TECHNICAL SUPPORT TO DEFENCE SPECTRUM

ISM Band Audit (Audit of the LE 2400 MHz band)

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Contents

1 INTRODUCTION AND SUMMARY

1.1 Project introduction

The Ministry of Defence (MOD) is working on the technical issues necessary to grant Recognised Spectrum Access (RSA) for the 2.3GHz band (2300-2390MHz) with Ofcom. This includes consideration of possible interference issues between the 2.3GHz band and neighbouring bands. One of the most used bands in the vicinity of the 2.3GHz band is the 2.4GHz Industrial Scientific and Medical (ISM) band (spanning 2400-2483MHz). To support this work, the MOD requires an audit to be conducted to clearly identify all civilian users in the ISM band (2400-2483MHz).

1.2 Context

The ISM band at 2400MHz occupies the frequency block 2400MHz to 2483.5MHz. It is designated globally as ISM spectrum. It contains many communications as well as ISM devices and is now very saturated. Most applications are licence exempt.

The ISM designation of the band is based round the use of microwave ovens, which use a magnetron to generate the radiation, and operate at 2.45GHz. The magnetron will not generate an exact frequency, but for dielectric heating this is not a problem. There are also medical diathermy equipments which operate on the same principle.

Due to the use of these ISM devices, the adjacent spectrum could not be guaranteed to have a quiet noise floor, and so has been designed by Ofcom for use by low power applications that can coexist in this environment.

As an available licence-exempt band at a reasonable frequency, services such as Wi-Fi (802.11b and g) and Bluetooth have been developed to use this band, and have increased considerably in popularity and usage in the last ten years, particularly with the advent of smartphones, tablet PCs and other mobile broadband devices, which typically include Wi-Fi and Bluetooth connectivity within the device, as well as being able to connect to a public cellular network via various frequency bands used for 2G, 3G (and 4G) networks. For example, there are believed to be more than 7 billion Bluetooth devices in use[1].

1.3 Document scope

The audit first reviews the current and potential users of the 2.4GHz ISM band, using publically available data. Once the users have been identified, the characteristics of the various solutions will be identified and, where appropriate, the sources of the standards to which the solutions must conform. The document is structured as follows:

- Section 2 provides details of the users who will be causing transmissions

- Section 3 gives the characteristics of the transmissions.

- Section 4 lists ETSI specifications which have relevance to the audit.

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[1] http://www.bluetooth.com/Pages/market.aspx

2 USERS

2.1 Introduction

The ISM band is generally used by licence-exempt communications devices, although there is a limited amount of registered licensed usage. In the following categories, the first two users have registered licensed usage, while the rest are licence exempt.

2.2 Spectrum summary

The following summarises the 2.4GHz ISM band.

Figure 1: Spectrum summary (MHz) [Source: Analysys Mason, 2012]
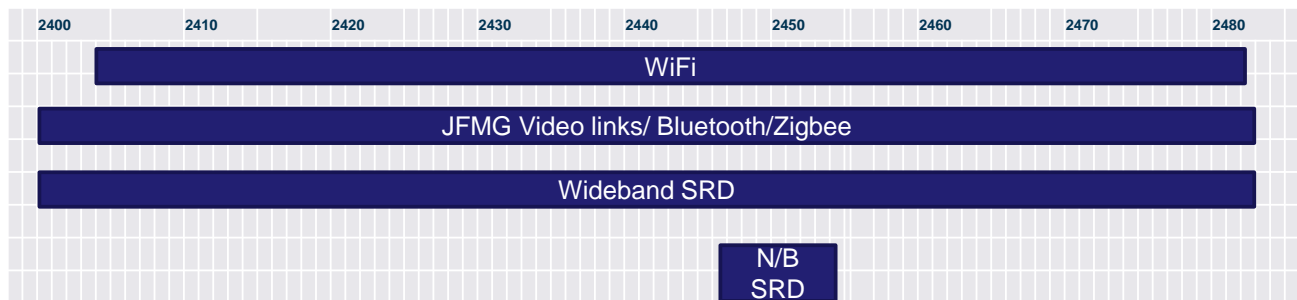
2.3 Users of licensed spectrum

2.3.1 Programme Making and Special Events

Programme Making and Special Events (PMSE) users have equipment which will tune over a wide frequency range. They have a number of channels (both analogue and digital) which are used for video links. These include channels in the ISM band, on the basis that there will be sharing with licence-exempt devices.

The usage of the channels is not identified by the JJFMG website. They are marked as liable to interference from licence-exempt devices.

2.3.2 Fixed Wireless Access

There was a trial business venture in Scotland by Atlantic Telecom using low power spread spectrum technology in the 2400-2483MHz band. The trial was successful and licences were offered throughout the rest of the UK by comparative selection. Atlantic Telecom was successful in bidding for licences in six regions and Kingston Communications secured a licence for one region (East Yorkshire). Services provided included fixed wireless access (FWA) telephony and Internet connectivity at data rates up to 2MBit/s.

Atlantic Telecom filed for administration in October 2001 and the service was discontinued. There is no evidence that Kingston Communications (now Kcom) provides any FWA services in the ISM band.

2.4 Users of licence-exempt spectrum

In the licence-exempt sector there are many device categories, which are generally devices that communicate over a few tens of metres and these cover every conceivable application. In many cases the majority of applications that use the 2.4GHz band are also permitted to operate in other frequency bands (e.g. Wi-Fi can operate in the 5GHz band), but since the Ofcom interface requirements for licence-exempt devices also include the 2.4GHz ISM band, it allows suppliers to use the band for a wide range of applications, if required.

2.4.1 Scientific, medical and industrial

Users of the band include many hospitals, which use the frequency for medical diathermy machines, industrial heating devices, and microwave ovens, which should be screened but will have low levels of radiation outside of the enclosure.

2.4.2 Wi-Fi (802.11 b/g/n)

Wi-Fi or WLAN operating to the IEEE802.11 standard in the 2.4HGz ISDM band has become very widespread for commercial use in recent years. The 802.11b version of the standard, which is the original Wi-Fi standard developed for the 2.4GHz band, provided connection speeds up to 11Mbit/s, while 802.11g – the newer update of the 802.11b standard – provides connection speeds up to 54Mbit/s. Almost all homes in the UK will have a WLAN router, and most offices will have at least one. The majority of these use the 2.4GHz band[2]. There are also a large of 'public' hot spot users, and laptops, phones and other mobile devices all have 802.11b/g devices.

Although a lot of the devices are indoors, many hotspots will cover the surrounding area, and BT Wi-Fi (previously BT Openzone) offers outdoor coverage in major city centres or 'wireless cities', including Westminster in London, Birmingham, Liverpool, Manchester and Newcastle. Another Wi-Fi hotspot service operating in the UK is The Cloud, which was purchased by Sky to provide its 'Sky Go' service.

802.11 is also the standard used for a number of outdoor rural community broadband schemes, where it performs the last-mile connection to the house, via line of site from a high point such as a water tower to an outdoor unit. There are an increasing number of these systems being deployed. Some of these will be 802.11g, but others could be 802.11n.

Locations will generally be rural locations, but not necessarily remote areas. For example, there are many rural community broadband schemes using 2.4GHz in the North Essex/Suffolk area. 4Appendix A lists those which have been identified from a review of publically available data.

2.4.3 Bluetooth

There are now more than 7 billion Bluetooth devices in use, in many applications. Bluetooth is effectively a proprietary technology, but one which has been accepted and become a worldwide standard[3], with good

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[2] Wi-Fi can also use the 5GHz band, based upon the IEEE802.11a standard. However, the number of devices using 5GHz is thought to be far more limited than 2.4GHz.

[3] A Bluetooth 'Special interest group' (SIG) developed the standard, which is now used worldwide
https://www.bluetooth.org/apps/content/

interoperability. It was originally conceived as a wireless replacement for an RS-232 serial link, but has evolved to support voice and data, and to operate in ad-hoc personal networks, so that devices can talk to other devices in the net, and can be in several nets simultaneously. Bluetooth devices have a short range, with a specified minimum of 10 metres.

2.4.4 Zigbee

Zigbee is an alliance or association of suppliers and other organisations which works to develop standards-based wireless technology, designed to address the needs of low-cost, low-power wireless sensor and control networks. The aim is for products to work together intelligently. While Zigbee is deployed in some countries outside of Europe (e.g. USA) it has had limited deployment within the UK or across Europe to date. It is proposed to be used in a number of upcoming applications, especially home automation and smart energy.

In the smart energy area it is one of the candidate technologies in the UK for smart metering communications. It is nominated as an interface for the home-area network (HAN), which communicates between the meters and remote display unit within a home, so there could be one unit in every house in the UK.

2.4.5 Short range devices

There are already many short range devices operating in the 2.4GHz band, and the potential for a much large number of devices in the future. These are covered by Ofcom Interface Requirement 2030. These could be railway devices, Radio Frequency Identification Devices (RFID), intruder detection, short range video links, etc. They must comply with EN300 328 or EN 300 440 and must comply with Directive 1999/5/EC or the RTTE Regulations. Examples are the Philex 27995R Audio Video Transmitter and the ONE FOR ALL Wireless Audio/Video Sender (SV-1715) which both operate at 2.4GHz. There is also a good ecosystem of radio data modems using the 2.4 GHz ISM band, using spread spectrum or OFDM, either proprietary or 802.11g compliant.

2.4.5.1 Railway applications

The frequency band 2446-2454MHz can be used for railway vehicle identification or for the provision of data links between the track and rail vehicles, in a railway environment. It is a dedicated 2.45GHz short range microwave link intended for a European-wide data communication system for railway applications, Automatic Vehicle Identification (AVI). This is a short range communication at low power. Suppliers make active 2.4GHz AVI equipment suitable for trains, and these are used in the London Underground to locate trains and initiate talkgroup change on the radio network.

2.4.5.2 Radio Frequency Identification Devices

This is equipment used for illuminating and identifying tags, which contain the unit identity. Equipment is low power, although if it is only used indoors there is provision for a high power device, as long as the power 10m outside the building or operator's boundary is measured as less than a specified value.

2.4.5.3   Radio determination

Radio determination is a form of radar, using an RF field and variations in that field to detect or monitor movement, using it as an intrusion detector.

2.4.5.4   Industrial/commercial telemetry and telecommand

This could be any relevant application. In other frequency bands it may be remote meter reading or asset tracking and tracing, but there are no restrictions in the ISM band, apart from speech and music which must be digitised.

2.4.5.5   Wideband data transmission system

This is equipment used for wireless networking between devices. Equipment may operate anywhere in the ISM band, at low power, and can be airborne. There are further requirements that govern emissions, dependant on the frequency mode of operation

2.4.5.6   Short range indoor data links

These are data links, which can carry music and speech if they are digitised.

2.4.5.7   Non-specific short range devices

'Non-specific' refers to any application which meets the ITU and Ofcom requirement conditions, so can include other short range data applications. Equipment may operate anywhere in the ISM band, at low power, and can be airborne.

2.4.5.8   Wireless audio applications

Equipment may operate anywhere in the ISM band, at low power.

2.4.5.9   Wireless video cameras – non broadcasting

This category will include wireless security cameras, and can include audio as well as video. Equipment may operate anywhere in the ISM band, at low power, and can be airborne.

2.4.6   Medical Body Area Network Systems

This is a new application which is now being considered for the 2.4GHz band (as well as other bands below and above the ISM band). Compatibility studies are considering 2360-2500MHz. Medical Body Area Network Systems (MBANSs) are wearable medical sensors working into a local controller. Initially they are likely to be in health centres, but could become used in the home environment. The FCC in the USA has allocated 40MHz of spectrum from 2360-2400MHz for this application on the basis that it is cleaner than the 2.4GHz ISM band[4]. In the EU compatibility studies are taking place, but no conclusions have been reached.

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[4] http://www.fcc.gov/document/fcc-dedicates-spectrum-enabling-medical-body-area-networks

2.5 Summary of users and usage

The following table lists the users, and gives information on the level of usage in the UK. *High* usage is intensive usage across the UK, *Medium* is where there is a good range of devices selling to the UK market and *Low* is where there are devices, but usage will not be common. No is for where no devices are being supplied at this point in time. Due to the way the Ofcom interface document is structured, it is very easy to introduce an EC-marked item into the market, either in an existing category or using the non-specific category.

Figure 2: Users and Usage Summary [Source: Analysys Mason, 2012]

	Usage				
Application	High	Medium	Low	No	Comment
PMSE					Usage unknown, but Ofcom can request data from JFMG
Fixed Wireless Access				✔	No use located
Medical, Scientific , Industrial	✔				Microwave ovens, diathermy and industrial heating.
Wi-Fi	✔				
Bluetooth	✔				
Zigbee			✔		Moves to high if adopted for the HAN with smart metering
Railway applications		✔			
RFID		✔			
Radio determination			✔		
Telemetry and telecontrol		✔			Radio modems
Wideband data transmission		✔			Video senders
Wireless audio			✔		
Wireless video (non-broadcast)		✔			Wireless CCTV security cameras
MBANS					Future possible application

3 CHARACTERISTICS OF USE AND EQUIPMENT

3.1 Licensed

3.1.1 Programme Making and Special Events

Although not thought to be commonly used, there is provision for five 20MHz FM channels in the band. There are also 11 10MHz DVB-T channels. Maximum ERP for digital signals is 20dBW (although any analogue use can be up to 40dBW). Equipment must comply with EN 302 064. Ofcom IR 2038 is the UK Interface Requirement specification.

3.1.2 Fixed Wireless Access

Fixed Wireless Access (FWA) systems in the 2,4GHz must operate to CEPT Recommendation 70-03 and ETSI standard ETS300 328 (wide-band data system specification).

3.2 Licence exempt

3.2.1 Wi-Fi (802.11g/b/n)

Wi-Fi or IEEE 802.11b/g/n was developed by a standards committee of the Institute of Electrical and Electronics Engineers (IEEE). 802.11b and 802.11g both operate in the 2.4GHz ISM band, while 802.11n can operate in both the 2.4GHz band as well as the 5GHz band, which is also where 802.11a operates.

802.11 b uses direct-sequence spread spectrum (DSSS) and has a maximum data rate of 11Mbit/s. 802.11 g is able to use orthogonal frequency-division multiplexing (OFDM) as well as backwards compatibility with direct-sequence spread spectrum (DSSS) and can operate up to 54Mbit/s. They both have a channel bandwidth of 20MHz. 802.11 n is much newer, introduces MIMO techniques and has channel bandwidths of 20 or 40MHz, with data rates up to 72 or 150Mbit/s respectively.

Although there are 13 channels listed for the UK, these overlap, and there is only space in the band for three non-overlapping channels.

Due to the roll off of the DSSS modulation the channel bandwidth allowed is 22 MHz, however with the Orthogonal Frequency Division Multiplexing (OFDM) waveform of 802.11 g, there is scope to have four non-overlapping channels (1, 5, 9 and 13).

This is illustrated in the following diagram.

Channel Number	Lower Frequency GHz	Centre Frequency GHz	Upper Frequency GHz	
1	2401	2412	2423	*Figure 3: 802.11 b/g channels [Source: Analysys Mason, 2012]*
2	2404	2417	2428	
3	2411	2422	2433	
4	2416	2427	2438	
5	2421	2432	2443	

Channel Number	Lower Frequency GHz	Centre Frequency GHz	Upper Frequency GHz	Figure 3: 802.11 b/g channels [Source: Analysys Mason, 2012]
6	2426	2437	2448	
7	2431	2442	2453	
8	2436	2447	2458	
9	2441	2452	2463	
10	2446	2457	2468	
11	2451	2462	2473	
12	2456	2467	2478	
13	2461	2472	2483	
14	2473	2484	2495	

Channels 1 to 13 are available in the UK. Channel 14 goes beyond the edge of the band and is not used.

Figure 4: 202.11 channel overlap [Source: Analysys Mason, 2012]
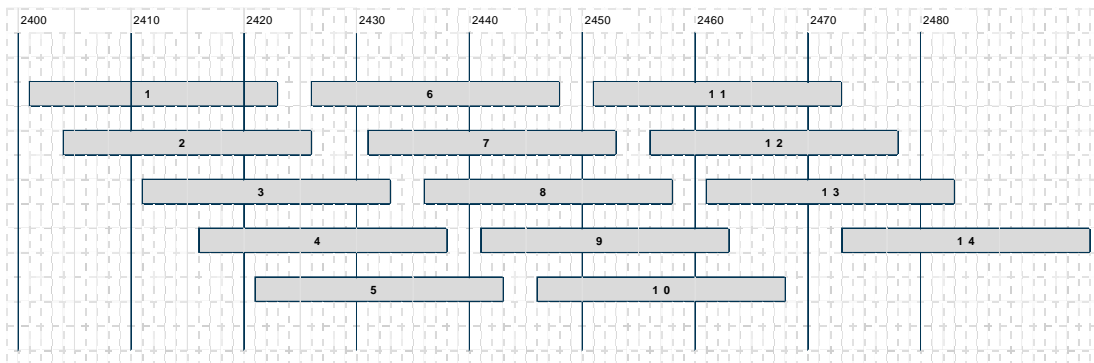
IEEE 802.11 devices will have a typical output power of 20dBm.

3.2.2 Bluetooth

Bluetooth technology operates using a spread spectrum, frequency hopping, full-duplex signal at a nominal rate of 1600 hops/sec. There are 79 1MHz bandwidth channels spaced at 1MHz intervals, starting at 2402MHz. Devices use adaptive frequency hopping to detect other devices using the spectrum and avoid those frequencies.

Maximum power output from a Bluetooth radio is 100mWatts, 2.5mWatts, and 1mW for Class 1, Class 2, and Class 3 devices respectively (with Class 2 being the most common device). Power control is optional.

Receiver sensitivity level is defined as the input level for which a raw bit error rate (BER) of 0.1% is met. The receiver sensitivity will be below or equal to –70 dBm with any Bluetooth transmitter compliant to the transmitter specification

Equipment conforms to ETSI EN 300 328.

According to the Bluetooth Special Interest Group (SIG), there are Bluetooth products designed for a wide range of current applications. The table below summarises these and the number of enabled devices for each[5]. It is not possible to estimate the number of these devices in operation in the UK since devices are exempt from licensing. Hence, there is no record of how many devices are in operation in any given year.

Figure 5: Bluetooth product types and number of supported devices [Source: Bluetooth SIG]

Product type	Number of supported devices
Audio and visual	1589
Automotive	1015
Gaming	84
Handheld (e.g. dongles, hands-free devices)	327
Headset	650
Home Environment (e.g. remote controls)	297
Input devices (e.g. Bluetooth mice, keyboards, etc.)	360
Medical	77
Phone	1153
Mobile phone accessory	598
Office equipment	72
Personal computer	518
Miscellaneous (e.g. hearing aids, remote controls)	585

A list of Bluetooth vendors for the main product categories is provided in Appendix B. The market shares of the top Bluetooth chipset vendors during 2011 are summarised below. This gives the market share of the largest WiFi and Bluetooth chipset vendors, and not the market shares of each vendor. We have not been able to source data to verify the latter.

Figure 6: Vendor market share by product type [Source: Gartner, 2011]

Vendor	Wi-Fi chipset market share (%)	Bluetooth chipset market share (%)	GPS chipset market share (%)
Broadcom Corporation (BRCM)	28	41	19

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[5] Source: http://www.bluetooth.com/Pages/Product-Directory.aspx

Vendor	Wi-Fi chipset market share (%)	Bluetooth chipset market share (%)	GPS chipset market share (%)
Qualcomm	30	-	-
CSR[6] / Samsung		36	41
Texas Instruments	6	3	9
Mediatek	9	9	3
Marvelll Semiconductor Inc	14	-	-
Intel	8	-	-
Others	5	12	29

3.2.3   Zigbee

Zigbee works in the 2.4GHz band based on the IEEE 802.15.4 standard, although it can also operate in the 868MHz band. An important feature of Zigbee is the possibility to handle mesh networking, thereby extending the range and making a Zigbee network potentially 'self-healing' if adjacent nodes are within range

IEEE 802.15.4 defines lower layers for wireless Low Rate Personal Area Networks, and defines the physical and MAC (addressing and channel access) layers. It uses DSSS with 16 channels, each up to 250kbit/s.

3.2.4   Short range devices

3.2.4.1   Railway applications

These operate in 2446-2454 MHz, with a maximum e.i.r.p. of 500mWatts, and a channel bandwidth less than 1.5MHz. These comply with EN 300 761-1, which is a railway-specific specification.

The in-track base station (interrogator) transmit and receive modulations are a combination of Amplitude Shift Keying (ASK) and Frequency Shift Keying (FSK) respectively.

3.2.4.2   RFID

These operate in 2446-2454 MHz, with a maximum e.i.r.p. of 500mWatts, and comply with EN 300 440. They can be used airborne.

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[6] Cambridge Silicon Radio, which was acquired by Samsung during 2012 – see
http://www.marketwatch.com/story/samsung-acquires-cambridge-silicon-radio-unit-2012-07-17

There is an extra category of indoor use only devices which can have an e.i.r.p. of 4 watts, but with a duty cycle of <15% and max transmit time of 30 milliseconds. Emissions measured 10 metres from the boundary of the operator's premises must be below 500mWatts. Again compliance is to EN 300 440.

3.2.4.3   Radio determination

These operate in 2445-2455 MHz, with a maximum e.i.r.p. of 100mWatts, and comply with EN 300 440. A variant with a maximum e.i.r.p. of 25mWatts can operate over the whole 2400-2483.5 MHz band, and may be used airborne. This also has to comply with EN 300 440.

3.2.5   Industrial/commercial telemetry and telecommand

This uses the band 2445-2455MHz and is low power at 100 mWatts e.i.r.p.. Compliance is to EN 300 440.

3.2.6   Wideband data transmission system

This is equipment used for wireless networking between devices. Equipment may operate anywhere in the ISM band, at a power of 100mWatts e.i.r.p., and can be airborne. There are further requirements that equipment must only generate emissions of 100mWatts/100 kHz e.i.r.p. density when frequency hopping modulation is used, or 10mWatts/MHz e.i.r.p. density when other types of modulation are used. Compliance must be to EN 300 328.

3.2.7   Short range indoor data links

These are data links, which can carry music and speech if they are digitised. This category could include wireless security cameras. This uses the band 2445-2455MHz and is low power at 100mWatts e.i.r.p.. Compliance is to EN 300 440.

3.2.8   Non-specific short range devices.

'Non-specific' devices may operate anywhere in the ISM band, at a low power of 10mWatts e.i.r.p., and can be airborne. Compliance is to EN 300 440.

3.2.9   Wireless audio applications

Equipment may operate anywhere in the ISM band, at a low power of 10mWatts e.i.r.p.. Compliance is to EN 300 422 (a specification specifically for wireless microphones).

3.2.10   Wireless video cameras – non-broadcasting

This category will include wireless security cameras, and can include audio. Equipment may operate anywhere in the ISM band, at a low power of 10mWatts e.i.r.p., and can be airborne Compliance is to EN 300 440.

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4   ETSI-REFERENCED SPECIFICATIONS

The Ofcom Interface Specification invokes a number of ETSI specifications, which define the characteristics of transmitter and receiver equipment. These are listed for reference in the following table. Note that some are exclusive to the ISM band, but others cover a range

Document Number	Date	Title
EN 300 328	2001-12	Data transmission equipment operating in the 2.4GHz ISM band and using spread spectrum modulation techniques
EN 300 422	2008-03	Wireless microphones in the 25MHz to 3GHz frequency range
EN 300 440	2010-08	Short range devices Radio equipment to be used in the 1GHz to 40GHz frequency range
EN 300 761-1	2001-06	Short range devices AVI for railways operating in the 2.45GHz frequency range
EN 302 064	2004-07	Wireless video links (WVL) operating in the 1.3GHz to 50GHz frequency band

APPENDIX A   WI-FI RURAL BROADBAND SCHEMES

A.1   Definite 2.4GHz schemes

Operator	Area	Users	Characteristics	Link
AirBand	Warwickshire, Worcestershir, Herefordshire, Shropshire and Powys	Residential and business	• Operator uses 2.4GHz and equipment which relies on a frequency hopping system which implies that data is sent by a different frequency every 50th of a second. If the frequency is in use by another device, the signal 'hops' to another unused frequency • Installation features a small box (~13 x 9cm), placed outside the residence • AirBand also offers other services such as wireless campus network deployment, leased lines, interconnect and hosting services	http://www.airband.co/about-us/
More speed	Revel community, Warwick shire (Harborough Magna, Pailton, Monks Kirby, Churchover & Brinklow)	Residential and business	• Rationale for provision of services is that Rugby is located in a rural area, which is not attractive to major broadband providers • The community network is built and operated by Morespeed Networks which is a division of OEM Computer Systems • Network is Wi-Fi-based (802.11) over 2.4GHz • Installation features wireless card in the PC and antenna installation outside the building • The operator has rented more leased lines to cater to growing demand	http://www.morespeed.net/index.htm
Stour Valley Wireless	Stour Valley, Essex/ Suffolk	Residential	• Data as of 2007 • Operator uses 2.4GHz band • Network topology features repeaters due to undulating terrain. Also uses dynamic routing via OSPF and QoS	http://www.stourvalleywireless.org.uk/
Speednet Scotland	Ayrshire, Scotland (many	Residential and business	• Operator uses both 2.4GHz and 5.8GHz • Business rationale are slow speeds prevalent in rural and urban Scotland	http://www.speednetscotland.net/

Operator	Area	Users	Characteristics	Link
	locations available – details on website)		• Speednet offers residential solutions of up to 20Mbit/s • Offer contention ratio of 20:1 • Installation includes an external receiver • Residential broadband prices are based on downlink speed, though all have upload link of 1Mbit/s. On a monthly basis, 5Mbit/s costs ~GBP23, 10Mbit/s costs ~GBP28, 15Mbit/s costs ~GBP33 and the fastest, 20Mbit/s package costs ~GBP38 • The operator also provides VoIP services for both residential and business customers and bonded DSL, targeted specifically at business customers	

A.2 Possible 2.4GHz schemes

Operator	Area	Users	Characteristics	Link
Quickanet	**Kings Hill, Kent**	**Business and residential**	• Operated on a "not for profit" basis • Founded in 2004 in an attempt to address shortcomings of local ADSL • Possible installation: small aerial is fitted to the top of the roof or chimney and provides a direct link back to one of the base stations • Wi-Fi hotspot deployment throughout Kings Hill	**http://www.quickanet.co.uk /index.php?option=com_con tent&view=article&id=107&I temid=145**
Digital Parish	Parish of Hayfield, Derbyshire	Residential	• Very easy access system • Information seems dated	http://www.digitalparish.com/in dex.html
AB Internet	Lincolnshire, North Wales , South East Wales	Residential and business	• Aim to address poor ADSL network coverage • Provide broadband service both for rural broadband project areas and cities such as Lincoln • Large scale Point to Multipoint deployments are core specialty • The operator has been commissioned to install Point to Multipoint systems for exclusive use of clients such as educational establishments	http://wireless.abinternet.co.uk/ ABInternet/index.php?option=co m_content&view=article&id=12& Itemid=31

Operator	Area	Users	Characteristics	Link
			and blue chip companies in covered areas	
HiWi-Fi	Hatch Warren, Beggarwood and Cufaude Village, Hampshire	Residential	• Service offered as replacement of fixed due to significant distance from the cabinet • Required installation of a wireless aerial on the residence which connects to an Ethernet socket • Three packages offered based on speed: silver (4Mbit/s downlink for GBP25.5), gold (8Mbit/s downlink for GBP37.8) and platinum (16Mbit/s downlink for GBP66.4)	http://www.hiwifi.co.uk/index.html

APPENDIX B   BLUETOOTH VENDORS

Main Bluetooth vendors	Products supported
Cambridge Silicon Radio (CSR)	Audio visual, headsets, home environment, handheld, phones
Intel Corporation	Automotive, mobile phone, medical, handheld, miscellaneous
Marvell Semiconductor Inc.	Automotive, home environment
MediaTek Inc.	Mobile handsets to personal navigation devices, gaming consoles and other mobile devices
Qualcomm INC	Notebooks, tablets, gaming controllers, consoles and portable players, audio and media devices, remote controls and mobile handsets
RDA Microelectronics	Phone, audio and visual
Renesas Electronics Corporation	Audio and visual, medical, personal computers, automotive, miscellaneous
STMicroelectronnics	Automotive, audio and visual
Texas Instruments Inc	Phones

APPENDIX C   REFERENCED DOCUMENTS

Document Title	Identification No. (Where Applicable)	Issue/ Date
• Wireless Local Area Network Standards	IEEE 802.11	Various
• ERC Recommentation relating to the use of Short Range Devices (SRD)	CEPT Recommendation 70-03	May 2012
• Low rate Wireless Personal Area Networks	IEEE 802.15.4	2005
• IR 2030 - UK Interface Requirements – Licence-exempt Short Range Devices	Ofcom IR 2030	Dec 2011
• UK Interface Requirement 2038 Programme making and special events (PMSE)	Ofcom IR 2038	Feb 2006

APPENDIX D   ABBREVIATIONS

Abbreviation	Expansion
AVI	Automatic Vehicle Identification
CCTV	Closed Circuit Television
DSSS	Direct Sequence Spread Spectrum
DVB-T	Digital Video Broadcasting — Terrestrial
e.i.r.p.	Effective Isotopic Radiated Power
FCC	Federal Communications Commission (US regulator)
FWA	Fixed Wireless Access
HAN	Home Area Network
ISM	Industrial, Scientific and Medical
JFMG	Spectrum manager for the PMSE users
OFDM	Orthogonal Frequency Division Multiplexing
MBANS	Medical Body Area Network System
PMSE	Programme Making and Special Events
RFID	Radio Frequency Identification
RSA	Recognised Spectrum Access
SIG	Special Interest Group
SRD	Short Range Device
WLAN	Wireless Local Area Network