Integrated Project - EUWB

Contract No 215669

Deliverable

D5.1

Application Definition & System Requirements for Multimode / Multiband Radios

Contractual date:	**M6**
Actual date:	**M11**
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Work package:	**WP5**
Security:	**PU**
Nature:	**Report**
Version:	**1.0**
Total number of pages:	**21**

Abstract

This document is the final version of Deliverable D5.1. It provides enumerated requirements based on application definitions for Multimode / Multiband radios, discusses the feasibility of these requirements and gives a short overview of the current standardization and regulatory situation.

Keywords

Multiband, Multimode, Hybrid Radio, Bluetooth HDR, WiMedia, 60GHz

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Abbreviations

60 GHz	A developing standard for short range unlicensed communications providing high rate wireless personal area network (including point-to-point) transport for both bulk data transfer and multimedia streaming, with supported data rates of up to 6 Gbps.
CMS	Cabin Management System
DRP	Distributed reservation protocol
HDR	High Data Rate - no absolute meaning just used in contrast to LDR
HW	Hard ware
IP	Internet protocol
LOS	Line of sight
MAC	Medium Access Controller - a layer of the stack which negotiates the use of the available wireless spectrum such that multiple devices can share it.
NLOS	Non-line of sight
WiMedia	A 350+ member global non-profit organisation, that defines, certifies and supports enabling wireless technology for multimedia applications based on MB-OFDM UWB radio technology.

Table 1: Terms and Abbreviations

1 Executive summary

WP5 has identified two application areas that require enhanced UWB platforms that can support throughput in excess of the current capabilities of standard WiMedia devices and may require the flexibility offered by multimode and multi-band radio architectures. These are;

- Public transport
- Home environment

This document takes the high-level requirements for the proposed application scenarios presented in;

1. Reference [1] where requirements for the public transportation applications are defined and,
2. Reference [2] where multi-mode UWB radio system is used in a wireless entertainment hub

And defines and enumerates the technical requirements for the Multimode / Multi-band platforms to be developed by WP5.

2 Introduction

This document describes the requirements for the multimode / multi-band radio platforms to be developed in WP5. The objective is to create a single platform that is capable of transmitting in the 3.1GHz to 10 GHz range, and in the 60 GHz range. Two application clusters, the Public Transportation cluster (WP8a) and the Home Environment cluster (WP8c), have identified a requirement for these platforms.

Before listing the requirements in chapter 3 and the feasibility considerations in chapter 4, the remainder of this chapter provides an overview of the application scenarios that can be found in detail in [1] and [2].

2.1 Public Transportation Scenario

Next generation aircraft need more flexible, scalable, less complex Cabin Management Systems (CMS), with less complex wiring looms, support for greater customization, and be faster and easier to install, test and maintain.

It is anticipated that the migration of CMS designs to include wireless connectivity will go some way to support these requirements A wireless extension should enable the CMS to support integrate simple and flexible integration with a range of components within the aircraft cabin, whether they are portable, re-configurable (moveable) or fix installed.

Three main fields of application can benefit from the use of the wireless technology:

1. Cabin Management System
2. Passenger communication and IFE
3. Mobile Devices

The Cabin Management System application field covers all core services and functions of the cabin. It includes passenger audio announcements services, reading lights, passenger call signs, passenger information displays, cabin illumination and light control units, monuments (light dome, bar, mobile office corner, lavatories, galleys), emergency lights (floor marking, exit Signs, etc…), sensors (smoke detection, doors, etc.), wireless information displays, and wireless crew services such as crew intercommunication and wireless cockpit alert. An important feature in the future CMS designs is the cabin security system. This includes Cabin Video Monitoring System (CVMS), aircraft access control and staff location & tracking.

The second application field is passenger communication and in-flight entertainment. This includes all services which are directly addressed to the passenger to enable an improved comfort experience, such as high definition video- and/or audio-on-demand and internet/intranet connectivity services for e-mail, internet access, information about flight status (position, speed, weather, etc.), information about the destination place and services like hotel booking, rental cars, restaurants etc.

The last application field addresses the mobile devices which could be part of the future cabin equipment, and includes a mobile wireless mini flight attendant panel (FAP) for crew or maintenance staff, a wireless trolley or a crew wireless communication terminal.

For all three application fields high date rates throughput and high reliability may be required. The use of two separate physical layer front-ends operating in different frequency ranges would provide an

additional level of redundancy and therefore increase the reliability and robustness of the communication link.

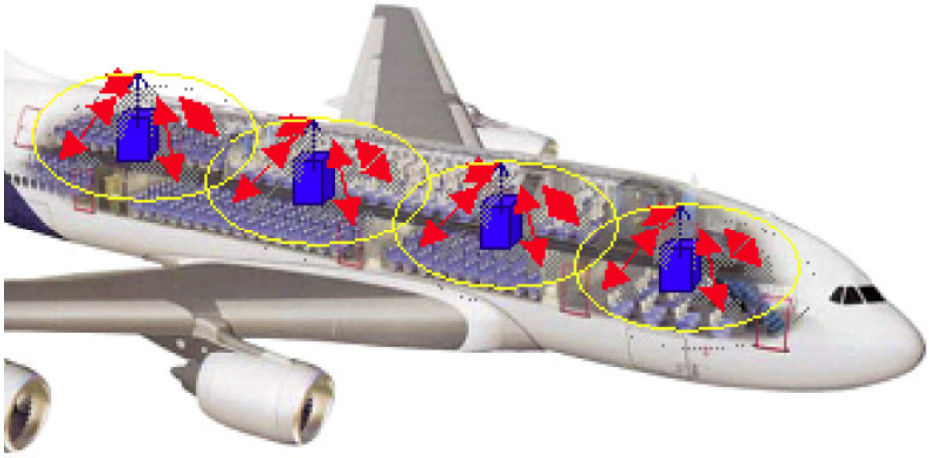

Figure 1: Wireless Connectivity in an Aeroplane Cabin UWB Application Scenario

2.2 Home Environment Scenario

In the home environment the growing assortment of HD TV broadcasts, video programmes, movies, games and user generated material is pushing the quality of the user experience to new heights for home entertainment applications. A parallel increase in the penetration of wireless connectivity at home has also placed new challenges for the wireless streaming of these contents within the home (and in-room) in relation to the very high data rates required, the level of quality of service expected and the new user expectation for total immersion in the entertainment experience. The novel techniques developed for in-room localisation and tracking using UWB combined with audio tuning algorithms that can adapt to the user location provide an optimum listening experience and can offer exciting opportunities for enriched home entertainment experience. Combining this with the available bandwidth at the 60 GHz band can also open the opportunity of streaming uncompressed HD quality video contents wirelessly in the room hence offering user flexibility and control, freedom from cable clutter and at the same time offering very high levels of entertainment quality and robustness.

The wireless entertainment hub as shown in Figure 1 is the only device capable of supporting multimode transmission. This hub is assumed to have some storage capability either to completely store data being transferred onto it, or buffer enough data to be able to start streaming the transferred content without interruption. The wireless hub is assumed to have the capability of handling the high rate data transfer and video streaming through establishing two different point-to-point links.

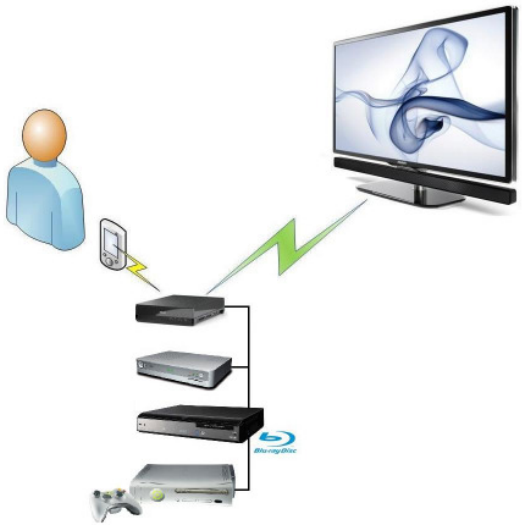

Figure 2: A Wireless Entertainment Hub with Multimode UWB Application Scenario

The concept of an entertainment hub might be implemented in many possible ways. In a simplest form it can be a wireless switch-box connecting to various source devices and allowing the user to select which source it wants to select via the TV menu. On the other hand it can be a full entertainment centre with HD TV tuner, BD player, hard disc drive as well an advanced video processing capability built in.

In any case, the scenario proposed here requires the hub to wirelessly support two different modes:

- Fast data transfer of content in close range (<1m)
- Lossless video streaming of HD content to the TV within the living room

3 Enumerated Requirements

3.1 Requirements Specific to Public Transport Scenarios

This table summarises the requirements for the multimode/multi-band platform. A detailed listing of the requirements for the public transportation application can be found in [3].

Function / Feature	WiMedia (HDR)	60 GHz
Antenna Design	Omni Directional	180 deg, high gain
Connectivity	Multi-point, Bi-Directional	
Range	Up to 10m NLOS	
Higher Protocol	IP	
Data rate	50 Mbps net available to IP-layer, per device	1 Gbps net to IP-layer, per device
Network architecture	Service-access-points (SAP) providing access to the wired board network, star-topology communication (only SAP-to-end device), multi-channel architecture (per SAP) required	
Bandwidth management	Each SAP-end device pair must have a guaranteed data rate	
Number of Units	Up to 1300 end-devices in the aircraft plus SAPs, up to 50 nodes per SAP	Up to 560 end-devices in the aircraft plus SAPs, up to 25 nodes per SAP
Device Synchronization	< 1 ms	
Transmission Delays	< 100 ms	
Power Consumption	Support for battery powered devices, minimum 24h operational with standby and adequate utilization time	Powered by cable
QoS	Support for at least 5 service classes for message prioritization	
Mobility	Support for handheld and wearable devices	None
Ease of use	Operation without human interaction (possible initial setup phase)	
Scanning	Channel scanning must be possible without loosing connection to other nodes	Scanning and being connected may exclude each other

Table 2: Public Transport Requirements

Function / Feature	WiMedia (HDR)	60 GHz
Wireless Link Robustness	Robustness sufficient enough for public transportation vehicles (e.g. sufficient to support problems resulting from reflection, moving obstacles, …)	
Localization	Accuracy 20 cm (seat localization)	
Multi Mode	Coexistence of HDR and 60Ghz	
Content Protection	Content may not be exposed to foreign devices	Not necessarily required
Usage	Used for signalling, audio, sensors, small displays	Used for in-flight entertainment and as backup-link for the HDR

Table 3: Public Transport Requirements contd.

3.2 Requirements Specific to Home Environment Scenarios

This table summarises the requirements for the multimode/multi-band platform in the home environment scenario. A detailed listing of the requirements for the home environment application can be found in [4].

Function / Feature	HDR	60 GHz
Antenna Design	Omni Directional	high gain
Connectivity	Point to point (bidirectional) Content source (PMP) ↔ Wireless Hub	Point-to-point (unidirectional) Wireless Hub → TV
Range	< 1 m LOS	In-room (Up to 10 m) NLOS
Higher Protocol	File transfer – buffer enabled protocol to be decided	Video Streaming Protocol to be decided
Data rate	Up to 1Gbps PHY	2-8 Gbps PHY
Network architecture	Point to point (just two devices involved for both cases)	
Bandwidth management	Not critical (channel not shared or minimum interference)	
Number of Units	1 (portable device) + 1 (wireless hub)	1 (wireless hub) + 1 (display receiver)
Device Synchronization	< 10 s	Not applicable
Latency	TBD (not critical)	< 5ms
Power Consumption	For wireless hub not critical (mains operated) For PMP it should meet the requirements of battery operated devices (<~1 W)	Not critical (mains operated)
QoS	2 modes: - File transfer (soft requirements) - Video transfer (needs buffering)	1 mode HD Video Streaming Low latency , ~10^{-9} BER
Mobility	Support for handheld and wearable devices (PMP end)	Stationary
Ease of use	Automatic device discovery and easy pairing	Automatic pairing

Table 4: Home Environment Services Requirements

Function / Feature	HDR	60 GHz
Scanning	Interference not expected	Channel scanning without losing connection in case interference is considered to be possible
Wireless Link Robustness	No special requirements (close range), many retransmissions possible	Link must be stable and resilient to changes in the environment and people shadowing
Localization	Not required	
Multi Mode	Coexistence of HDR and 60Ghz in the Wireless hub	
Content Protection	Required	Required
Usage	Used for data transfer between portable device and wireless hub	Used for video streaming to a display

Table 5: Home Environment Services Requirements contd.

4 Requirements Feasibility

The public transport and home entertainment application scenarios, as described in reference [1] and [2] respectively, show clearly there is a system requirement for a multimode / multi-band platform with capabilities to address wireless connectivity using a WiMedia based UWB radio in the 3.1GHz to 10 GHz range in combination with a very high data rate 60 GHz radio.

However the enumerated requirement tables presented in sections 3.1 and 3.2 show only minimal correlation, demonstrating that each application scenario cannot easily be supported by a single platform. Additionally, some requirements can be considered to be beyond the current state of the art in short range wireless communications.

The challenge of providing a single platform to fulfil the needs of each scenario is therefore significant. In order to address this challenge the following approach is proposed;

1. Describe the capabilities of the current components and/or state of the art
2. Identify those system requirements listed in sections 3.1 and 3.2 that are beyond the state of the art
3. Provide a high-level system diagram describing the proposed approach

Points 1 and 2 above have been addressed in Table 7 below.

Function / Feature	WiMedia			60 GHz		
	Public Transport	**Home Entertmnt.**	**State of the Art**	**Public Transport**	**Home Entertmnt.**	**State of the Art (Wireless HD)**
Antenna Design	Omni-directional	Omni directional	Omni directional	180 deg. high gain	High gain	Tx and Rx antenna arrays
Connectivity	Multi-point / Bi-directional	Point-point / Bi-directional	Multi-point / Bi-directional	Multi-point / Bi-directional	Point-point / Uni-directional	Point-point
Range	10 m LOS	< 1 m LOS	30 m LOS with Tzero 2 Rx ant.	10 m LOS	10 m NLOS	10 m NLOS
API Protocol	IP	File transfer Protocol TBD	WUSB / IP	IP	Media streaming Protocol TBD	N/A
App. Level Throughput	50 Mbps	1 Gbps	>100 Mbps with iperf test	1 Gbps	2-8 Gbps	3 Gbps
Network Topology	Star	Point-to-point	Star	Star	Point-to-point	Point-to-point
Bandwidth Management	Guaranteed	N/A	DRP	Guaranteed	N/A	Reserved slots
Number of Units	1300 devices, 50 per SAP	2	127 per host	560 devices, 25 per SAP	2	N/A
Device Sync.	< 1 ms	< 10 s	No HW sync.	< 1ms	N/A	N/A
Transmission Delay (latency)	< 100 ms	TBD (not critical)	< 100 ms	< 100 ms	< 5 ms	2ms
Power Consumption	Battery powered 24 hr operational	Battery powered < 1 W	Battery powered, >1W	UPS	UPS	UPS
QoS	5 service classes	2 service classes	Available, but inflexible	5 service classes	1 service classes	N/A
Mobility	Handheld / Wearable / Mobile	Handheld / Wearable / Mobile	Built in laptops	N/A	N/A	Stationary and mobile with advanced power management
Ease of Use	Fully automated (no HMI)	Fully automated (no HMI)	Fully automated	Fully Automated (no HMI)	Fully Automated (no HMI)	N/A
Scanning	Scanning whilst connected	N/A	N/A	connected mutually exclusive	Scanning whilst connected	N/A
Link Robustness	Sufficient for public transport	Sufficient for home use	Even with NLOS	Sufficient for public transport	Sufficient for home use	N/A
Localisation	20cm	N/A	Not implemented	20cm	N/A	N/A

Table 6: Comparison of Requirements with State of the Art

Content Protection	Required	Required	DCP LLC with Tzero chip	Not required	Required	DTCP, DTLA in Wireless HD
Usage	Signalling, audio, sensors, small displays	Data transfer. Portable device to hub for the HDR)	Video streaming	In-flight entertainment (and backup-link for HDR)	Video streaming to display	delivery of high quality, uncompressed A/V content

Table 7: Comparison of Requirements with State of the Art (contd)

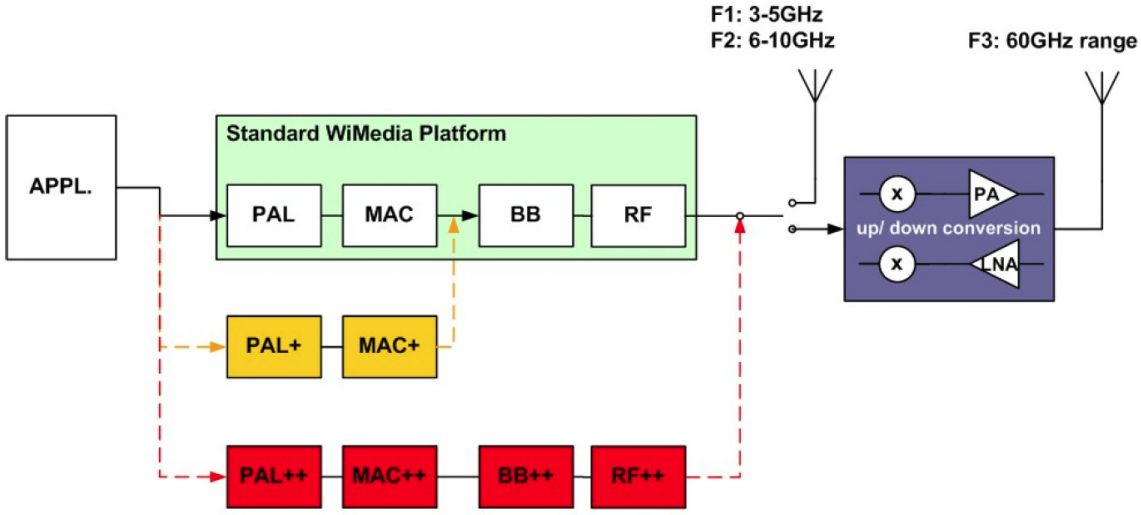

Figure 3: Possible Solutions for Multimode/Multi-band

The proposed system, shown in Figure 3, contains a state of the art standard WiMedia radio system in combination with additional functional blocks that include the 60 GHz up/down converters, power amplifier, low noise amplifier and filters. They are attached to the WiMedia platform via a RF switching circuit. Several combinations of WiMedia MAC and PHY could be used to realise the WiMedia radio system and modifications may be required to the Wimedia system to support integration with the 60 GHz up/down converter, multiple paths through PAL/MAC/BB and PHY are shown on figure 3.

It is clear that a strategy will need to be formulated for the new system in order to determine when the system switches to 60 GHz operation, based on channel conditions, traffic type, and application requirements.

Generally, two basic modes of operation need to be addressed.

- Mode 1: The 60 GHz up/down converter provides ONLY an alternative operating frequency range from the standard WiMedia radio, and the functionality of the WiMedia radio system should only change to support integration of the new 60 GHz radio system.
- Mode 2: The 60 GHz up/down converter provides an alternative operating frequency range from the standard WiMedia radio AND the capabilities of the key functional blocks of the WiMedia system have been modified to handle the higher data transfer rates that the 60 GHz radio system can support.

Mode 1 may require adaptation of the PAL (Protocol Adaptation Layer) and MAC and control functions, but would not require changes to the existing BB and RF WiMedia blocks to support switching to 60 GHz band.

Mode 2 would support application scenarios that require much higher throughput than the capabilities of a standard WiMedia system. In this case the changes and adaptations need to be performed to the major functional blocks of the radio system, including the PAL, MAC, BB and RF parts of the chain. The PAL and the MAC data planes will, for example, need to be modified to support up to 8 times larger data rates for file transfer profiles (up to 6 Gbps). Baseband processing needs to provide potential functions for channel bundling of the WiMedia channels, increasing the modulation depth of the OFDM carriers, new synchronisation strategies, and also a potential reduction of the number of OFDM carriers in order to address the phase noise demands and linearity issues of the 60 GHz up and down conversion Block. The RF chain will need to cope with multiplied WiMedia channels (2 or 4).

5 Regulatory and Standardisation Activities

The Ultra Wideband technology developments in recent years have been driven by standardisation process in high data rate and low data rate domains. The high data rate standard (also known as ECMA 368 and promoted by WiMedia Alliance) uses Multiband Orthogonal Frequency Division Multiplex (MB-OFDM) technique within several 528 MHz wide channels in the frequency range 3-10 GHz [5]. Some products made according to this standard are already available and known as Wireless USB - WUSB[6]. This high data rate UWB technology is focuses on sub 10 GHz frequency range and various applications demanding high data rate, like the USB 2.0. WUSB is used in game controllers, printers, scanners, digital cameras, MP3 players, hard disks and flash drives. It is also suitable for transferring parallel video streams. The data rate provided by existing WiMedia standard solution is up to 480 Mbps at 3m to 4m distance, depending of the environment. On one side the coverage is insufficient for different applications, on the other side the net throughput after protocol overheads of 70-200 Mbps (WUSB & Native Interface) is insufficient to support large set of the high data applications like:

- Efficient wireless uncompressed video streaming over HDMI (High-Definition Multi-Media Interface)
- Fast point to point downloading and data transfer.

Also from regulatory point of view several applications may be in case of WiMedia (3-10 GHz) used in very limited manner for outdoor and limited outdoor application, whereby in case of 60 GHz application those regulatory problems are not existing. This imply that simple mode of providing data throughput same as WiMedia in the 60 GHz range for outdoor applications would be very attractive. These are basic motivations, for the proposal of our system concept described further in the paper.

Data rate demand for wireless systems due to a variety of applications is permanently growing. To meet the increased demand a new generation of systems has to be targeted. Due to the common spectrum availability it is required to envisage possible solutions at frequencies in the higher microwave and lower mm-wave bands. However, possible future systems have to additionally provide features of utilising technologies having the prospective of being low cost in the near future, to provide easy backward capability to lower generation system and comprehensive interworking functionality. An upcoming WiMedia 1.1 specification, expected in 2009, will increase speed up to 1 Gbps and working frequencies in the 6 GHz range.

Wireless Home Digital Interface (WHDI) is a new short range wireless MIMO transmission technology intended to replace cables between video sources and televisions and other displays [7]. It sets a new standard for wireless high-definition video connectivity. WHDI provides a high-quality, uncompressed wireless link which can support delivery of equivalent video data rates of up to 3 Gbps (including uncompressed 1080p) in a 40 MHz channel in the 5 GHz unlicensed band, conforming to worldwide spectrum regulations. Equivalent video data rates of up to 1.5Gbit/s (including uncompressed 1080i and 720p) can be delivered on a single 20 MHz channel in the 5 GHz unlicensed band, conforming to worldwide 5 GHz spectrum regulations.

In December 2008 is published ECMA 387 standard for multi gigabit wireless applications in 60 GHz range [8]. It contains PHY and MAC for short range unlicensed communications and declares high rate wireless (up to 5 Gbps) personal area network with applications: high definition AV streaming, wireless docking station, short range Sync&Go.

The WirelessHD standard [9] is focused on the 7 GHz of continuous bandwidth around the 60 GHz radio frequency and allows for uncompressed, digital transmission of full HD video and audio and data signals, essentially making it equivalent, in theory, to wireless HDMI. The specification has been designed and optimized for wireless display connectivity, achieving in its first generation implementation high-speed rates from 4 Gbps for the CE, PC, and portable device segments. The signal operates on the 60 GHz Extremely High Frequency band and supports the bandwidth required to support both current and future HD signals. The 60 GHz band requires line of sight between transmitter and receiver, and the WiHD standard overcomes this limitation through the use of beam forming at the receiver and transmitter antennas.

The IEEE 802.15.3 Task Group 3c (TG3c), formed in March 2005, is developing a mm-wave-based alternative physical layer (PHY) for the existing 802.15.3 Wireless Personal Area Network (WPAN) Standard 802.15.3-2003 [10]. This mm-wave WPAN will operate in the new and clear band including 57-64 GHz unlicensed band defined by FCC 47 CFR 15.255. The mm-wave WPAN will allow high coexistence (close physical spacing) with all other microwave systems in the 802.15 family of WPANs. In addition, the mm-wave WPAN will support high data rate at least 1 Gbps applications such as high speed internet access, streaming content download (video on demand, home theatre, etc.). Very high data rates in excess of 2 Gbps in option will be provided for simultaneous time dependent applications such as real time multiple HDTV video stream and wireless data bus for cable replacement.

An approach with dual frequency systems are addressed previously in [11], [12]. The reuse of system designed and working in 5 GHz for 60 GHz band was previously done also within the ICT project BROADWAY [13]. The aim was extending existing wireless local area network (WLAN) technology in terms of capacity and privacy in an evolutionary way while providing additionally ad-hoc network functionalities, taking into account Hiperlan II (evaluating joined operation of the IEEE 802.11.a and 60 GHz with 20 MHz channels. This is the path we follow in this paper and propose high data rate UWB system concept using WiMedia UWB technology as its basic ingredient.

6 Conclusions

In this document the requirements of the multimode / multi-band platforms for the public transportation and home environment scenarios have been listed. The platform shall combine the 3.1 – 10 GHz WiMedia technology and a 60 GHz technology in a single platform. Both scenarios show the clear need for the combined platform.

The collated requirements listing revealed partial commonalities in the scenarios requirements. Two major issues are the different connectivity and data rate requirements. Developing one platform satisfying both scenarios and both frequency ranges is challenging. Furthermore several requirements are beyond state of the art technology, for example the desired throughput and localisation features.

The Requirements Feasibility section shows three possible approaches, each containing a different degree of existing platform reuse. Extending an available WiMedia platform with a 60 GHz converter and a multiplexer is the easiest way, but will not satisfy all requirements. In contrast a complete new platform fulfils all needs, but is extremely time consuming and expensive. In between exists the approach to take a WiMedia platform and modify the abstraction layer and MAC layer for the 60 GHz mode. If this approach satisfies the requirements is unclear for now.

From the standardisation and regulation perspective several technologies currently under development are targeting the license free 60 GHz frequency bands. The potential of these bands for successful high data rate applications is well known. It is obvious that future wireless multimedia communication for short distances will be driven by 60 GHz communication technologies.

References

[1] S. Bovelli, F. Leipold: "EUWB-D8a.1 - Scenario description for public transport applications"

[2] P. Hafezi, M. del Rey: "EUWB-D8c.1 - Scenario Descriptions for Multiband/Multimode UWB Home Entertainment Applications"

[3] S. Bovelli, F. Leipold: "EUWB-D8a.2 - Requirements for public transport applications"

[4] P. Hafezi, M. del Rey: "EUWB-D8c.2 - System parameters and Technical Requirements for Multiband/Multimode UWB Home Environment Applications"

[5] Standard ECMA 368, High Rate PHY and MAC, 2005. Available online: www.ecma-international.org

[6] http://en.wikipedia.org/wiki/Wireless_USB

[7] http://www.whdi.org/Technology/

[8] Standard ECMA 387, High Rate 60GHz PHY, MAC and HDMI PAL, Dec. 2008. Available online: www.ecma-international.org

[9] http://www.wirelesshd.org

[10] IEEE 802.15.3c http://www.ieee802.org/15/pub/TG3c.html

[11] V. Brankovic, T. Dolle, T. Konschak, D. Krupezevic, R. Ratni, "High data rate wireless system solution: 60 GHz/5 GHz dual frequency operation", in Proc of the 11th IEEE International Symposium on Personal, Indoor and Mobile Radio Communications 2000, PIMRC 2000, Volume 1, Issue , 2000 Page(s):196 – 199.

[12] A. Nesic, V. Brankovic, D. Krupezevic, I. Radnovic, "24 to 5 GHz Up/Down Converters with Integrated Antennas" in Proc. of the 29th European Microwave Conference, 1999. Volume 2, Issue, Oct. 1999 Page(s):153 – 156.

[13] M. de Courville, S. Zeisberg, Markus Muck, J. Schönthier, BROADWAY - the Way to Broadband Access at 60GHz, 2001.