peripherals would be relatively close at hand. A cable segment can be as long as 5 meters. Other interfaces, such as EIA-232, EIA-485, and Ethernet, allow much longer cables. It is possible to increase the length of a USB link to as much as 30 meters by using cables that link five hubs and a device, using 6 cable segments of 5 meters each.

To extend the range beyond this, an option is to use a USB interface on the PC, then convert to EIA-485 or another interface for the long distance cabling and peripheral interface.

5.5.2 Data Reliability

Both USB and Firewire are protected by error control codes and they both provide high data reliability. EIA-485 is also reliable as differential output voltage provides optimal noise immunity.

5.5.3 Power Efficiency

EIA-485 chipsets are typically designed in a "ruggedised" manner with isolated ports to drive disparate circuits over long distances. This surplus functionality requires multiple power sources leading to higher power demand. Furthermore, the latest devices are using silicon technologies of several years age (Maxim 2003), implying less efficient silicon implementation.

USB and Firewire, on the other hand, demand a larger market volume, driving continued competition and development of power control features, especially since their widespread inclusion into the Laptop and the GSM terminal. Shutdown functionality is common on USB and Firewire chipsets with the ability to wake on connection, leaving quiescent currents of the order of 10 to 100 µA.

5.5.4 Robustness

It is possible for the TETRA manufacturers to use specific connectors that are robust. For example, there are sealed circular connectors in the market and they are designed to provide secure and safe connection.

International standard IEC classifies the level of protection that electrical appliances provide against the intrusion of solid objects or dust, accidental contact, and water. The resulting International Protection (IP) rating, is identified by a code that consists of the letters IP followed by two digits and an optional letter.

There is a wide range of Firewire, USB and USB OTG connectors that prove to be very robust. For example Bulgin Components Plc [i.10] manufactures waterproof Firewire, USB and USB OTG connectors that have IP68 rating. This is identified as a connector type that:

1) Guarantees no ingress of dust and complete protection against contact.

2) The equipment is suitable for continuous submersion in water under conditions which should be specified by the manufacturer.

In figure 5.1, a waterproof USB connector is shown.

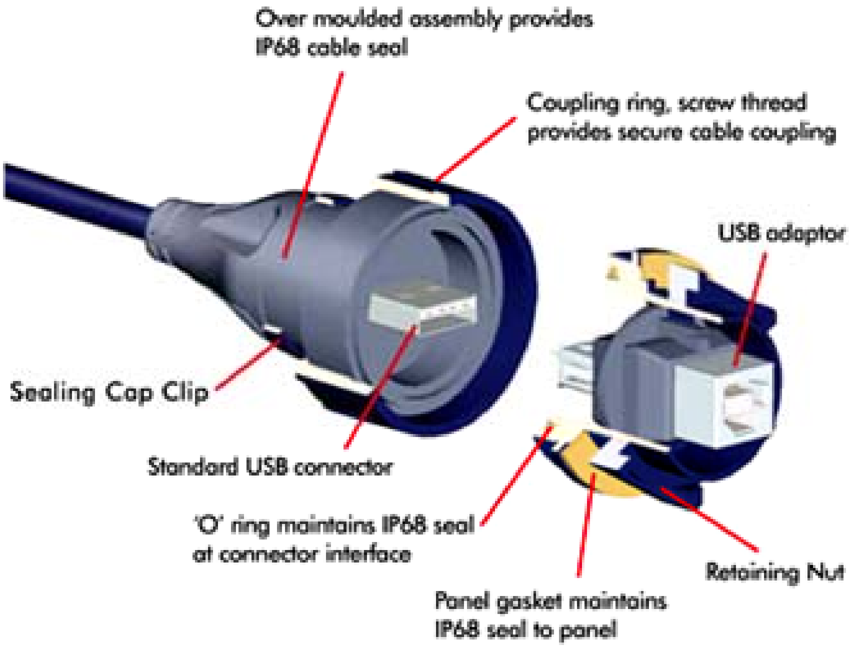

Figure 5.1: IP68 Rated USB Connector (from http://www.bulgin.co.uk/Products/Buccaneer/Buccaneer_USB.html)

The EIA-485 is also a very robust physical link that can provide almost the same robustness.

5.5.5 Ease-of-Use

No user settings

USB and Firewire peripherals do not have user-selectable settings such as port addresses and interrupt-request (IRQ) lines. Available IRQ lines are in short supply on PCs, and not having to allocate one for a new peripheral is often reason enough to use USB.

Easy to connect

The number of ports for USB can be expanded by connecting a USB hub to an existing port. Each hub has additional ports for attaching more peripherals or hubs. However, most recent peripherals are not equipped with EIA-485. Even new PCs have only EIA-485 pins on the motherboard. These connections are not always available to the PC users. Similar to USB, Firewire is easy to connect, however it is not always present on devices.

Hot pluggable

USB, USB OTG and Firewire connections can be connected and disconnected whenever required, whether or not the system and peripheral are powered, without damaging the PC or peripheral. The operating system detects when a device is attached and readies it for use. USB OTG further improves ease of use with the ability to negotiate the role of host controller. Where many different peripherals exist with many different features, this enables any OTG device to control data flow without any user intervention. This is especially the case for controlling network interface flows where multiple TE2 devices may be used. EIA-485 is not hot pluggable.

5.5.6 Widely Adopted in the Information Technology World and Compatibility with Other Data Systems

USB can connect peripherals such as mouse devices, keyboards, gamepads and joysticks, scanners, digital cameras, printers, external storage, networking components, etc. For many devices such as scanners and digital cameras, USB has become the standard connection method. USB is also used extensively to connect non-networked printers, replacing the parallel ports which were widely used; USB simplifies connecting several printers to one computer. As of 2004 there were about 1 billion USB devices in the world. As of 2005, the only classes of peripherals that cannot use USB are those which required a higher data rate than USB can provide. Such devices include displays and monitors, and high-quality digital video components.

For USB, instead of a confusing collection of incompatible devices and connectors, you have a one-size-fits-all connection that works on nearly all PCs manufactured in the last 5 to 8 years.

While USB has not completely replaced PS/2 ports, USB mice and keyboards are readily available. Nearly all recent scanners and printers have USB connections, as do most other low-bandwidth peripherals. On the other hand, Firewire is almost completely absent from this category. As mentioned earlier in the present document, Firewire is impractical for low-bandwidth devices; this, coupled with the fact that most computers (besides Macintoshes) do not include Firewire ports by default, has kept Firewire-enabled devices in this category out of this market.

Currently the support for EIA-485 is less than USB devices. EIA-485 is mainly used for the following applications:

- EIA-485 is often used with common UARTs to implement low-speed data communications in commercial aircraft cabins.
- EIA-485 sees widespread use in programmable logic controllers and on factory floors in order to implement proprietary data communications.
- EIA-485 is used in large sound systems, as found at music events and theatre productions, for remotely controlling high-end sound-processing equipment from a standard computer.
- EIA-485 is also used in Building automation as the simple bus wiring and long cable length is ideal for joining remote devices.

5.5.7 Data overhead

FireWire is a true peer-to-peer technology, so two or more FireWire peripherals can communicate with each other directly as peers, sending each piece of data over the bus only once, directly to its destination. USB 2.0 works in a master/slave arrangement that adds significant overhead to data transfers. However USB OTG has overcome this shortfall.

6 Wireless Solutions - Background

6.1 Wireless USB

6.1.1 Certified Wireless USB (CWUSB)

Certified Wireless USB (CWUSB), from the USB Implementers Forum [i.11], is a new short-ranged high-bandwidth wireless extension to USB intended to combine the speed and security of wired technology with the ease-of-use of wireless technology. CWUSB is based on Ultra-WideBand (UWB) wireless technology defined by WiMedia Alliance [i.12]. In May 2005, the CWUSB Promoter Group announced the completion of the Wireless USB specification. The first CWUSB product is expected to hit the market at the end of 2006 in Japan.

6.1.2 CWUSB Technical Specification and Architecture

CWUSB specification does not support the use of hubs. Although a CWUSB host supports the architectural limit of 127 devices. A new Wire Adapter device class has been defined. Also known as a Host Wire Adapter; it acts as a host for a CWUSB system and provides a way to upgrade an existing PC to have CWUSB. In addition, a device wire adapter acts as a host for a wired USB system which allows wired USB devices to be connected wirelessly to a host PC. CWUSB also supports so-called dual-role devices, which in addition to being a CWUSB client device, can function as a host with limited capabilities. For example, a digital camera could act as a client when connected to a computer, and as a host when transferring pictures directly to a printer.

6.1.3 Versions and Data Rates

CWUSB is capable of sending 480 Mbit/s at distances up to 3 meters, and 110 Mbit/s at up to 10 meters. It operates in the 3,1 GHz to 10,6 GHz band-range and spreads communication over an ultra-wideband of frequencies.

NOTE: There is also another wireless technology developed by Cypress Semiconductor [i.13] which is designed for short-range multipoint-to-point wireless connectivity. Cypress' latest offering, Wireless USB device combines very low power, long range (10 m+), with the data rate at Maximum 1 Mbit/s.

6.1.4 UWB Noise

Due to the low power and spread-spectrum nature of the signal, an UWB receiver operating within the ISM band should see (at worst) a slight rising of the noise background. For example, in the US the radiated power is regulated by FCC where the specification relates to a spread-spectrum signal. The power limit is defined as a spectral density -41,3 dBm/MHz. The signal strength is below background noise and is unlikely to cause any problems for the TETRA terminal. Furthermore, regulatory bodies have ensured that methods are employed in UWB system where it may be necessary to prevent the UWB signal from combining or interfering with other RF signals hosted within the same device.

6.2 Bluetooth

Bluetooth [i.14] is a radio standard and communication protocol primarily designed for low power consumption, with a short range based around low-cost transceiver microchips in each device. Bluetooth allows these devices to communicate with each other when they are in range. The devices use a radio communication system, so they do not have to be in line of sight of each other, and can even be in separate rooms, so long as the received transmission is powerful enough.

6.2.1 Technical Specification and Features

Bluetooth systems operate in the unlicensed Industrial-Scientific-Medical (ISM) radio band at 2,4 GHz. Low-power RF transmission provides communication between devices over a range of 10 meters to 100 meters. A Bluetooth device playing the role of the "master" can communicate with up to 7 devices playing the role of the "slave". This network of "group of up to 8 devices" (1 master + 7 slaves) is defined as a piconet. Up to 255 further slave devices can be inactive, or parked, which the master device can bring into active status at any time. At any given time, data can be transferred between the master and 1 slave; but the master switches rapidly from slave to slave in a round-robin fashion. Simultaneous transmission from the master to multiple slaves is possible, but not used much in practice. Either device may switch the master/slave role at any time.

6.2.2 Versions, Features and Data Rates

Bluetooth 1.1

- Many errors found in the 1.0B specifications were fixed.
- Added support for non-encrypted channels.
- Received Signal Strength Indicator.
- The general or basic rate modulation is GFSK. Data is transmitted using one bit per symbol at a data rate of 1 Mbit/s.

Bluetooth 1.2

This version is backwards compatible with 1.1 and the major enhancements include:

- Adaptive Frequency-Hopping spread spectrum (AFH), which improves resistance to radio frequency interference by avoiding the use of crowded frequencies in the hopping sequence.
- Higher transmission speeds in practice.
- Extended Synchronous Connections, which improves voice quality of audio links by allowing retransmissions of corrupted packets.
- Host Controller Interface (HCI) support for 3-wire UART.
- HCI access to timing information for Bluetooth applications.

Bluetooth 2.0

This version is backwards compatible with 1.x. The main enhancement is the introduction of Enhanced Data Rate (EDR) of 3,0 Mbps. This has the following effects:

- Three times faster transmission speed (up to ten times in certain cases, 2 Mbit/s and 3 Mbit/s).
- Lower power consumption through a reduced duty cycle.
- Further improved bit error rate performance.

6.3 Infrared Data Association

The Infrared Data Association (IrDA) [i.15] defines physical specifications communications protocol standards for the short range exchange of data over infrared light, for uses such as personal area networks. IrDA is a very short-range example of free-space optical communication.

6.3.1 Technical Specification and Features

The mandatory Infrared Physical Layer Specification (IrPHY) is the lowest layer of the IrDA specifications. IrDA transceivers communicate with infrared pulses in a cone that extends minimum 15 degrees half angle off centre. The IrDA physical specifications require that a minimum irradiance (Radiant power incident per unit area upon a surface) be maintained so that a signal is visible up to a meter away. Similarly, the specifications require that a maximum irradiance not be exceeded so that a receiver is not overwhelmed with brightness when a device comes close. In practice, there are some devices on the market that do not reach one meter, while other devices may reach up to several meters. There are also devices that do not tolerate extreme closeness. The typical sweet spot for IrDA communications is from 5 cm to 60 cm away from a transceiver, in the centre of the cone. IrDA data communications operate in half-duplex mode because while transmitting, a device's receiver is blinded by the light of its own transmitter, and thus, full-duplex communication is not feasible. The two devices that communicate simulate full duplex communication by quickly turning the link around. The primary device controls the timing of the link; however both sides are bound to certain hard constraints and are encouraged to turn the link around as fast as possible.

6.3.2 Versions, Features and Data Rates

Transmission rates fall into three broad categories: SIR, MIR, and FIR. Serial Infrared (SIR) speeds cover those transmission speeds normally supported by an EIA-232 port (9 600 bit/s, 19,2 kbit/s, 38,4 kbit/s, 57,6 kbit/s and 115,2 kbit/s). Since the lowest common denominator for all devices is 9 600 bit/s, all discovery and negotiation is performed at this baud rate. MIR (Medium Infrared) is not an official term, but is sometimes used to refer to speeds of 0,576 Mbit/s and 1,152 Mbit/s. Fast Infrared (FIR) is deemed an obsolete term by the IrDA physical specification, but is nonetheless in common usage to denote transmission at 4 Mbit/s. "FIR" is sometimes used to refer to all speeds above SIR. However, different encoding approaches are used by MIR and FIR, and different approaches are used to frame MIR and FIR packets. For that reason, these unofficial terms have sprung up to differentiate these two approaches. The future holds faster transmission speeds (currently referred to as Very Fast Infrared, or VFIR) which will support speeds up to 16 Mbit/s. There are (VFIR) infrared transceivers available such as the TFDU8108 operating from 9,6 kbit/s to 16 Mbit/s. The UFIR (Ultra Fast Infrared) protocol is also in development. It will support speeds up to 100 Mbit/s. In table 6.1, transfer times for a 2-megapixel image using IrDA, is presented.

Table 6.1: IrDA transfer times

Comparison of IrDA protocols Transfer times when transferring a 2-megapixel image (approximately 500KB)			
Protocol:	IrSimple-4M protocol	IrDA-4M protocol	IrDA-115K protocol
Physical layer:	FIR (Fast IrDA) (4 Mbit/s)	FIR (Fast IrDA) (4 Mbit/s)	SIR (serial infrared) (115.2 Kbit/s)
Transfer time (approx.):	1 second	4 to 11 seconds	50 to 100 seconds
(Based on a table from NTT DoCoMo)			

6.4 Comparisons between Wireless Solutions

6.4.1 Support of High Data Rates

USB, USB OTG and Bluetooth support maximum transmission rate required by TETRA Release 2 technology. However, IrDA supports lower transmission speeds and it would be a useful technology for transmission of small files such as text.

6.4.2 Data Reliability

In the absence of interference, the Bit Error Rate (BER) for Bluetooth system is almost negligible for the transmitter powers and ranges under consideration. In other words, the signal-to-noise-ratio (SNR) is high enough so that the BER is less than 10^{-5}. When there is interference from the other system, this factor is what limits performance; the SIR is insufficient to provide an acceptable BER. The Bluetooth standard requires a receiver sensitivity of -70 dBm for a raw BER of 0,1 % [i.14].

For the case of CWUSB, in figure 6.1, packet errors are presented as a factor of distance between the transmitter and receiver:

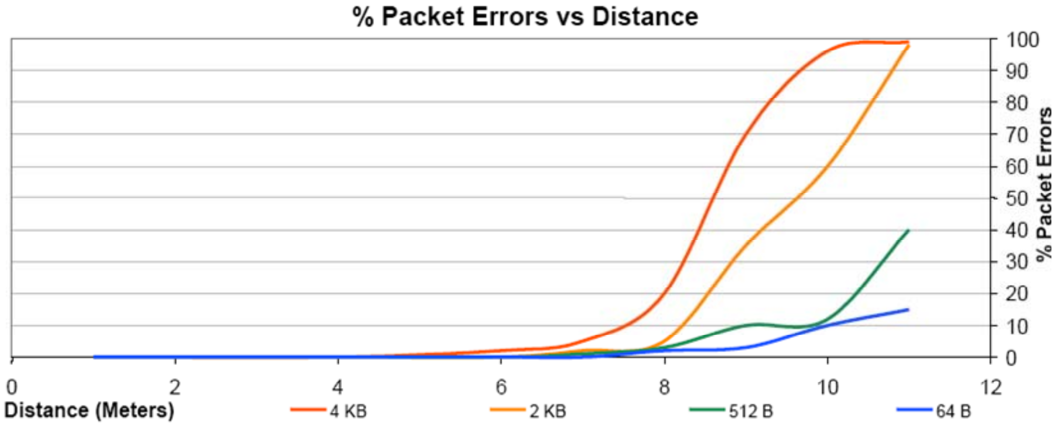

Figure 6.1: CWUSB percentage of packet errors

The IrDA standard [i.15] recommends the bit error rate (BER) should be less than 10^{-8}. However, due to the ad hoc nature of infrared link, many factors can increase the BER to higher than 10^{-8}, e.g. careless aligning, high ambient noise (close to fluorescent light source), and partial blockage.

NOTE: As CWUSB devices are still being tested and final product is not ready, is it difficult to provide accurate figures on the BER.

6.4.3 Power Efficiency

Underlying, the technology of Wireless USB is UWB. Because UWB transmits energy over such a wide spectrum, it should transmit at very low power to avoid interfering with numerous other wireless applications. In the US, the FCC has specified a maximum transmit power density of -41 dBm/MHz; essentially the level of electronic noise radiated by common consumer devices. Low-power transmission means low power consumption. Wireless USB devices use far less power than IEEE 802.11 (WiFi) devices [i.16].

Wireless USB provides longer battery life than Bluetooth does, even though it operates at a higher maximum power level. IrDA consumes less power in comparison with Bluetooth.

6.4.4 Robustness

As the wireless devices are not connected using cables, connections between peripheral equipments and TETRA mobiles would be more robust in harsh conditions and emergency cases where the users are on the move (in comparison with the wired solutions). However the receiver and transmitter should be kept within the range; this is particularly a restricting factor for IrDA as optimum distance is between 5 cm to 60 cm.

6.4.5 Ease-of-Use

Wireless USB and Bluetooth are very easy to use. The only consideration is to keep transmitter and receiver within their effective communication range. Establishing a stable connection is more difficult in the case of IrDA, where the transmitter and receiver should face each other in a restricted space.

6.4.6 Widely Adopted in the Information Technology World and Compatibility with Other Data Systems

Currently Bluetooth is used for wireless control of and communication between a cell phone and a hands free headset or car kit; wireless networking between PCs in a confined space; wireless communications with PC input and output devices,; transfer of files between devices; transfer of contact details, calendar appointments, and reminders; replacement of traditional wired serial communications in test equipment, GPS receivers and medical equipment; sending small advertisements from Bluetooth enabled advertising hoardings to other, discoverable, Bluetooth devices.

CWUSB will be used in devices that are now connected via regular USB cables, such as game controllers, printers, scanners, digital cameras, MP3 players, hard disks and flash drives, but it is also suitable for transferring parallel video streams as well as covering most of the applications currently supported by Bluetooth technology. IrDA interfaces are less frequently used, mostly in palmtop computers and mobile phones.

6.4.7 Security

Wireless USB

Wireless implementations of USB are wire-replacement technologies, where it provides two security services [i.11]:

1) it connects the nodes the owner/user specifically wants connected;

2) it protects all data in transit from casual observation or malicious modification by external agents.

The goal of USB Security is to provide this same level of user-confidence for wirelessly connected USB devices.

The standard method of encryption for the first generation of wireless USB is Advanced Encryption Standard 128 (AES-128), which is a block cipher with key size of 128 bits and adopted as an encryption standard by the U.S. government. It is capable of real-time operation when implemented in hardware. Wireless USB also supports Public Key (PK) encryption, but only for authentication. Devices may choose to start a 1st time authentication with PK encryption [i.11]. In this case, PK encryption is used to authenticate the device and to protect the distribution of the initial Counter with CBC-MAC (CCM). CCM mode combines the well-known counter mode of encryption with the well-known CBC-MAC mode of authentication. The CCM encryption suite provides 128 bits of security for run-time operation. The PK cryptography suite should provide the same level of strength. For this reason, Wireless USB will use RSA with 3 072 bit keys for encryption and SHA-256 for hashing. The security architecture also recognizes a wired connection as an encryption method. This allows for wired/wireless devices, where the wired connection can be used for initial CCM Connection Key distribution.

Bluetooth

Bluetooth wireless technology provides peer-to-peer communications over short distances. Bluetooth provides security measures both at the application layer and the link layer [i.14]. These measures are designed to be appropriate for a peer environment.

This means that in each device, the authentication and encryption routines are implemented in the same way. Four different entities are used for maintaining security at the link layer: a Bluetooth device address, two secret keys, and a pseudo-random number that should be regenerated for each new transaction. The four entities and their sizes are summarized in table 6.2.

Table 6.2: Entities used in authentication and encryption procedures

BD_ADDR	Entity Size
Private user key, authentication	48 bits
Private user key, encryption configurable length (byte-wise)	128 bits 8 bits to 128 bits
RAND	128 bits

The Bluetooth device address is the 48-bit address. Device address can be obtained via user interactions, or, automatically, via an inquiry routine by a device. The secret keys are derived during initialization and are never disclosed. The encryption key is derived from the authentication key during the authentication process. For the authentication algorithm, the size of the key used is always 128 bits. For the encryption algorithm, the key size may vary between one and 16 octets (8 bits to 128 bits). The size of the encryption key is configurable for two reasons. The first has to do with the many different requirements imposed on cryptographic algorithms in different countries - both with respect to export regulations and official attitudes towards privacy in general. The second reason is to facilitate a future upgrade path for the security without the need of a costly redesign of the algorithms and encryption hardware; increasing the effective key size is the simplest way to combat increased computing power at the opponent side.

The encryption key is entirely different from the authentication key. Each time encryption is activated, a new encryption key should be generated. Thus, the lifetime of the encryption key does not necessarily correspond to the lifetime of the authentication key.

It is anticipated that the authentication key will be more static in its nature than the encryption key - once established, the particular application running on the device decides when, or if, to change it. To underline the fundamental importance of the authentication key to a specific link, it is often referred to as the link key. The RAND is a pseudo-random number which can be derived from a random or pseudo-random process in the device. This is not a static parameter, it will change frequently.

IrDA

IrDA does not provide any link-level security, so there is no authentication or authorization, and all information is sent unencrypted. If authentication, authorization or encryption is needed, it has to be implemented at software level. IrDA supports only Point-to-Point connections, and requires direct line-of-sight between two IrDA devices as figure 6.2 illustrates. In addition, typical range of IrDA communication is only up to 2 meters. So, in spite of lacking support for explicit security measures, IrDA can be considered as a relatively secure technology.

Figure 6.2: IrDA point to point link (from: http://www.sixca.com/eng/articles/irda)

7 Background Conclusions

7.1 Comparison of technologies

In this report, different aspects of wired and wireless communication links that were initially considered suitable to be recommended as a physical link for the PEI of the TETRA Release 2 are presented.

To summarize this study and provide a recommendation, tables 7.1 and 7.2 assess both wired and wireless solutions. Letters a, b, c, d, e and f present the following criteria:

a. Support of High Data Rates.

b. Data Reliability.

c. Power Efficiency.

d. Robustness.

e. Ease-of-Use.

f. Widely Adopted in the Information Technology World and Compatibility with Other Data Systems.

g. Security (for Wireless Links).

Table 7.1: Assessing suitability of the wired physical links

Technology	*a*	*b*	*c*	*d*	*e*	*f*
Firewire	Very Good	Good	Good	Good	Very Good	Good
EIA-485	Good	Good	Fair	Good	Fair	Poor
USB	Good	Very Good	Good	Good	Very Good	Excellent
USB OTG	Good	Very Good	Very Good	Good	Excellent	Excellent

Table 7.2: Assessing suitability of the wireless physical links

Technology	*a*	*b*	*c*	*d*	*e*	*f*	*g*
CWUSB	Excellent	Good	Excellent	Good	Very Good	Poor	Good
WUSB (see note)	Good	Good	Excellent	Good	Very Good	Poor	Good
Bluetooth	Good	Good	Fair	Good	Very Good	Good	Fair
IrDA	Fair	Fair	Good	Fair	Good	Fair	Good
NOTE: WUSB Developed by Cypress Semiconductor [i.13]. Final product is still under development and test.							

7.1.1 Summary of table 7.1

USB OTG is recommended as the best candidate.

Considerations:

- Firewire and EIA-485 would be a better choice in cases where the peripheral equipments need to be connected using long cables (> 5m).
- Firewire, EIA-485, USB and USB OTG all provide data rates required by TETRA Release 2.

7.1.2 Summary of table 7.2

Considerations:

- Based on the specifications CWUSB and WUSB would outperform the Bluetooth however CWUSB and WUSB are yet to appear in the market (2007).

- IrDA is recommended to be considered as a physical link option only if compatibility with legacy peripheral equipments.

8 User Requirements for Enhancements of the TETRA Peripheral Equipment Interface standard

8.1 Introduction

The enhancements of the TETRA Peripheral Equipment Interface standard aim at:

- Providing a state-of-the-art point-to-point physical link.
- Providing Multimedia capability.
- Providing QoS negotiation.

The following clauses state user requirements for these enhancements.

8.2 Physical Link

The PEI physical link for TETRA 2 should support the following as standard:

- Multiplexing of multiple communication paths down one physical link.

NOTE: This does not stop an MT from implementing more than one instance of the PEI physical link.

- Support the speeds of TETRA 2 TEDS.
- Should support secure data communications.

8.2.1 USB

The TETRA PEI on terminals should support a USB interface.

The electrical USB interface should enable to connect the TETRA MS directly (without extra electrical interfaces) to existing PCs, PDAs.

The use of USB in an MT implemented according to the TETRA 2 PEI standard should support the ability to be either a function (e.g. a modem that is a slave to a PC) or a host (i.e. the master of the communications) so that, for example, it could connect directly to a USB device such as a camera without the need for a PC and upload data from the camera without the need for a PC).

The connector used for USB should be:

- Ruggedised.
- Waterproof.
- Latching.
- Preferably already existing on the market.

NOTE: To be able to support the TEDS data rates, the speed of USB 1.0 for the TETRA PEI seems to be acceptable.

8.2.2 Bluetooth

The TETRA PEI should support Bluetooth.

The Bluetooth interface should enable to connect the TETRA MS directly (without extra electrical interfaces) to existing PCs, PDAs.

The Bluetooth interface needs to support secure pairing.

A Bluetooth interface needs to support Bluetooth 2.0 or later.

A Bluetooth interface if implemented should meet the requirements of the relevant national technical agencies for security if used for public safety sector customers.

8.2.3 Wireless USB

Wireless USB should be considered for the TETRA PEI.

The Wireless USB should support secure associations and pairing of devices, and support all the facilities of the wired USB interface.

A Wireless USB interface if implemented should meet the requirements of the relevant national technical agencies for security if used for public safety sector customers.

8.3 Multimedia capability

The PEI for TETRA 2 should allow multi-media connections to be set-up through it in either direction.

8.4 QoS negotiation

The TETRA 2 PEI should support the ability to negotiate and maintain a quality of service across the PEI link between TE and MT.

NOTE: This does not prevent the PEI from supporting end-to-end quality of service negotiation and maintenance.

The TETRA 2 PEI should allow IETF methods of traffic QoS marking to be supported, e.g. DiffServ CodePoints (DSCP).

8.5 Circuit mode data, SDS, and STATUS messaging

The TETRA 2 PEI should support circuit mode data.

The TETRA 2 PEI should allow SDS and STATUS messages to be sent and received concurrently with circuit mode data.

8.6 Multiple services on PEI

The PEI for TETRA 2 should support as standard the ability to run multiple virtual connections multiplexed on to a single physical link instance.

NOTE: This does not prevent a mobile station from supporting more than one instance of the PEI physical link.

8.7 Void

8.8 Multiple applications

The TETRA 2 PEI should support the ability for multiple applications to be hosted on a TE.

The MT should support steering of data to the correct application in the TE in some way, e.g. through the support of IETF port numbers for UDP and TCP and software such as portmappers.

8.9 Embedded systems

The TETRA2 PEI should be capable of efficient implementation in embedded systems, which are often characterized by finite memory and processor capacity.

8.10 Legacy applications support (TETRA and GSM)

The TETRA 2 PEI should be backward compatible with the TETRA 1 PEI, in terms of:

- Supporting the same mandatory ITU-T Recommendation V.250 [i.17] commands and extensions as in EN 300 392-5 [i.18].
- Supporting the ability for existing TETRA applications to work unchanged at OSI-RM layer 3 and above.
- Supporting the ability for GSM applications to work unchanged on TETRA 2 devices.
- The existing TETRA 1 PEI physical layer should be retained in the standard.

8.11 Standardized complete support similar by all manufacturers

The TETRA 2 PEI should be implemented by all manufacturers in a complete way.

8.12 Interoperable

The TETRA 2 PEI should support the concept of the open standard and open market such that applications designed to work according the TETRA 2 PEI should be able to work with MT from more than one manufacturer.

NOTE 1: Using existing published standards should help in meeting this requirement.

NOTE 2: The TETRA Association IOP process may assist in meeting this requirement.

8.13 Developing a driver from scratch

The definition of the TETRA 2 PEI standard should help manufacturers of MT and applications in developing the necessary software to implement the standard on the operating system of their choice.

8.14 Multiple platforms

The TETRA 2 PEI standard should be defined in detail such that:

- Manufacturers of applications and MT can implement the standard on the operating system of their choice.
- Manufacturers can implement the standard on both big-endian and little-endian microprocessor based devices.

8.15 Ease of application developers

The TETRA 2 PEI should be defined in a clear and unambiguous manner and in sufficient detail that it is clear for application developers to implement and know which features are mandatory for compliance with the standard.

NOTE: The use of formal notation such as ASN-1 should be considered to assist in meeting this requirement.

8.16 Circuit mode data, PD, SDS and STATUS messaging

The TETRA 2 PEI standard should support circuit mode data and packet data.

The TETRA 2 PEI standard should support SDS and STATUS messaging concurrently with an active circuit mode connection.

The TETRA 2 PEI standard should support SDS and STATUS messaging concurrently with an active packet data session, e.g. PPP link.

8.17 Minimum cost

The TETRA 2 PEI standard should be designed such that the resources required to implement it are minimized.

NOTE: The re-use of existing published standards from other bodies should assist in meeting this requirement.

8.18 Time to market

The TETRA 2 PEI standard should be designed such that it facilitates rapid time to market.

NOTE: The re-use of existing published standards from other bodies should assist in meeting this requirement.

8.19 Open source driver layers

The TETRA 2 PEI standard should be defined such that existence of open source software drivers is considered.

NOTE 1: The existence of open source drivers under licences such as GPL should be used as a consideration in meeting this requirement.

NOTE 2: The licensing on FRAND terms of drivers in source code to application or MT manufacturers may help in meeting this requirement.

8.20 Freely available drivers

The TETRA 2 PEI standard should be designed such that it uses standards that are currently available as commercial or open source software in order to limit implementation time and expense for application or MT manufacturers.

8.21 IPR licensing costs - FRAND

Any technology incorporated in the TETRA 2 PEI standard should be licensed on FRAND terms in accordance with the ETSI IPR policy.

8.22 Resilient to errors on the interface

The TETRA 2 PEI should be resilient to errors on the PEI interface.

Errors should be detected and indicated to applications and MTs.

Applications and MT should be able to implement different classes of error correction that meets the QoS requirements of the application being implemented.

NOTE: Some applications do not require full error correction at the expense of delay or reduction in throughput.

8.23 Future upgradeability

The TETRA 2 PEI standard should use technology and standards from other bodies that have a roadmap of future enhancements.

8.24 Hot-pluggable

The TETRA 2 PEI standard should support the connection and disconnection of the physical links whilst either the TE, MT or both devices are powered on.

8.25 Easy to test and certify

The TETRA 2 PEI standard should be defined such that it is easy to test and certify for compliance with the standard and interoperability.

NOTE: The reuse of existing standards and technology that already has certification processes and test tools available should assist in meeting this requirement.

8.26 Low CPU and memory overhead

The TETRA 2 PEI standard should be defined such that it is capable of being implemented on TE and MT that have low CPU and memory capabilities.

The amount of CPU and memory required to implement the TETRA 2 PEI standard should be estimated.

8.27 Battery life concerns

The TETRA 2 PEI standard should be defined such that it can be implemented on low weight battery powered devices.

8.28 Flow control

The TETRA 2 PEI should implement flow control in order to avoid buffer overflow conditions.

NOTE 1: Buffer overflow in either the TE or MT may cause loss of data.

NOTE 2: Causing deliberate buffer overflow to occur is a well known security attack technique.

Annex A: Indicative data throughput rates for example TETRA 2 data applications.

In order to assist technical working groups in defining the capability of the TETRA 2 PEI standard, the following table of example TETRA 2 data applications is included.

A.1 Data rates

Table A.1

Applications	Min Speed (kbits/s)	Transaction time (Seconds)	Public Safety	Possibility for IP Based	Services Used/Type of Interaction	Real Time	Telemetry	Back-ground
Telemetry (real time transfer)	3	0,5	√	√	SDS	√	√	
Hazardous Materials Information	3	1	√	√	SDS		√	
Biodynamic vital data sampling, inc. ECG	4	5	√	√	SDS or IP.	√	√	
Online forms (1 Kbyte/s)	8	1	√	√	Database Interaction	√		
STATUS indication	16-bits	0,5	√		16-bit STATUS messaging	√		
Status/location/messaging (1 Kbyte/s)	10	1	√	√	SDS	√	√	
On-Site PMR	12	1	√	√	SDS /Voice	√		
Transport: Taxis, Private hire, Couriers	12	1	√	√	SDS /Voice	√		
Police finger print access (20 Kbyte type-3 grey scale at 500 ppi)	12	360	√	√	Data Services	Soft		
Transport: Railways	30	1	√	√	SDS/Voice/Data Services	√		
Utilities: Water, Electricity, Gas, Coal	30	1	√	√	SDS/Voice/Data Services	√	√	
Land and Natural Resource Management	30	1	√	√	SDS/Voice/Data Services	√	√	
Image Transfer (50 Kbyte compressed JPEG)	50	2	√	√	File transfer	√		√
Special Event Planning Groups (No video)	60	1	√	√	SDS/Voice/Data Services	√	√	
E-mails including Attachments 2 Mbytes	53	30	√	√	File Transfer			√
Connect to hospitals and national health comm. network	80	10	√	√	File Transfer	√	√	
Non-Safety Local Government, comm. Network	80	1		√	SDS/ File Transfer	√	√	
Optimum Performance Monitoring in Sports	100	0,5		√	SDS/Voice/Data Services	√	√	
Internet including. web browsing 10 Kbyte to 100 Kbyte (per page)	100	1	√	√	Office Application /Data Services	√		
Airport Security Services	150	2	√	√	SDS/Voice/Data Services	√	√	√
Intelligent Transport Systems	150	2	√	√	SDS/Voice/Data Services	√	√	√
Police	200	2	√	√	SDS/Voice/Data Services	√	√	√
Managing Fleet Operations (location, group communications, etc.)	200	2	√	√	Data Services/File Transfer/ Voice	√	√	√
Emergency Management or Disaster Recovery Agencies	250	2	√	√	Data Services/File Transfer/ Voice	√	√	√
Fire Services (includes search and rescue)	250	2	√	√	Data Services/File Transfer/ Voice	√	√	√
Police (multimedia, database access)	2000	5	√	√	Data Services/File Transfer/ Voice	√	√	√

NOTE: "Soft" in the Real-Time column refers to the fact that the information transfer is expected to occur in near real-time but that non-instantaneous transfer will not result in the failure of a safety-critical system or industrial process.

Annex B: Comparisons between data format, number of supported devices, maximum data speed and usage of well-known physical links

Table B.1

Interface	Format	Number of Devices (maximum)	Speed (maximum, bits/sec.)	Typical Use
USB	asynchronous serial	127	1,5 M, 12 M, 480 M	Mouse, keyboard, disk drive, modem, audio
RS-232 (EIA/TIA-232)	asynchronous serial	2	20 k (115 k with some hardware)	Modem, mouse, instrumentation
RS-485 (TIA/EIA-485)	asynchronous serial	32 unit loads (up to 256 devices with some hardware)	10 M	Data acquistion and control systems
IrDA	asynchronous serial infrared	2	115 k	Printers, hand-held computers
Microwire	synchronous serial	8	2 M	Microcontroller communications
SPI	synchronous serial	8	2,1 M	Microcontroller communications
I^2C	synchronous serial	40	3,4 M	Microcontroller communications
IEEE-1394 (FireWire)	serial	64	400 M (increasing to 3,2 G with IEEE-1394b)	Video, mass storage
IEEE-488 (GPIB)	parallel	15	8 M	Instrumentation
Ethernet	serial	1024	10 M/100 M/1 G	Networked PC
MIDI	serial current loop	2 (more with flow-through mode)	31,5 k	Music, show control
Parallel Printer Port	parallel	2 (8 with daisy-chain support)	8 M	Printers, scanners, disk drives

History

Document history		
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