Short Range Devices operating in the 863 - 870 MHz frequency band

Office of Communications (Ofcom)

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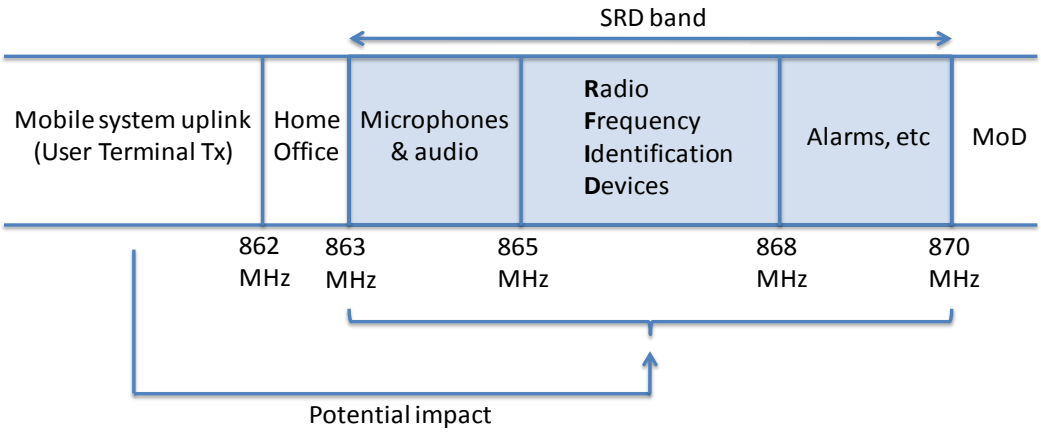
1 EXECUTIVE SUMMARY

Background

As a result of the switchover from analogue to digital television, an amount of radio spectrum will be released for uses other than television. This release of spectrum is widely known as the "Digital Dividend".

There is a likelihood that the frequency band 790–862 MHz will be used for mobile broadband services in line with plans being formulated in Europe. In order to manage the radio spectrum effectively Ofcom needs to understand what the implications of such use will be for Short Range Devices (SRDs) operating in the frequency band just above the digital dividend spectrum in terms of the potential for interference.



Ofcom has therefore commissioned two pieces of work relating to the 863–870 MHz frequency band; one looking at the market for SRDs (as reported on here) and the other investigating SRD receiver characteristics followed by measurements of their performance (reported on elsewhere).

A further piece of work has been undertaken by other parties for Ofcom regarding the implications for the frequency band sandwiched between the top of the digital dividend spectrum and the bottom of the SRD frequency band, namely the 1 MHz segment 862–863 MHz.

In order to better understand the current and future use of the 863–870 MHz SRD band Ofcom requested that market research should address:

- the different services/applications/products that utilise this band
- the manufacturers of devices used and the end users
- the number of these different devices active in the UK

- the likely demand from service providers/ manufacturers for this spectrum in the future (including applications not yet using this spectrum but who might choose to in the future).

Approach

In order to meet the main objective of the study, namely to estimate the market size for Short Range Devices (SRDs) operating in the 863–870 MHz frequency band five years ahead, we have undertaken three main tasks:

- secondary research—an analysis of applications, systems and products based on publicly available information
- primary research—a programme of interviews with representatives from the industry
- analysis and forecasting—identification of application drivers/substitutes and the forecast of future demand.

As a starting point we analysed the products and services offered by current and past members of the Low Power Radio Association (LPRA). We were also able to identify a number of suppliers who are not members of the LPRA.

In order to provide market forecasts for different applications it was firstly necessary to group them by type. We have done this with respect to the three distinct parts of the frequency band as follows:

Low-band (863–865 MHz)	**Mid-band (865–868 MHz)**	**High-band (868–870 MHz) [1]**
Wireless microphones	Manufacturing and distribution	Fire alarm systems
Wireless audio	Individual item tagging	Intruder alarm systems
Assistive listening devices	Asset tracking	Home/Office automation
		Access control
		Remote controllers
		Medical
		Social alarms/Telecare
		Smart meters
		Telemetry
		Automotive

Note 1—This includes the non-specific underlay across the whole band 863–870 MHz.

Amongst the LPRA members and other companies having an interest in this band that were investigated, other less application-specific categories were also identified (e.g. modules / chips / components / antennas, and design houses / test houses / consultancies). These categories were not analysed in any great detail.

Representatives across the industry and covering all the categories identified in the table above were contacted and questioned on all aspects of the market for their devices and systems. This was undertaken through a mix of telephone interviews, questionnaires and face-to-face meetings.

Low band devices

The 863–865 MHz portion of the 863–870 MHz band is used predominantly by wireless microphones and wireless audio applications. While accounting for a significantly smaller portion of the users in this band, assistive listening devices are another application.

Mid band devices

This part of the 863–870 MHz band is used predominantly by Radio Frequency Identification Devices (RFIDs) which consist of a combination of readers and either active or passive tags. Typically, RFID technology can be employed as part of innovative applications or as a replacement technology, either for other older wireless technologies or for barcodes. RFIDs operate in many different frequency bands; for the purposes of this report, however, we focus exclusively on UHF RFIDs that operate in the 865–868 MHz band.

In general, RFIDs are used to locate and track items, whether these are individual items such as clothes, containers used for transporting items in the supply chain or high value items that require swift location. These general applications for RFIDs can be divided into three categories: manufacturing and distribution, individual item tagging and asset tracking; this study focuses specifically on these categories.

High band devices

The high band (868–870 MHz) is primarily used by wireless alarm systems, including **fire, intruder and social alarms** which are each subject to different operational and technical requirements. The band is subdivided further into a number of sub-bands, based primarily on technical characteristics such as power and duty cycle. Parts of the band are specifically identified for alarm systems, although alarms may also operate in the part of the band identified for non-specific devices. One of the alarm sub-bands is identified specifically for social alarms.

Underlay systems may utilise the whole 863–870 MHz band and typically deploy spread spectrum or other wideband RF technologies. Applications are non-specific and may include any of the applications associated specifically with the low, mid and high bands.

Apart from the three types of alarm system already identified (i.e. **fire, intruder and social alarms**), a number of other applications take advantage of the non-specific

aspect of the regulations. These applications include **home/office automation, access control, remote controllers, medical, telecare, smart meters, telemetry and automotive.**

The forecasts

We have provided forecasts for most of the SRD applications operating in the 863–870 MHz frequency band. We have not been able to do so for some of the market sectors due to lack of data. This includes the more general sector of telemetry and it has not been possible to address non-specific SRDs as by definition these could be anything.

It is interesting to note from information provided by respondents that, particularly with regard to applications using the high part of the band (and the underlay), the industry still appears to exist in an interim period in moving from 433 MHz to 868 MHz as a preferred frequency. While there are undoubtedly cases where 868 MHz has been chosen from the outset, there are many cases where predominant supply has been, and still is, based on 433 MHz but with 868 MHz being offered as a new option.

Furthermore, also mainly with respect to applications using the high part of the band, a high uncertainty is attributable to the forecasts because alternatives are available and standardisation has not run its course. For example, in the case of smart meters depending on the outcome of standardisation activities all meters might end up using the 868 MHz band or none at all. If there is no standardisation with respect to frequency band then supply may be fragmented with suppliers opting for differing frequency bands.

Uncertainty is compounded by the possibility of convergence between different applications. Currently, application development is fragmented even within very large companies. However, it is not difficult to see that a number of applications could be supported by a single system (requiring one receiver), for example, intruder alarm, home automation, access control and smart metering. For this to become widespread would probably require a wider standardisation effort than is currently going on. We therefore do not think this affects the forecasts for the timescale considered by this study.

Summary of forecasts

	2010	2011	2012	2013	2014	2015	Notes
WIRELESS MICROPHONES *(forecast in thousands of microphones)*							
Conservative	138	144	152	159	167	175	
Aggressive	138	159	182	207	234	263	
ASSISTIVE LISTENING DEVICES *(forecast in thousands of ALDs)*							
Conservative	176	186	197	209	222	235	
Aggressive	176	197	220	246	274	305	
RETURNABLE CONTAINERS *(forecast in millions of containers)*							
Conservative	29	34	39	46	53	62	1
Aggressive	29	36	44	53	65	79	
RFID TAGS *(forecast in millions of tags)*							
Conservative	336	390	452	524	606	699	2
Aggressive	336	410	499	606	732	875	
FIRE ALARM RECEIVE DEVICES *(forecast in millions of devices)*							
Conservative	10.2	12.7	15.9	19.8	24.7	30.7	3
Aggressive	10.2	13.4	17.6	23	30	39.1	
INTRUDER ALARM RECEIVERS *(forecast in millions of receivers)*							
Conservative	6.1	9	12.8	17.9	24.6	33.3	4
Aggressive	6.1	9.5	14.4	21.2	30.8	43.9	
REMOTE CONTROLLERS *(forecast in thousands of controllers)*							
Forecast	1.9	2.2	2.5	2.8	3.2	3.5	
SOCIAL ALARM SYSTEMS *(forecast in millions of alarm systems)*							
Conservative	1.8	2.1	2.5	2.9	3.4	4.0	
Aggressive	1.8	2.4	3.1	4	4.9	5.0	
SMART METERS *(forecast in millions of meters)*							
Conservative	0.8	1.3	2	3.2	5.1	7.9	
Aggressive	0.8	1.5	2.7	4.8	8.7	15.4	

Note 1: It is estimated that the ratio of readers to tagged containers is in the region of 1:1400.

Note 2: It is estimated that the ratio of readers to tags is approximately 1:16800.

Note 3: Based on an assumed 50 receiver devices per system.

Note 4: Based on the number of receivers per system increasing from an average of 5 currently to 10 over the period.

2 INTRODUCTION

This report details the results of a market research study undertaken by Aegis Systems and Ovum Consulting for Ofcom, the topic of the market research being the equipment, applications, manufacturers and users of the 863–870 MHz band.

2.1 Background

As a result of the switchover from analogue to digital television, an amount of radio spectrum will be released for uses other than television. This release of spectrum is widely known as the “Digital Dividend”.

There is a likelihood that the frequency band 790–862 MHz will be used for mobile broadband services in line with plans being formulated in Europe. In order to manage the radio spectrum effectively Ofcom needs to understand what the implications of such use will be for Short Range Devices (SRDs) operating in the frequency band just above the digital dividend spectrum (i.e. 863–870 MHz) in terms of the potential for interference.

Ofcom therefore commissioned two pieces of work relating to the 863–870 MHz frequency band; one looking at the market for SRDs (as reported on here) and the other investigating SRD receiver characteristics followed by measurements of their performance (reported on separately).

A further piece of work has been undertaken by other parties for Ofcom regarding the implications for the frequency band sandwiched between the top of the digital dividend spectrum and the bottom of the SRD frequency band, namely the 1 MHz segment 862–863 MHz.

2.2 Scope of report

In order to better understand the current and future use of the 863–870 MHz SRD band Ofcom requested that the market research should address:

- the different services/applications/products that utilise this band
- the manufacturers of devices used and the end users
- the number of these different devices active in the UK
- the likely demand from service providers/ manufacturers for this spectrum in the future (including applications not yet using this spectrum but who might choose to in the future).

In meeting this brief it is important to note the focus on the UK market and to understand that, because the interference implications for SRDs are an important consideration, the focus is on the number of receivers. For example, an alarm system may have many sensors connected wirelessly to a hub or control panel. In this instance there is only one receiver supporting many transmitting devices (although there is a trend towards bidirectional communication to improve the performance of such systems in which case the sensors become receivers as well).

It is the number of receivers that is of direct interest with the number of transmitting devices only being of indirect interest.

In terms of structuring the forecasts we may initially be interested in other indirect aspects (e.g. the number of RFID tags) which are quantified. These quantities can then be related to receiver quantities.

An important caveat relating to this study concerns two factors that do not apply to other types of radio spectrum usage:

a) use of the band is licence-exempt and therefore there is no record of the numbers of users or number of devices operating in the band

b) some parts of the band (including underlay use) are designated for non-specific SRDs. As the name of this designation implies, applications using these parts of the band could be many and varied.

Because of these factors there is an inherent difficulty in guaranteeing to provide a comprehensive view of use of the band. However, the authors believe that within the resources and timescale available for the work a representative view has been achieved as outlined in the remainder of this report.

Approach

In order to meet the main objective of the study, namely to estimate the market size for Short Range Devices (SRDs) operating in the 863–870 MHz frequency band five years ahead, we have undertaken three main tasks:

- secondary research—an analysis of applications, systems and products based on publicly available information
- primary research—a programme of interviews with representatives from the industry
- analysis and forecasting—identification of application drivers/substitutes and the forecast of future demand.

The results of these activities are detailed in this report.

Categorisation

As a starting point we analysed the products and services offered by current and past members of the Low Power Radio Association (LPRA). We were also able to identify a number of suppliers who are not members of the LPRA.

In order to provide market forecasts for different applications it was firstly necessary to group them by type. We have done this with respect to the three distinct parts of the frequency band as follows:

Table 1: Applications by band

Low-band (863–865 MHz)	**Mid-band (865–868 MHz)**	**High-band (868–870 MHz) [1]**
Wireless microphones	Manufacturing and distribution	Fire alarm systems
Wireless audio	Individual item tagging	Intruder alarm systems
Assistive listening devices	Asset tracking	Home/Office automation
		Access control
		Remote controllers
		Medical
		Social alarms/Telecare
		Smart meters
		Telemetry
		Automotive

Note 1—This includes the non-specific underlay across the whole band 863–870 MHz.

Amongst the LPRA members and other companies having an interest in this band that were investigated, other less application-specific categories were also identified (e.g. manufacturers and distributors of modules / chips / components / antennas, and design houses / test houses / consultancies). These categories were not analysed in any great detail except in the case of RF module suppliers where it will be seen that an effort was made to obtain information in support of the examination of telemetry applications.

It can be noted that while we have used the separate categories identified in the table above there is the very real possibility of convergence between different applications. Currently, application development is fragmented even within very large companies. However, it is not difficult to see that a number of applications could be supported by a single system (requiring one receiver), for example, intruder alarm, home automation, access control and smart metering. It is not expected that this convergence will be significant in the timescale of the forecasts so we have retained the categories identified above.

Interview programme

Representatives across the industry and covering all the categories identified above were contacted and questioned on all aspects of the market for their devices and systems. This was undertaken through a mix of telephone interviews, questionnaires and face-to-face meetings. The remainder of this report is largely based on comments from these representatives and because of the commercially

sensitive nature of some of the information it has not been attributed to individual companies. Where a company is mentioned it is because the information has come from a publicly available source.

2.3 Acknowledgments

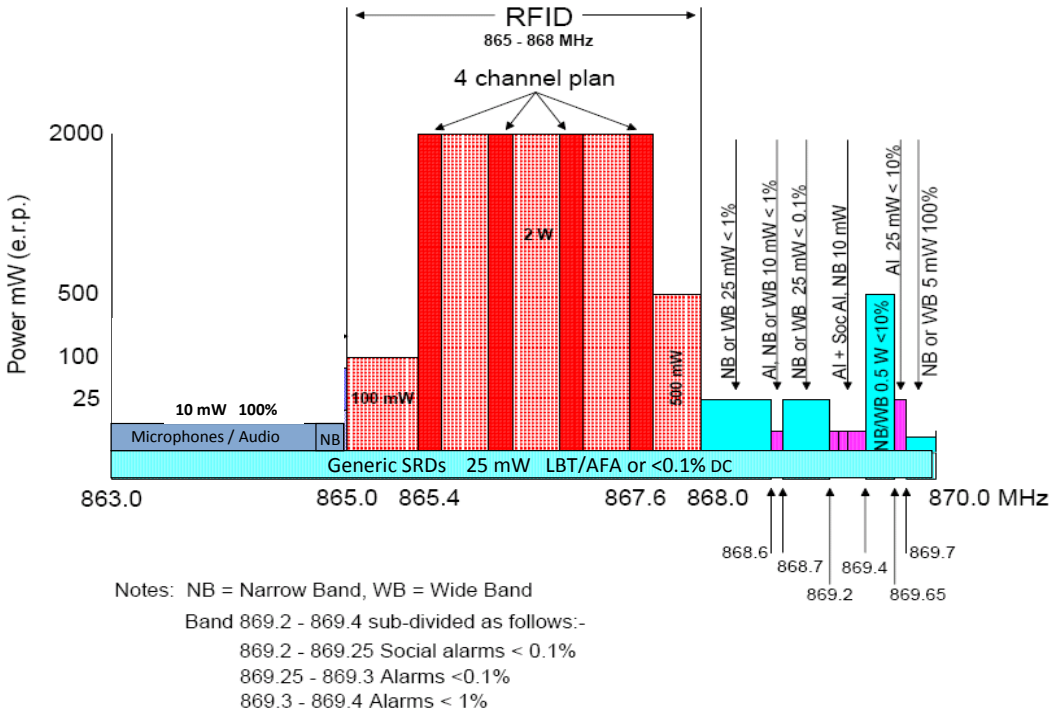
During the course of the study that is the subject of this report we contacted a wide range of companies to solicit information in support of our work. We acknowledge with gratitude the help of representatives from those companies we received in this work. We would usually name the companies and individuals involved as a sign of our acknowledgement. However, we are unable to do so in this case as the nature of some of the information provided was commercially confidential and identifying individuals or companies would compromise the source. In spite of this the authors of this report would like to reiterate their thanks to the individuals involved—they know who they are.

3 THE 863 –870 MHZ FREQUENCY BAND

The 863–870 MHz band has been identified by CEPT as a European harmonised band for licence-exempt operation of a wide range of specific and non-specific short range devices (SRDs). Various sub-bands have been defined for specific applications and with differing technical parameters such as radiated power limits or duty cycle. The various sub-bands and the corresponding technical parameters and standards are defined in the annexes of ERC Recommendation 70-03 [1], which is updated on a regular basis by the CEPT SRD Maintenance Group (SRD/MG).

The sub-bands and technical parameters contained in Recommendation 70-03 are transposed into national regulations by CEPT Member States for licence exemption purposes. In the UK various Statutory Instruments achieve this transposition and the technical conditions of operation are embodied in Ofcom's Interface Requirement IR2030—Licence exempt Short Range Devices [2]. These conditions are summarised in Figure 1 below.

Figure 1: Overall band plan for 863–870 MHz



(Note: From many sources including [3] but modified to indicate the availability of the non-specific SRD underlay across the whole frequency band.)

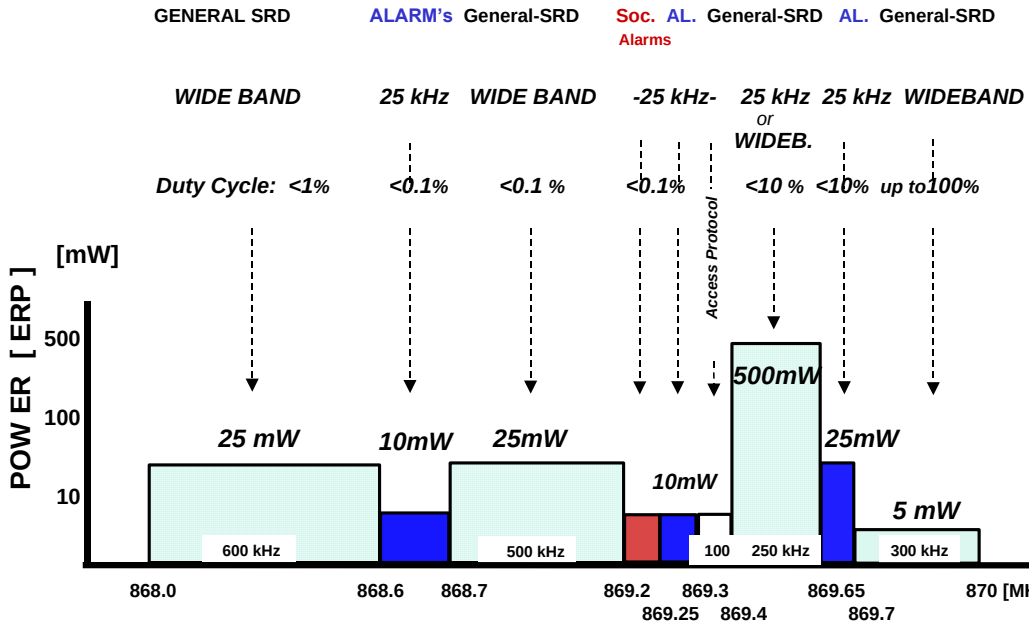
More detailed technical and operational parameters are defined in various ETSI and CENELEC standards, depending on the type of device and application concerned.

The band is segmented into three main sub-bands, each of which reflects the predominant applications that are associated with each sub-band. Note however that the entire band can be used by non-specific short range devices subject to compliance with the technical parameters defined in Annex 1 of Recommendation 70-03. The three main sub-bands are:

- Low band (863–865 MHz): wireless audio devices, including speakers, headphones, microphones and assisted listening devices.
- Mid band (865–868 MHz): Radio Frequency Identification (RFID) devices.
- High band (868–870 MHz): Wireless alarms, including intruder, fire and social alarms and other non-specific applications.

Each of these sub-bands is further divided on the basis of transmit power and/or duty cycle, to cater for particular requirements and to minimise the risk of harmful interference arising between different types of SRD. Non-specific SRDs are permitted anywhere in the 863–870 MHz band subject to a maximum effective radiated power (ERP) of 25 mW and either a maximum duty cycle of 0.1% or deployment of a "listen before talk" transmission protocol. Different limits apply to non-specific SRDs that operate within certain sub-bands defined in Annex 1 of Recommendation 70-03. Similar interference mitigation techniques are specified for wireless alarm systems operating in the high band. These conditions are summarised in Figure 2 below.

Figure 2: Regulatory envelope for the band 868–870 MHz



(Note: From many sources including [4])

The following chapters address each of the three sub-bands identified above. For each application permitted in the relevant sub-band, the following information is presented:

- description of the application
- users and motivation for use within this frequency band
- alternative frequency bands and methods (e.g. wired)
- research methodology and key findings (e.g. drivers)
- methodology for the forecast
- 5-year forecast (for all applications where data is available).

As the underlay non-specific SRDs are subject to similar technical parameters to wireless alarms and other systems operating in the high band, these categories are addressed together in chapter 6.

Further detail on the assumptions behind the forecasts is contained in Annex C.

4 LOW-BAND

The 863–865 MHz portion of the 863–870 MHz band is used predominantly by wireless microphones and wireless audio applications. While accounting for a significantly smaller portion of the users in this band, assistive listening devices are another interesting application. This section details each of these applications and provides forecasts for future use of both wireless microphones and assistive listening devices in the 863–865 MHz band.

4.1 Wireless microphones

Wireless microphones have an extremely diverse user base and serve both the consumer and professional markets. Typical users on the consumer side include churches, schools, boardrooms and pubs while examples of more professional users are professional musicians and bands, west-end theatres and sports presenters.

While many wireless microphones purchased for consumer use do operate in the 863 – 865 MHz band, almost all the wireless microphones used by professionals elect to operate either exclusively in a lower frequency band (such as channel 69, or even down to channel 21) or, if the professional user requires a large number of channels, predominantly in lower channels with only minimal use in the 863–865 MHz band. Professional use of these lower frequency channels is subject to licensing and co-ordination by the programme making and special events industry body JFMG. The primary reason that professional users avoid the licence-exempt 863–865 MHz band relates to interference; professional users regard the band as overcrowded and they cannot afford the possibility of experiencing interference between their microphones and other devices. Consumer microphones designed to operate in the 863 – 865 MHz band cannot be re-tuned to lower frequencies.

The last few years have seen demand for wireless microphones steadily increasing, with users shunning the more restrictive wired counterparts; the need to move around while talking or singing clearly advocates the need for a wireless method through which voice can be amplified.[1] In some instances, the wireless microphone is the only product required by the consumer; in other instances, the wireless microphone might be an integrated part of a larger audio system.

In order to forecast the number of wireless microphones in the UK, we estimate the number of these microphones currently in use in the 863–865 MHz band. We achieve this as follows (further detail can be found in Annex C.1.1):

[1] We note, however, that one vendor we interviewed highlighted the fact that their sales of wireless microphones have decreased by approximately 30% over the last year, predominantly due to increased uncertainty regarding the usability of different frequency bands.

1. We estimate the number of wireless microphones sold in the UK over the last year. This estimate is produced based on inputs from a number of interviews.
2. We use the number of microphones sold in a year to estimate the number of wireless microphones currently in use. Once again, this estimate is obtained through interview responses, all of which independently corroborate the estimate.
3. We estimate the number of wireless microphones operating in the 863–865 MHz band by considering that most consumer microphones operate either in this band or in the VHF band (used mostly for low cost equipment) and that most professional users avoid this band.

Having determined the current use of wireless microphones, we present a simple forecast for the future use of wireless microphones operating in the 863-865 MHz band by applying a market growth rate of 5% for future demand as well as conservative and aggressive estimates for future penetration in the 863-865 MHz band.[2]

Table 2 and Figure 3 provide the forecast number of wireless microphones over a 5-year period.

Table 2: Number of wireless microphones

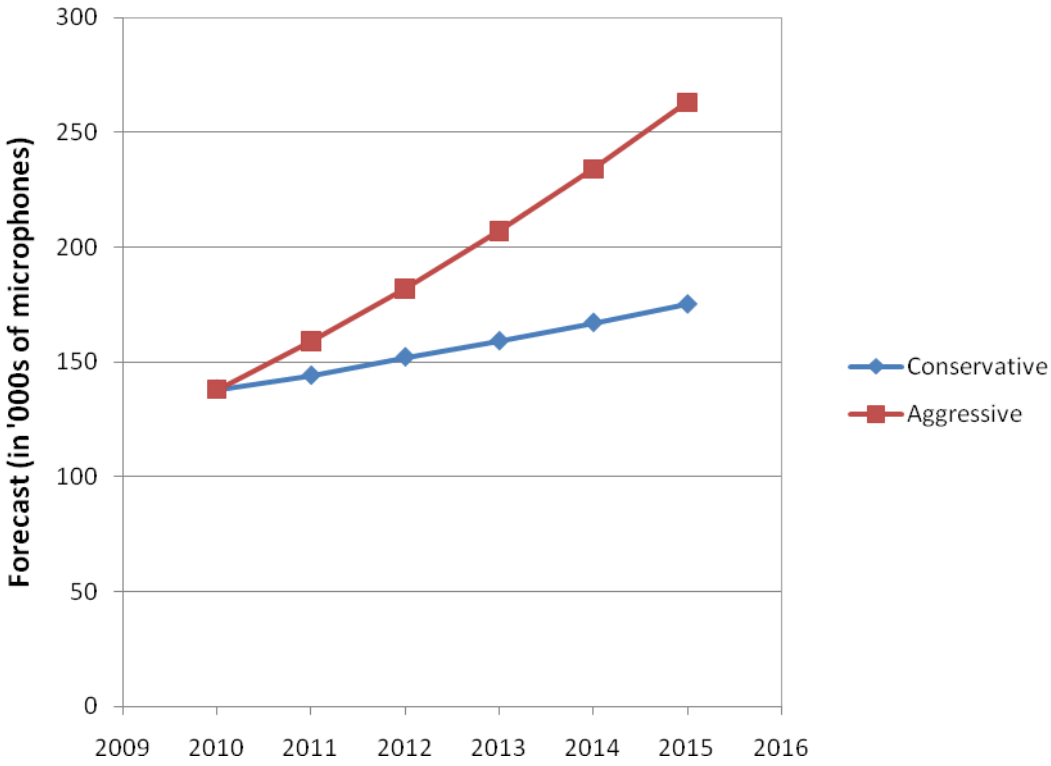
	Forecast (in '000s of microphones)					
	2010	**2011**	**2012**	**2013**	**2014**	**2015**
Conservative	138	144	152	159	167	175
Aggressive	138	159	182	207	234	263

As there is a one-to-one relationship between the number of wireless microphones used and the number of receivers required, the above forecast applies to receivers as well as to the actual wireless microphones[3].

[2] The growth rate of 5% is obtained by combining existing research [5] with responses gained from interviews with a number of key manufacturers in the industry.

[3] Although several microphones may connect to a single receiver unit, the latter will include a separate receiver module for each microphone as each requires its own individual radio channel.

Figure 3: Number of wireless microphones



4.2 Wireless audio systems

Wireless audio systems rely on wireless technology and include all applications that enable individuals or groups to listen to and/or communicate with each other without the need for setting up a wired system. Examples of these applications include wireless conferencing systems, wireless home entertainment centres, audio guides and in-ear monitoring systems.

The users of these applications are typically corporate organisations (for example, conferencing within a meeting so that individuals both present and connecting in via telephone can communicate with each other), museums and tourist attractions where individuals can be guided through what they are viewing, performing artists (who require in-ear monitoring systems to play background music or instructions directly into their ears) and individuals and organisations who want the flexibility of entertainment systems without wires or cables everywhere. Other users are likely to be church halls, schools and courtrooms, where audio systems need to be in place and the venues are sufficiently large that setting up wired systems would be impractical.

Appearing both as a stand-alone product and as a component to these systems, wireless headphones are the most common application. Wireless headphones feature significantly more in the consumer than the professional market, with a typical use for these wireless headphones being television watching. All wireless headphones are able to tune to frequencies in the 863–865 MHz band, with most

headphones operating either in this frequency band or in the 2.4 GHz band. While the 863–865 MHz band has the advantage that the consumer need not purchase a licence, a concern mentioned by one interview respondent indicated that a number of users find that headphones operating in this frequency are vulnerable to interference.

An interview with a vendor in the wireless audio industry revealed that the number of wireless headphones sold is significantly higher than the number of wireless microphones sold in a given year. However, interview responses, and indeed additional research, have not yielded the quantitative data required for the construction of a forecast.

4.3 Assistive listening devices

Assistive listening devices (ALDs) enable individuals who are hard of hearing or partially deaf to hear an audio transmission (speech, music, etc). Some of the devices work alongside traditional hearing aids while many others are stand-alone products. ALDs differ from traditional hearing aids as ALDs are intended to amplify specific sound sources while hearing aids aim at amplifying all ambient sounds. In this section we focus specifically on ALDs rather than traditional hearing aids as research showed the latter do not generally use the 863–865 MHz band.

ALDs work by taking the signal the individual is interested in hearing and amplifying it relative to surrounding sounds—this is achieved by placing a microphone near the sound source. While wired versions of these devices exist, wireless alternatives are desirable due to the improved flexibility and mobility they afford.

ALDs are used by both groups and individuals. Devices aimed at group use broadcast the sound to more than one person; examples include induction loop, infrared and frequency modulation (FM) systems. Devices designed for personal use are generally configured to work with a single speaker; examples include wireless personal FM systems and wireless headphones.

In general, these devices operate in the following frequency bands:

- 173.965–174.015 MHz
- 169.4–169.475 MHz
- 169.4875–169.5875 MHz
- 169.4–174 MHz – Limited implementation only of this European band in the UK. 173.325 to 175.075 MHz at 2 mW power limitation.
- 863–865 MHz

Devices cannot generally switch between the UHF and VHF bands.

The frequency band employed depends on the specific application. Typically, the ALDs that operate at UHF frequencies are those that are body worn medical devices (placed in and around an individual's ear, or around the neck). Discussion with one market participant indicated that there has been an attempt to put these

devices in the medical implant band (401–406 MHz) but there has been little support for this in the relevant standardisation bodies; there is now increased interest in the 863–965 MHz band. Alternative frequencies, from very low bands up to the 169–217 MHz band, are also occasionally employed.

One of the key uses for ALDs is to provide enhanced audio reception when watching television. These assistive systems generally operate using infrared or radio frequency (RF), some of which use the 863–865 MHz band. Infrared systems are generally more expensive than RF systems, and they require the receivers to be in direct line of sight of the device but they do have the advantage, from an interference point of view, that signals do not go through walls. RF systems, on the other hand, are cheaper initially but the signals are able to go through walls, raising interference as a concern.

In order to provide a forecast for the number of ALDs in the 863–865 MHz band, we begin by determining the number of ALDs currently operating in this band. We calculate this figure as follows (further detail can be found in Annex C.1.2):

1. We identify the number of individuals with hearing impairments in the UK, the number of individuals who would benefit from hearing assistance and the number of individuals prescribed with a hearing aid. We obtain these estimates using established research in the UK [6] [7].
2. We then conduct market research to estimate the current penetration of ALDs and the percentage of these devices currently operating in the 863–865 MHz band.

Having identified this starting point, we generate a forecast for the future use of ALDs in this frequency band. We achieve this by estimating the level of penetration of ALDs in the 863–865 MHz band when the market is saturated[4], using an estimate for growth in the number of ALDs and an estimate for the proportion of ALDs that will operate in this frequency band.

The growth rates we employ are estimated using a combination of interview responses and research. As there is a considerable degree of uncertainty predicting these growth rates, we consider growth on two levels, one that represents aggressive estimates of growth and another which is more conservative.

We conclude our forecast by plotting Gompertz curves (see Annex C.4) for the estimates of aggressive and conservative growth, using the estimates of current and saturated market sizes as inputs.

Table 3 and Figure 4 provide the forecast number of ALDs operating in the 863–865 MHz band.

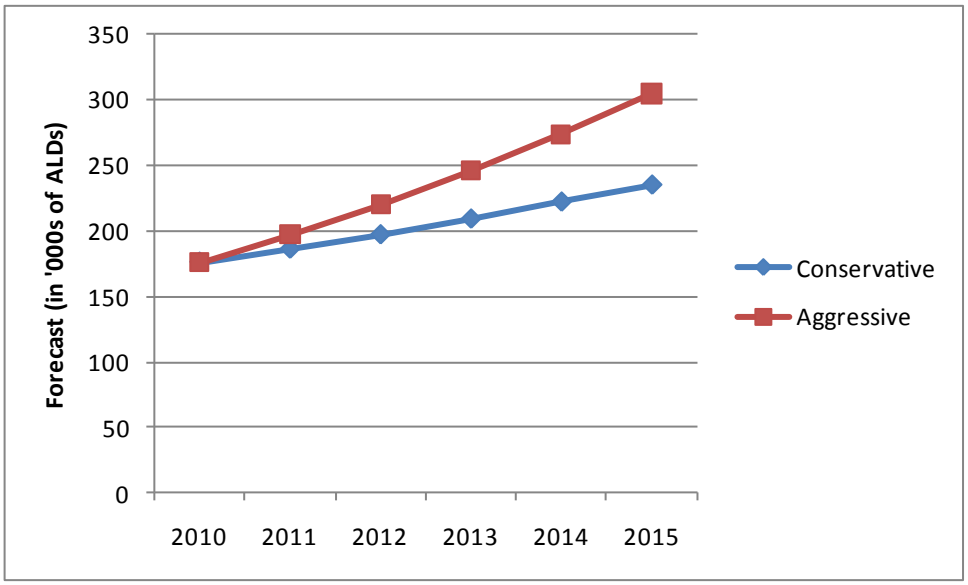
[4] We refer to market saturation as the situation in the future when the number of devices in use in the market equals the maximum potential demand for those devices. That is, after saturation, growth in usage of the device is expected to be matginal.

Table 3: Number of ALDs

	Forecast (in '000s of ALDs)					
	2010	**2011**	**2012**	**2013**	**2014**	**2015**
Conservative	176	186	197	209	222	235
Aggressive	176	197	220	246	274	305

As the ALDs that operate in this band typically require one receiver for every device, the forecast above applies to receivers as well as to the ALDs themselves.

Figure 4: Number of ALDs



5 MID-BAND

This part of the 863–870 MHz band is used predominantly by Radio Frequency Identification Devices (RFIDs) which consist of a combination of readers and either active or passive tags. Typically, RFID technology can be employed as part of innovative applications or as a replacement technology, either for other older wireless technologies or for barcodes. RFIDs operate in many different frequency bands; for the purposes of this report, however, we focus exclusively on UHF RFIDs that operate in the 865–868 MHz band.

One of the prominent areas in which RFIDs are used is transport and logistics. Here, RFIDs are employed to track and locate shipping containers, track air freight, track vehicles within a fleet or within a large warehouse and assist with yard management. The ability to track items in this manner ensures that progress in transport can be monitored, theft or misplacement of items can be identified and rectified and any logistical concerns can be dealt with in a timely manner. Similar benefits can be seen in the automotive industry where RFID technology is used both for tracking finished items in the supply chain and for tracking individual parts in the manufacturing process.

In general, RFIDs are used to locate and track items, whether these are individual items such as clothes, containers used for transporting items in the supply chain or high value items that require swift location. These general applications for RFIDs can be divided into three categories: manufacturing and distribution, individual item tagging and asset tracking. In this section, we focus specifically on these three categories and detail the applications of particular interest.

5.1 Manufacturing and distribution

Discussions with UK manufacturers of RFID tags and readers have identified manufacturing and distribution as a mature area for RFID deployment. In instances in which this technology has been adopted, organisations have benefitted from improved efficiency in the supply chain and a reduction in human error that is often associated with distribution. Furthermore, the ability to track items throughout the distribution process ensures detailed information, for example the current status of a delivery, is instantly available.

Information provided by one vendor indicated that the supply chain is the main platform for RFIDs, with this platform accounting for approximately 30% of overall volumes. In this section we employ the supply chain as a proxy for RFID use in manufacturing and distribution, specifically investigating the method through which manufacturers supply retail outlets with a final product.

The most common way for manufacturers to distribute products to retailers is via returnable containers. These containers, or pallets, leave the manufacturer, transport the individual product items to the retailer, and then return to the manufacturer to be reloaded with items for another delivery; in other words, they

operate in a closed loop. The use of RFID has been introduced into this process in order to track the returnable containers, thereby ensuring the containers can always be located and the distribution of the items for delivery can be as efficient as possible.

One retailer to implement RFID effectively in this way is Marks and Spencer (M&S). M&S first tagged returnable containers in 2002, with an initial pilot scheme that employed these containers for 42 stores. In 2005 the Marks and Spencer Food Supply Chain Project comprised 4.5 million returnable containers. Now, M&S successfully use a significant number of tagged containers in their UK distribution.[5]

Typically these containers are tracked using passive RFID technology. The use of active RFID for container tracking is too expensive, the cost being driven by features such as real-time tracking which is not required for the supply chain. Passive tags are preferred as they are relatively inexpensive and highly reliable; these tags operate well in both HF and UHF bands.

Most of the containers use generation 2 UHF.[6] The readers for these containers are based at the suppliers' premises, the retailers' warehouses and at the final retail locations. While current penetration of RFID technology in the supply chain is low, it is expected that new solutions are likely to use UHF due to benefits of physical interaction between the tags and readers within a warehouse. However, one vendor that we interviewed indicated that there are concerns that the 865–868 MHz band might be too restrictive; the power of this band is appropriate but a large warehouse may need to use more than four channels.

In order to quantify the use of RFID tags in closed loop applications[7] in the Distribution and Manufacturing sectors, we use the grocery retail industry as a proxy for the distribution sector and the automotive industry as a proxy for the manufacturing sector.

The first stage in the forecasting process is to identify the number of returnable containers currently operating in the 865–868 MHz band (see Annex C2.1 for further detail on the forecast).

1. We estimate the current number of returnable containers in each of the grocery retail and automotive industries. These estimates are produced based on inputs from interviews and research [9] [10] and are calculated by extrapolating figures available for Tesco and Honda, respectively.

[5] Updated information regarding the number of M&S returnable containers in operation was provided during an interview with an industry vendor

[6] Generation 2 contains a number of features that solidify the adoption of RFID in the UHF band [8].

[7] Use of RFID tags in closed loop applications in the Distribution and Manufacturing sectors refers to the tagging of returnable pallets, metal cages and containers. For simplicity we will refer to these different elements as 'returnable containers'.

2. We estimate the percentage of these returnable containers that currently have RFID tags and the percentage of these tags that operate in the 865–868 MHz band. These estimates are produced based on inputs from the interviews with RFID vendors, available data on publications [11], and expert opinion from Datamonitor/Ovum analysts.

To construct this forecast, we use grocery as a proxy for the distribution sector and automotive as a proxy for the manufacturing sector. Using an assumption for the contribution of grocery retail and automotive in relation to the use of RFID overall in the distribution and manufacturing sectors in the UK, we determine the estimate for the current number of returnable containers used in manufacturing and distribution that have RFID tags operating in the 865–868 MHz band. Our assumptions are informed by conversations with RFID device manufacturers and calibration with existing forecasts at European level.

The next step of the forecast focuses on estimates of the growth rate and the level of penetration when the market is saturated[8].

The level of penetration when the market is saturated is calculated with reference to an estimation of growth in the number of returnable containers and the expected contribution of grocery retail and automotive to the use of RFID in the 865–868 MHz band in the distribution and manufacturing sectors at the time of saturation.

The recent and expected growth rates are estimated using inputs from interviews and are cross-checked with information of growth rates from existing forecasts for Europe. As there is a considerable level of uncertainty predicting future growth behaviour, we consider two levels of growth rate, one that represents aggressive estimates of growth and another which is more conservative.

We conclude our forecast by plotting Gompertz curves (see Annex C.4) for the estimates of aggressive and conservative growth, using the estimates of current and saturated market sizes as inputs.

Table 4 and Figure 5 provide the forecast number of returnable containers using RFID in the 865–868 MHz band.

Table 4: Number of returnable containers

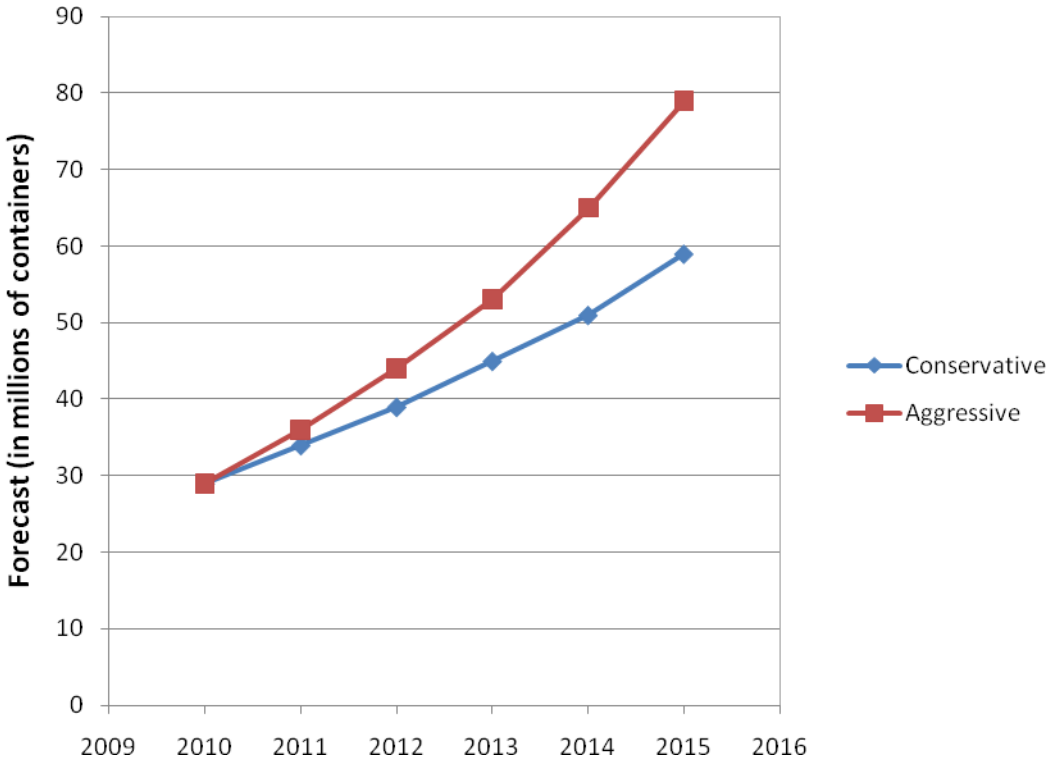
	Forecast (in millions of containers)					
	2010	**2011**	**2012**	**2013**	**2014**	**2015**
Conservative	29	34	39	46	53	62
Aggressive	29	36	44	53	65	79

In terms of the number of RFID readers, interview responses indicated that approximately 40 000 readers are demanded, for supply chain purposes and individual item tagging, in the UK in a year. Furthermore, we received indication that there are approximately 5 to 6 readers per retail store and, combining this with

[8] See footnote 4 for definition.

information on the number of stores likely to use RFID in individual item tagging, this suggests there are approximately 20 000 readers used in manufacturing and distribution and approximately 20 000 readers employed for individual item tagging. This indicates that the ratio of readers to tagged containers is in the region of 1:1400. We expect the number of readers to grow at a similar rate to, or slightly faster than, the number of tagged containers; however, we do not expect the high densities seen by barcode readers, primarily due to the characteristics (such as signal range) of RFID technology.

Figure 5: Number of returnable containers



5.2 Individual item tagging

Another key application of RFIDs in the 865–868 MHz band is the tracking of individual items. These items can range from clothes in a retail outlet, such as M&S, to individual parts used in a manufacturing process, such as automobile assembly.

One vendor we interviewed identified individual item tagging as one of the biggest potential growth areas for RFIDs. Attaching RFID tags to individual items, and thus enabling tracking of the items, has been shown to improve efficiency in stock control and ensures that any item can be reliably identified and quickly located. This has some obvious benefits; for example, for a retailer who is concerned about managing stock efficiently and tracking items to reduce theft from stores.

The automotive industry provides another example where these RFID tags are used. In this industry, RFIDs are employed largely for safety concerns with tags being included on airbags, on ABS systems and embedded within tyres. Not only do these tags have the advantage of being placed in areas where it is not viable to scan a barcode, they also ensure that individual parts can be identified, located and recalled if, for example, a fault is detected at some future date.

As mentioned, one alternative technology that might be employed is barcodes. However, the fact that the distance between the scanner and the barcode needs to be very small means that this technology is not practical in many instances. Further, the fact that barcodes need to be scanned manually means that the number of items that can be processed within a given time frame is severely limited; for example, an RFID reader can scan 250 tags a second while a person scanning a barcode is only likely to scan 1 barcode a second.

These facts support the industry's opinion that implementation of RFID technology for individual items is likely to grow significantly in the future. One consideration, however, is that because the number of tags that can be read is limited by the bandwidth, the 3 MHz available in the 865–868 MHz band may be insufficient to deal with future volumes of individual item tags.

In terms of selecting a frequency for operation, the RFID handheld readers employed are manufactured to work with different frequency ranges; the change from one frequency to another frequency is done via software. However, within Europe the 865–868 MHz band is the only frequency band available with sufficiently high power for use with these readers.

In order to quantify the number of RFID tags employed in individual item tagging, we focus specifically on the garment retail industry, using this industry as a proxy for the use of individual item tagging more generally. We begin the forecast by estimating the number of tags that are currently attached to individual items and that operate in the 865–868 MHz band. We achieve this as follows (further detail can be found in Annex C.2.2):

1. We estimate the potential number of tags used in the retail garment industry. We do this by extrapolating figures for a garment retailer, relating to both the total number of tags used and the number of tags per store. These figures were obtained from an interview with a vendor in relation to an unnamed garment retailer.[9]
2. We then estimate the likely number of stores that use tags to identify individual items as well as the percentage of these tags that operate in the 865–868 MHz band. These estimates are obtained by combining research and interview responses and are compared with existing forecasts.

[9] Because of strong consumer reaction due to privacy concerns, individual item tagging in the retail space is treated with a high degree of confidentiality.

Having attained an estimate for the number of tags currently employed using the 865–868 MHz band; we generate a forecast for the future use of these tags. We achieve this as follows:

1. We estimate the level of penetration of RFID tags, as well as the penetration of RFID tags in the 865–868 band, when the market is saturated[10]. We obtain the estimates of penetration by studying current growth trends; these trends have been identified by vendors in the interviews and by examining existing forecasts.

2. We estimate the growth rates for these tags. This is achieved by using inputs from interviews and cross-checking the estimates with information of growth rates from existing forecasts for Europe. As there is a considerable level of uncertainty predicting future growth behaviour, we consider two levels of growth rate, one that represents aggressive estimates of growth and another which is more conservative.

We conclude our forecast by plotting Gompertz curves (see Annex C.4) for the estimates of aggressive and conservative growth, using the estimates of current and saturated market sizes as inputs.

Table 5 provides the forecast number of individual item tags using RFID in the 865–868 MHz band.

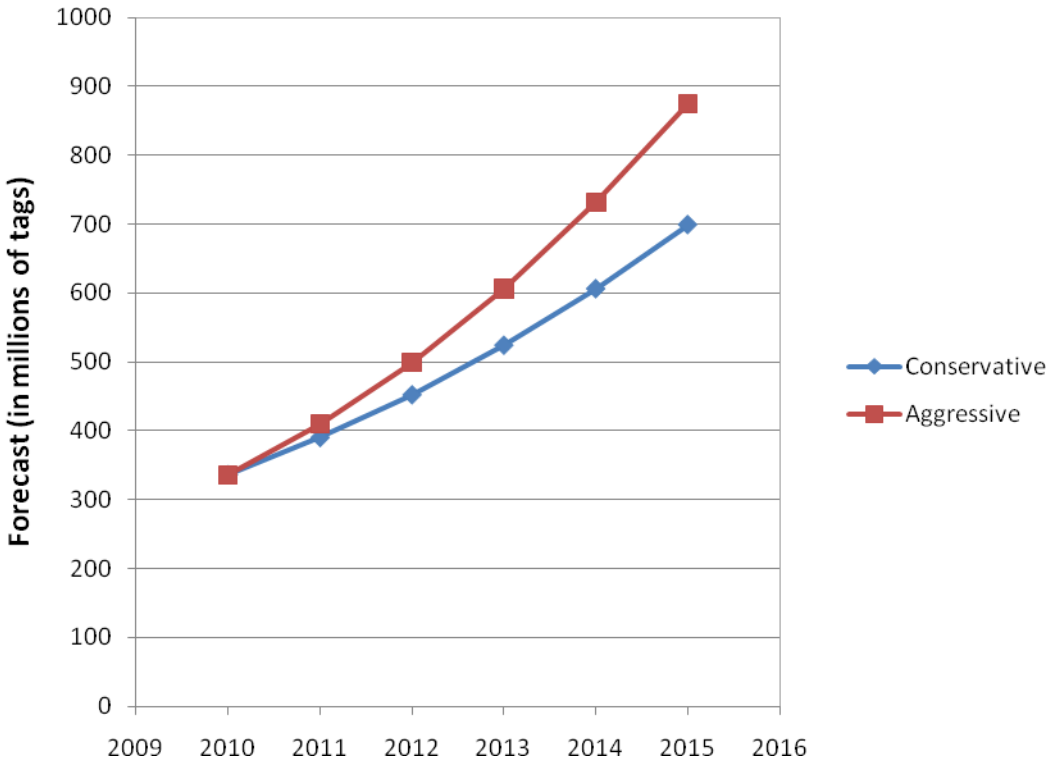
Table 5: Number of RFID tags

	Forecast (in millions of tags)					
	2010	**2011**	**2012**	**2013**	**2014**	**2015**
Conservative	336	390	452	524	606	699
Aggressive	336	410	499	606	732	875

As detailed in the preceding section, interview responses enabled us to conclude that there are around 20 000 readers employed in the UK for individual item tagging. This represents a ratio of readers to tags of approximately 1:16800. As before, we predict that the number of these readers will grow in line with, or slightly faster than, the number of tags.

[10] See footnote 4 for definition.

Figure 6: Number of RFID tags



5.3 Asset tracking

A further area in which RFID technology has been adopted is asset tracking. Here, RFID tags are placed on individual assets, typically high-value items, and ensure these items can be traced and located. This use of RFID is especially prominent in relation to IT equipment tracking; for example, Wells Fargo in the US place a UHF chip in each piece of equipment.

Some general examples of assets that are tracked using RFID technology include equipment in a hospital, legal and medical records and airline baggage. Another use for asset tracking is illustrated in the beer industry where approximately 200,000 beer barrels in the UK are tagged; this represents 10% of all barrels and one vendor we spoke to estimates this will grow by 10-15% every year.[11] A further example is provided by the Home Office who employ active tags, in approximately 70 sites, to monitor the movements and location of prisoners.

One sector that provides a more in-depth example is the health sector. In this sector, four key uses of RFID have been identified as patient wristbands (active

[11] While one might view beer barrels as returnable containers, these barrels differ from typical returnable containers as they are used specifically by a particular supplier to transport beer from the brewery to the distributers and then track the barrels back to that particular supplier. The primary use of the RFID tags is thus to enable a supplier to track his assets (the beer and the barrels). In contrast, returnable containers are used more generically for transporting different goods between various parts of the supply chain.

RFID tags to enable real time location), proximity warning devices (to monitor patients who might wander off), labels on blood bags (passive labels to track the bags) and labels on medical documents (passive labels to track the documents). These devices, therefore, ensure that people can always be located, especially important for individuals such as dementia patients and babies, and that the vital assets within a hospital can be located.

As mentioned previously, barcodes are an alternative to the RFID tags and are used more widely than RFID in the health sector. The primary reason for this is cost; RFID remains significantly more expensive than competing technologies.[12] However, for tasks in which it is desirable to reduce manual intervention or where it is necessary to increase the speed and efficiency with which assets can be located, RFID technology is favoured.

As the benefits of RFIDs are realised, and the costs are likely to decrease, the expectation is that more and more sectors will adopt this technology. Indeed, the challenge of competing technologies to certain RFID tags is very limited. For example, an interview with one vendor highlighted that there are some extra long range tags that are employed, for example in the health sector, for which there are no real alternative technologies.

RFID tags employed in asset tracking typically operate in the 865–868 MHz band, although other bands are also available. While some concerns regarding interference have been raised, particularly in relation to the health sector, an interview with practitioners within this sector indicated that no problems with interference had been experienced within the 865–868 MHz band.

Finally, one vendor indicated two potential future applications for RFID use in asset tracking. The first application is in the pharmaceutical industry where it is especially important to check the authenticity of medication and ensure the drugs that reach the end user remain tamper proof. The second application is in the supply chain where interest is growing for RFIDs with temperature sensors.

Unfortunately neither interviews held nor additional research conducted has provided any of the relevant data necessary for the construction of a forecast.

[12] The relative costs of RFID tags differ significantly depending on factors such as the volume of tags purchased, the memory required and the packaging of each tag. However, in general, barcodes cost approximately 0.5 cents (US) while passive RFID tags cost between 7 and 30 cents (US).

6 HIGH-BAND AND UNDERLAY

The high band (868–870 MHz) is primarily used by wireless alarm systems, including fire, intruder and social alarms which are each subject to different operational and technical requirements. The band is subdivided further into a number of sub-bands, based primarily on technical characteristics such as power and duty cycle. Parts of the band are specifically identified for alarm systems, although alarms may also operate in the part of the band identified for non-specific devices. One of the alarm sub-bands is identified specifically for social alarms.

It should be noted that fire and intruder alarm systems are generally installed as separate, independent systems as they have to conform to different operational standards. The only exception to this tends to be in the residential sector where wireless smoke detectors can be provided as add-ons to intruder alarm systems. Hence we have treated fire and intruder alarms as separate market sectors.

Underlay systems may utilise the whole 863–870 MHz band, with the exception of the high band sub-bands identified for alarm systems, and typically deploy spread spectrum or other wideband RF technologies. Applications are non-specific and may include any of the applications associated specifically with the low, mid and high bands.

6.1 Fire alarm systems

Wireless fire alarm systems are widely deployed in commercial and industrial premises such as hotels, factories, offices and shops. Wireless technology is most often deployed in older buildings where installation of wired systems would cause disruption, disfigure historic or listed buildings or lead to excessive installation costs. In new buildings wired systems are generally preferred as they are perceived to be more reliable; however, wireless components are sometimes used to extend existing wired installations (these are referred to as hybrid installations) and, according to industry sources, there is a long term trend towards adoption of wireless systems.

Fire alarms may include a large number of individual components, for example one UK manufactured system can accommodate up to 2,048 connected devices[13]. Although the 868 MHz frequency band is increasingly being deployed, there is still extensive use of lower frequencies, notably the 458 MHz and 173 MHz bands where higher transmit powers and correspondingly higher range is available. However, one large UK based supplier of wireless fire alarm systems claimed that pending EU legislation mandating the replacement of former national technical standards by the harmonised European standard for wireless fire alarms (EN 54 Part 25 [12]) would prevent it from installing new systems operating in these lower frequency bands, as

[13] Firecell, manufactured by EMS Group.

these are based on legacy national standards and not fully compliant with the EN54 standard. As a result this supplier will only be supplying 868 MHz equipment once this legislation is enacted in April 2011 Performance and functionality improvements arising from the adoption of this standard (such as mandatory bidirectional communication between wireless devices) is likely to increase attractiveness of wireless systems in the future.

In order to detail the current and expected number of non-residential fire alarms in use in the UK, we begin by determining the number of fire alarm devices currently in use in the 868–870 MHz band. We derive this number as follows (further detail can be found in Annex C.3.1):

1. We calculate the number of commercial and industrial properties in the UK, including properties relating to hospitals and schools. The figures for this calculation are obtained from public information provided on various government and community interest websites [14] [15] [16].
2. We estimate the average number of fire alarm devices likely to operate within each of these properties. This estimate is based on interview responses from a number of fire alarm manufacturers and information from vendors' web sites.
3. We then estimate the percentage of these properties that have installed fire alarms, the percentage of fire alarms that are wireless and the penetration of wireless alarms operating in the 868–870 MHz band. These estimates are reached based on regulation relating to fire alarm installation in the UK and responses from interviews held with various industry participants.

Having estimated the number of wireless fire alarm devices currently operating in the 868–870 MHz band, we focus on obtaining a forecast based on estimates of growth rate and the level of penetration when the market is saturated[14].

The level of penetration when the market is saturated is calculated with reference to an estimation of growth in the number of wireless fire alarms, and the number of these operating in the 868–870 MHz band. These estimates are based on interview responses and pending European legislation mandating the use of the EN 54-25 standard for wireless fire alarm systems which will effectively require new systems installed after March 2011 to operate in the 868–870 MHz band.

As there is a considerable degree of uncertainty surrounding the growth rate predictions, we consider growth on two levels, one that represents aggressive estimates of growth and another which is more conservative.

We conclude our forecast by plotting Gompertz curves (see Annex C.4) for the estimates of aggressive and conservative growth, using the estimates of current and saturated market sizes as inputs.

[14] See footnote 4 for definition.

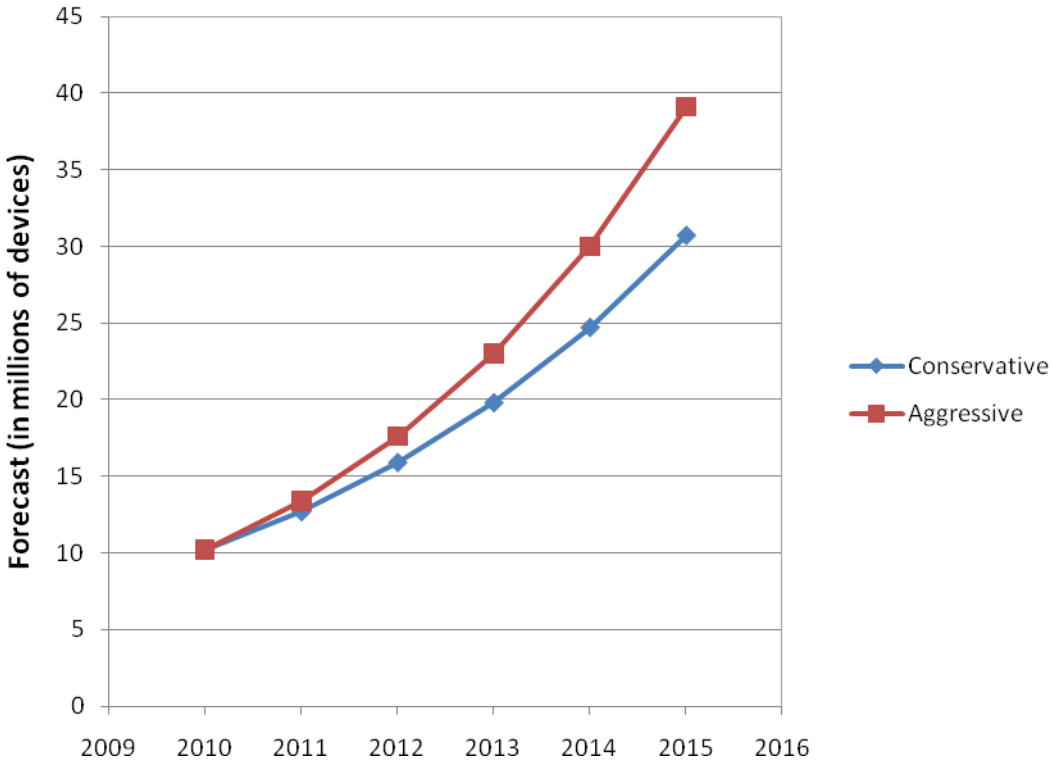
There is a wide variation in the size and complexity of fire alarm systems, depending on the nature of the premises being protected, Taking account of typical system dimensions and assuming each wireless alarm component includes a receiver (for bidirectional communication) we estimate that on average there will be approximately 40–60 receivers per system. This estimate is based on a multi-zone system comprising 6 zones each of which contains 6 to 10 devices.

Table 6 and Figure 7 provide the forecast number of wireless fire alarm receiver devices operating in the 868–870 MHz band, based on an assumed 50 receiver devices per system.

Table 6: Number of fire alarm receiver devices

	Forecast (in millions of devices)					
	2010	**2011**	**2012**	**2013**	**2014**	**2015**
Conservative	10.2	12.7	15.9	19.8	24.7	30.7
Aggressive	10.2	13.4	17.6	23	30	39.1

Figure 7: Number of fire alarm receiver devices



6.2 Intruder alarm systems

In contrast to the fire alarm market, wireless intruder alarms are most widely deployed in the residential sector; commercial and industrial users still tend to prefer wired systems as these are perceived to be more reliable and less limited in terms of range. According to one vendor, the residential market for wireless alarms is approximately ten times the size of the industrial market in volume terms.

The number or receivers per intruder alarm system depends on the type (residential or commercial) and the technology. Current low-cost residential systems use unidirectional transmission from the various sensors to the control panel so a receiver is only present in the control panel and the siren, i.e. two per system. There is however a trend towards bidirectional communication where each wireless element has a receiver (this enhances system reliability) and this would push the number of receivers in a typical residential environment up to typically 10–12 per system, though the number could be higher if additional home automation functionality were to be included. Commercial wireless systems are also likely to use bidirectional communication and depending on the size of building may have potentially hundreds of receivers, though probably 20–30 would be a more appropriate assumption for the “average” system.

Historically, most domestic alarm systems in the UK used the 433 MHz band on cost grounds but this has become increasingly prone to interference from other wireless devices such as baby monitors. One vendor reported that whereas up to 30% of systems at 433 MHz could suffer interference there had been no reported cases to date at 868 MHz. There has therefore been a marked migration to 868 MHz in recent years and virtually all new products now operate in this band. The small physical size of many of the wireless sensors and devices used in the home also tends to favour the use of the higher frequency. Although 2.4 GHz has been used by at least one supplier, this band requires higher power to achieve the same range with adverse implications for battery life.

According to one vendor, the current penetration of alarm systems (wired and wireless) in the UK residential market is 12–14 %. This is relatively low by European standards but there are signs that the UK is catching up, driven by perceptions of increased criminal activity. According to this vendor, in 5 years the penetration is expected to grow to 18-20%. The market share of wireless systems (according to the same vendor) has grown significantly from 5-10% five years ago to approximately 25% today. The main drivers of wireless systems are ease of installation and the ability to add on extra features like home automation.

Another vendor estimated that approximately 35% of the overall intruder alarm market is wireless, but the proportion may be as high as 60% or more in the DIY market (we have been unable to obtain any firm data for the latter, however).

Alongside the growth in new systems there is also a thriving market in upgrades—residential alarm systems are upgraded typically every 5–10 years and larger

companies often provide additional features (such as home automation) as an incentive for users to upgrade.

The take up of wireless alarms in the UK has historically differed from the rest of Europe in that it was driven initially by low cost far eastern products aimed at the retail / DIY market, whereas in Europe there was a much stronger interest in professional wireless systems. The UK now appears to be catching up with Europe in this area.

Some equipment vendors are developing increasingly elaborate systems including various home automation functions and providing connections to PSTN or mobile data networks. These allow alarms and other domestic functions to be controlled remotely and could in future be extended to include functionality like remote meter reading. Intel has been working on a similar concept in the US referred to as “home dashboard”, which creates a home area network (HAN) to connect smart devices to a central control unit using ZigBee wireless technology.

One recent technical innovation that may increase the attractiveness of wireless intruder alarms in non-residential sectors is the use of mesh wireless techniques, which allow bi-directional communication between each element in the system, diverse routing between wireless nodes and improved coverage and reliability compared with conventional wireless systems. For example, coverage of an existing system with a central controller serving a network of sensors in a conventional “star” configuration could be affected by the opening and closing of metal doors or changes to the building infrastructure (e.g. new partitions), whereas a mesh based system would simply re-route the wireless signal via a different set of mesh nodes.

One vendor that currently installs tens of thousands of (mainly wired) alarm systems in the UK has recently introduced a wireless mesh system and expects that in the longer term all of their products could become wireless. This supplier estimated that wireless accounted for 5-10 % of the UK intruder alarm market 10 years ago, has now grown to 30% and could reach 100% in a further 10 years.

In generating a forecast for intruder alarms, we exclude the DIY market, due to lack of data, and focus on the professional residential and commercial markets. Current vendors focus more on the residential markets although recognise that demand for wireless alarms in the commercial sector will increase over the next few years. In order to determine the future market for intruder alarms, we begin by calculating the number of these alarms that are wireless and currently operate in the 868–870 MHz band. We reach this calculation through the following process (further detail can be found in Annex C.3.2):

1. We determine the number of residential households and commercial premises currently in the UK. These figures are provided by the Office of National Statistics and various government and community websites.

2. We estimate the penetration of intruder alarms in the residential market and in the commercial market. These estimates are guided by responses from interviews with market participants.

3. We estimate the percentage of intruder alarms that operate wirelessly in both the residential and commercial markets. As above, these estimates are based on a number of interview responses.

4. As the majority of new intruder alarms operate in the 868–870 MHz band, we assume that penetration in this band is 100%.

The next step in the forecast focuses on estimates of growth rate and the level of penetration when the market is saturated[15].

1. The level of penetration is calculated using estimates from interview responses. These responses detail expected penetration of intruder alarms in the residential and commercial markets as well as penetration of wireless versions of these alarms.

2. The growth in the number of wireless intruder alarms is calculated with reference to expected saturation of the market. As in the previous forecasts, there is a considerable degree of uncertainty surrounding the estimates of growth; thus, we consider growth on two levels, one that represents aggressive estimates of growth and another which is more conservative.

We conclude our forecast by plotting Gompertz curves (see Annex C.4) for the estimates of aggressive and conservative growth, using the estimates of current and saturated market sizes as inputs.

Table 7 and Figure 8 provide the forecast number of wireless intruder alarms operating in the 868–870 MHz band.

Table 7: Number of intruder alarms

	Forecast (in millions of alarms)					
	2010	**2011**	**2012**	**2013**	**2014**	**2015**
Conservative	1.2	1.5	1.8	2.2	2.7	3.3
Aggressive	1.2	1.6	2.1	2.7	3.4	4.4

As noted previously, the average number of receivers per intruder alarm system is likely to increase over this time frame, due to increasing use of bidirectional technology. We estimate that the number of receivers per system will increase linearly from an average of 5 currently to 10 by 2015.

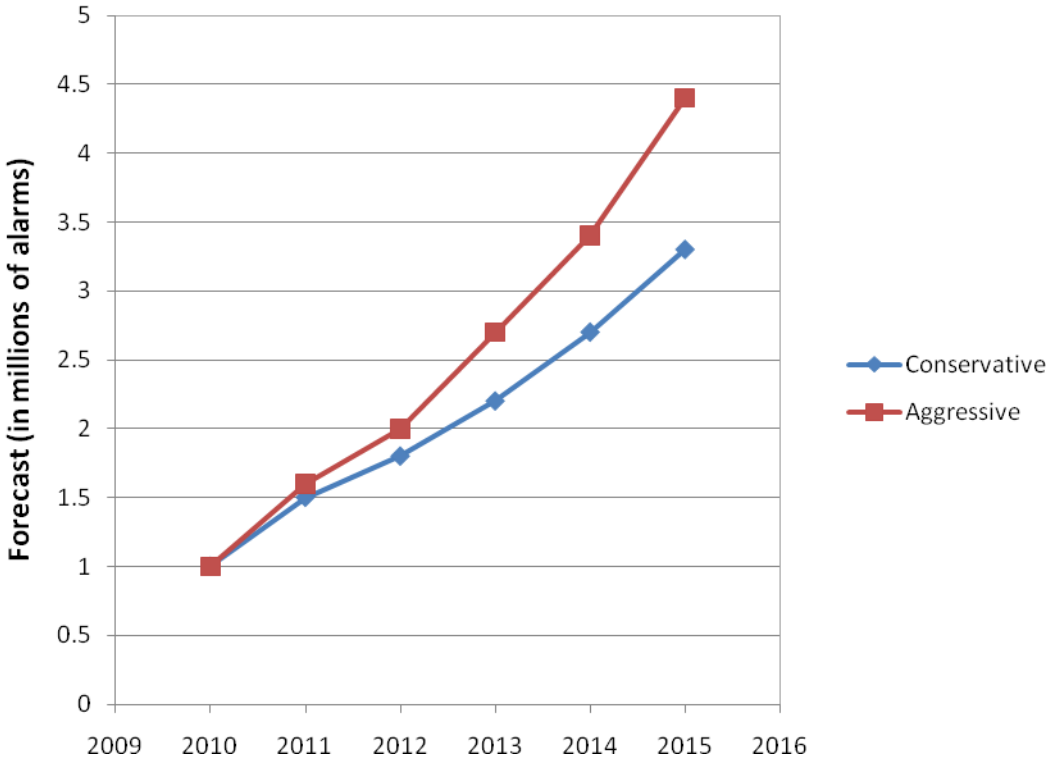
[15] See footnote 4 for definition.

On this basis the total number of receivers would be as follows:

Table 8: Number of intruder alarm receivers

	Forecast (in millions of receivers)					
	2010	**2011**	**2012**	**2013**	**2014**	**2015**
Conservative	6.1	9	12.8	17.9	24.6	33.3
Aggressive	6.1	9.5	14.4	21.2	30.8	43.9

Figure 8: Number of intruder alarms



6.3 Home/Office automation

There are a number of applications relating to home automation. One area that has been growing in recent years and was highlighted in a recent ETSI Technical Report [17] is that of indoor climate control, which involves automatic opening and closing of windows alongside monitoring of temperature and humidity and activation of heating or air conditioning systems. According to the ETSI report, such systems may involve up to 50 wireless nodes per dwelling and the most likely frequency band for deployment is in the region of 870 MHz.

In the UK, increasing saturation of the 434 MHz SRD band is driving a move towards the 869 MHz band, which in Europe is already the preferred frequency. The specific sub-band preferred for these applications is 869.85 MHz using

Wideband FM technology at 10 mW power. There has been a trend in recent years towards two-way communication, facilitated by the introduction of low cost transceiver chip-sets. This has addressed client concerns with uni-directional wireless technology, which does not provide any means of verifying that an instruction has been carried out. Bidirectional communication allows reception of transmitted data to be verified to the originator. Many utility meter manufacturers are now embedding these chipsets into their meters.

One supplier indicated that future demand would be of the order of 100,000 units per annum, but observed that there was a lot of competition from low cost ZigBee devices operating in the 2.4 GHz band. As there is now provision for 869 MHz in the ZigBee standard, this may actually lead to increased use of this band over time. Other alternatives to 869 MHz in this sector include 2.4 GHz, 802.15.4 technology, VHF chipsets on 169 MHz (which provide better range) and low cost GSM/GPRS devices that can be embedded into devices.

Unfortunately neither interviews held nor additional research conducted has provided any of the relevant data necessary for the construction of a forecast.

6.4 Access control

Wireless access control systems may be regarded as a subset of remote control systems (see following section) and typically include garage and gate openers. Both 433 MHz and 868 MHz frequencies are deployed and there is generally one receiver per system. We have been unable to find specific market information on the number of remote access control systems in the UK but would expect this to be substantially less than the take up of intruder alarm systems (since access control is perceived to be more of a luxury item). It is also likely that homes that have remote door opening systems will also have intruder alarms, the majority of which will be wireless and likely to include several receivers per system. The presence of an access control system with a single receiver is therefore not likely to impact significantly on the overall number of receivers per household and consequently we have not undertaken a detailed analysis of this sector.

6.5 Remote controllers

Wireless remote controls are used in a variety of applications, in both the residential and industrial sectors. Residential applications typically include control of heating systems, windows, air vents etc and are covered under home automation in section 6.3 above. Industrial applications include control of cranes and hoists, where the 869 MHz band is one of a number of frequencies that are used. Not all suppliers of industrial remote control gear use this band however. One supplier that caters for large industrial and construction sites indicated a preference for 433 MHz (where short range and intensive frequency re-use was required) and the non-harmonised 458 MHz band where longer range is required. According to this supplier there were too few frequencies available in the 869 MHz band to cater for large sites with multiple cranes operating in close proximity.

Conversely, another supplier said they now preferred the 869 MHz band, as 433 MHz and 458 MHz were very cluttered. This supplier uses the low power (5 mW) sub band 869.70625–869.99375 MHz and claims this provides up to 100 metres range. The 869 MHz devices are digital whereas the previous 433 MHz and 458 MHz were analogue.

Volumes are relatively low—one supplier which estimated they have 30–35% of the UK market for industrial remote controls said they had sold approximately 6,000 in the UK since 1994 and were currently selling 300–600 units per year. Although mainly used for cranes on building sites they are trying to develop new markets relating to vehicle hoists for example.

There are protocols on the link that ensure that the system goes into a failsafe mode (e.g. the crane stops its activity) if there is any interference on the radio link.

In order to generate a forecast for these controls, we begin by estimating the number of remote controls currently in use in the UK and operating in the 868–870 MHz band (see Annex C3.3 for further detail on the forecast).

We follow this by estimating the number of remote control units sold within a year. This estimate is based on sales and market share information provided during an interview with one of the key market players.

We then estimate the number of units currently in the market. This is achieved by estimating the replacement cycle for remote control units, an estimate that is guided by information provided during an interview.

Finally we estimate the percentage of units currently in use that operate in the 868–870 MHz band. This estimate is generated by corroborating the responses from two independent interviews.

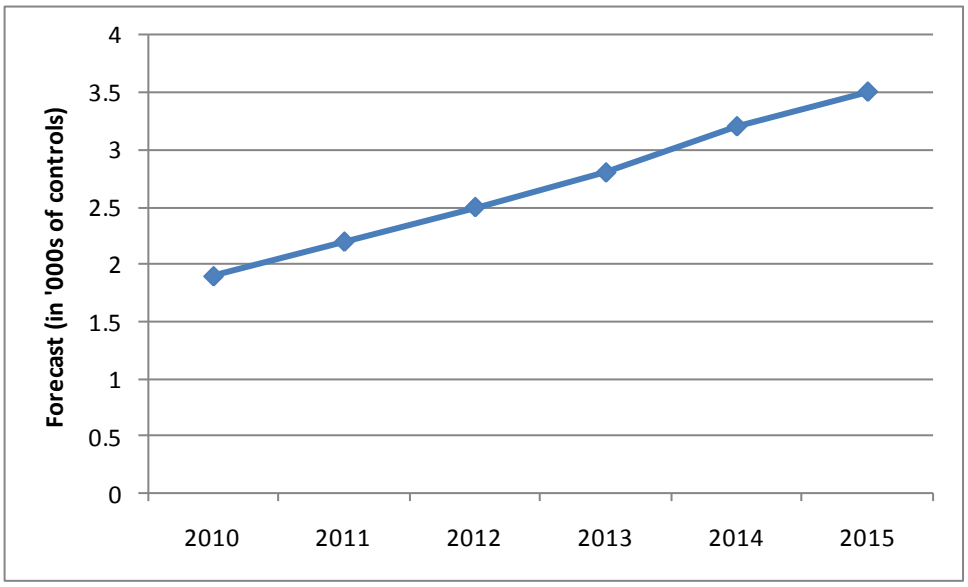
Having determined the number of remote controls currently in use and operating in the 868–870 MHz band, we focus on providing a forecast for these controls. We arrive at this forecast by estimating the growth of the overall remote control market as well as the percentage of sales that is likely to account for replacement of wired systems and new deployments.

Table 9 and Figure 9 provide the forecast number of remote controls operating in the 868–870 MHz band.

Table 9: Number of remote controls

Forecast (in '000s of controls)					
2010	**2011**	**2012**	**2013**	**2014**	**2015**
1.9	2.2	2.5	2.8	3.2	3.5

Figure 9: Number of remote controls



6.6 Medical

It has been noted that one company, Toumaz, is using this SRD frequency band for a medical application. More precisely this frequency band is being used to deploy a Body Area Network which connects a central hub containing a processor and data storage with various sensors on and around the body (e.g. to measure pulse rate, blood pressure etc). Such a capability provides for regular readings, including through the night, and replaces a nurse having to obtain the data for example. There is also a crossover for such capability in the sport sector, both professional and recreational.

Currently these devices are Category 2 with respect to the general SRD radio standard [18]. This means that the wireless communication is of medium reliability and can therefore be used where some inconvenience to the user is acceptable. This contrasts with Category 1 devices which provide a higher reliability and should be used where there is a physical risk to a person. These devices may well be upgraded to Category 1 performance to improve their reliability for measurements where there might be some degree of physical risk to a person. However, it is not thought likely that operation in a non-specific licence-exempt band would qualify these devices to support medical intervention that is in any way life threatening.

Other frequency bands were considered for this application, namely around 400 MHz and 2.4 GHz, but 863–870 MHz was selected as offering the best compromise in terms of antenna performance, power requirements and congestion.

It can be noted that previous sectoral studies for Ofcom concerning healthcare and assisted living addressed the issue of body area networks and identified the possible need for dedicated spectrum for this type of application. The FCC in the US is currently going through a formal process to identify possible frequency

allocations for Medical Body Area Networks to complement their allocations for wireless telemetry in hospitals. If the UK or Europe follows this lead there will be no need to focus on using the 863–870 MHz band for medical applications except for those of a less critical / routine nature or where it is less medical and more to do with general health / performance e.g. relating to sport and fitness.

It has not been possible to obtain sufficient market data in order to provide a forecast of device numbers.

6.7 Social alarms/Telecare

Telecare systems provide a mix of facilities for infirm and disabled people including self and/or automatically triggered alarms. Alarms can be triggered by sensors around a dwelling (to detect an overflowing bath for example) or on the person (to detect a fall for example). Such alarms are received by a hub unit which then communicates with a remote monitoring centre where appropriate action can be initiated.

Each hub can accommodate many devices but in general there are only 2 or 3 sensors per installation. The hub only responds to sensors carrying a particular signature on the data stream with messages being sent by a sensor several times in order to mitigate the possibility of interference. Currently the communications link is one way only (i.e. the sensor is a transmitter and the hub is a receiver). Although two way communications would be desirable, Category 1 receivers are very power hungry and this would not sit well with a sensor's power supply.

Although there are some installed systems using 173 MHz these are legacy systems and the majority of companies now use the 869 MHz social alarm sub-band. There is one company that uses the 169 MHz allocation. There is no practical alternative for the pendant type personal alarm as it has to be mobile. The fixed sensors, on the other hand, could be wired but the cost would be prohibitive. In terms of future developments it is likely that the types of different sensor will increase but the hub unit will remain largely the same.

The key driver of the market is the aging population. One vendor reported 1.6 million installed units in the UK where one unit is a hub with a number of sensors. Total annual sales in the UK across the market are approximately 500,000 per year.

To determine the market for these social alarms, we begin by establishing the number of social alarms currently operating in the 868–870 MHz band (see Annex C3.4 for further detail on the forecast).

The first step is to calculate the addressable market. As mentioned above, the market for social alarms comprises the elderly and the disabled. We calculate the number of individuals in each of these groups using data provided by the Office of National Statistics. We define the elderly as anyone over 65 years old and the disabled as anyone with a recorded disability.

The next step is to determine the number of social alarms currently in use. This figure is based on a combination of interview responses and data provided by the Social Alarms and Telecare Association [19].

We then estimate the penetration of social alarms within the addressable market and estimate the percentage of these social alarms that operate in the 868–870 MHz band. Both estimates are guided by interview responses.

Having determined the number of social alarms currently operating in the 868–870 MHz band, we then focus on generating a forecast for how this number will evolve over time.

We estimate the level of penetration when the market is saturated[16]. We examine penetration both in terms of social alarms used by the addressable market and then in terms of those alarms operating in the 868–870 MHz band.

We estimate the recent and expected growth rates using inputs from interviews and by conducting additional research, especially in relation to the growth in the aging population. As there is a considerable level of uncertainty predicting future growth behaviour, we consider two levels of growth rate, one that represents aggressive estimates of growth and another which is more conservative.

We conclude our forecast by plotting Gompertz curves (see Annex C.4) for the estimates of aggressive and conservative growth, using the estimates of current and saturated market sizes as inputs.

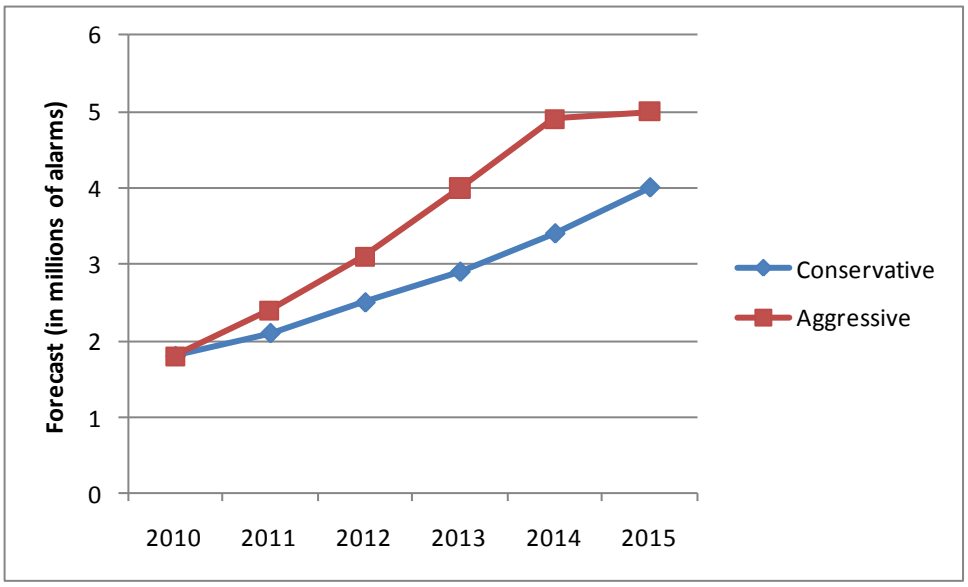
Table 10 and Figure 10 provide the forecast number of social alarms operating in the 868–870 MHz band.

Table 10: Number of social alarm systems

	Forecast (in millions of alarms)					
	2010	**2011**	**2012**	**2013**	**2014**	**2015**
Conservative	1.8	2.1	2.5	2.9	3.4	4.0
Aggressive	1.8	2.4	3.1	4	4.9	5.0

[16] See footnote 4 for definition.

Figure 10: Number of social alarm systems



6.8 Smart metering

The possibility of reading meters remotely over a wireless connection has been around for some years [20]. Such systems provide for bidirectional communication over a fixed infrastructure or allow for walk-by and/or drive-by readout.

More recent developments, largely spurred by international interest in energy efficiency, has led to a wider concept often referred to as smart grids whereby there is a more regular exchange of information across and between the infrastructure of energy suppliers and the local distribution of energy in consumers' properties. In terms of wireless communication to support smart grids one can distinguish between a local network within a consumer's property and a wider area network connecting the consumer's property back to the supplier.

At present there are a number of devices on the market that can be applied in a straightforward manner to monitor electricity consumption. These involve clipping a sensor around the live mains wire just before the meter. The sensor is attached to a wireless transmitter which then transfers the data output of the sensor to a control panel where the consumer can monitor the rate and cost of electricity consumption.

It is not possible for the consumer to monitor and analyse patterns of gas consumption with the same ease (in terms of DIY installation) so there hasn't been the same consumer interest in energy efficiency relating to gas. There is however a UK Government target that smart meters should be fitted in all 26 million households by 2020 and this has been confirmed in more general terms by the incoming administration; the Conservative–Lib Dem coalition agreement which states that the parties agree to implement a full programme of measures to fulfil their joint ambitions for a low carbon and eco-friendly economy, including the establishment of a smart grid and the roll-out of smart meters. The latter is already

underway - the first half of 2010 saw at least three energy suppliers (British Gas, npower, and Scottish and Southern Energy) announce the roll out of smart meters both for gas and electricity. British Gas alone intends to install smart meters in 2 million homes by 2012.

In terms of the frequency bands that might be used to support smart meters within the home there are at least two options. It might be argued that technologies operating in the 2.4 GHz band are suitable as they are well established with many homes having a wireless network and users being familiar with the technology. However, there are questions about range at these frequencies, particularly when meters are located at the extremities of a property. An alternative that also has some traction is the 868 MHz SRD band which has already been identified for meter reading and it is also know that smart meters built by Landis+Gyr, a partner of British Gas, use this frequency. At this stage, given that there is not a single standard that applies, it is difficult to say whether smart meters will end up using a single frequency band or whether different systems will use different frequency bands or perhaps a wired alternative such as powerline.

The forecast for the use of smart metering is guided predominantly by the government's declaration that they aim to have smart meters in every UK household by 2020 (see Annex C3.5 for further detail on the forecast).

As smart meters were only introduced towards the end of 2008 in the UK and the use of these meters is still very much in the pilot phase, the number of smart meters currently in use is relatively low. We estimate the current use of smart meters by assuming very low penetration and then combining this assumption with the number of UK households [21].

In order to calculate the likely uptake of smart meters over the next 11 years, we consider both the government's aim to have 47 million smart meters installed by 2020 and the aim for the mass roll-out of smart meters to begin in 2013. We then apply both conservative and aggressive estimates of the growth rate in order to attain a forecast for the roll out of these smart meters over the next 11 years, at which point the market will be saturated[17].

We conclude our forecast by plotting Gompertz curves (see Annex C.4) for the estimates of aggressive and conservative growth, using the estimates of current and saturated market sizes as inputs.

Table 11 and Figure 11 provide the forecast number of smart meters over the forthcoming five year period.

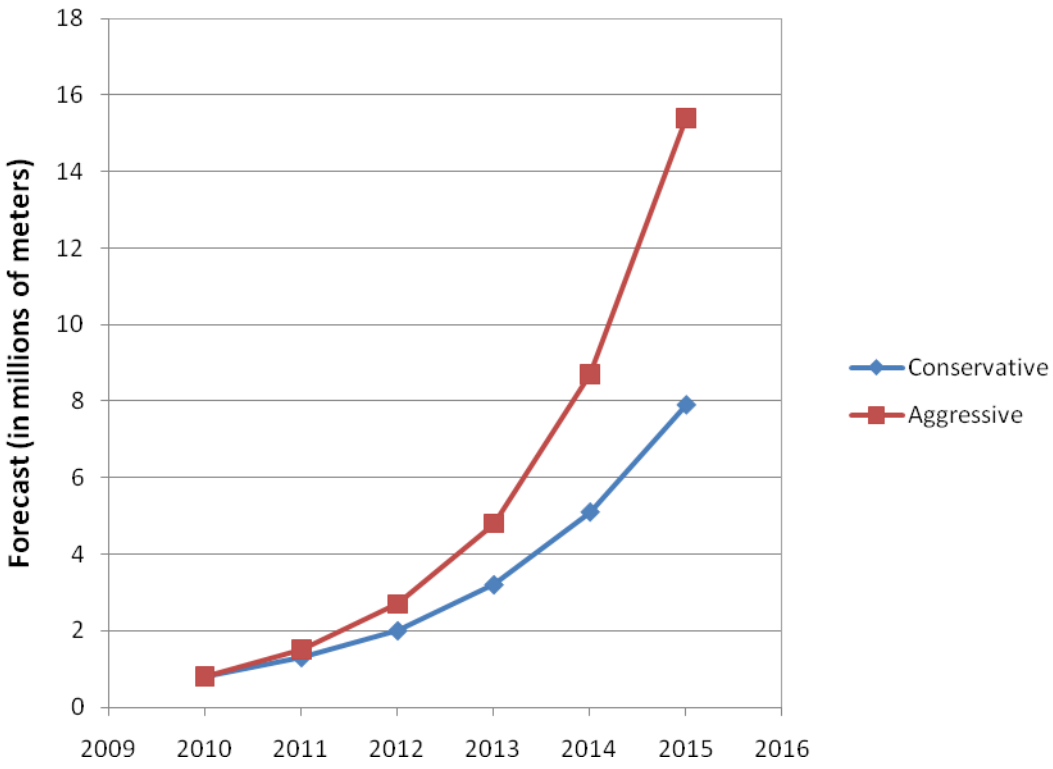
[17] See footnote 4 for definition.

Table 11: Number of smart meters

	Forecast (in millions of meters)					
	2010	**2011**	**2012**	**2013**	**2014**	**2015**
Conservative	0.8	1.3	2	3.2	5.1	7.9
Aggressive	0.8	1.5	2.7	4.8	8.7	15.4

Note that the above forecast is in numbers of meters. We have assumed there will be one meter for each of electricity, gas and water and we have assumed that there will be no replacement of meters over this time horizon.

Figure 11: Number of smart meters



There are two inter-related factors involved in converting the number of meters to the number of 868 MHz receivers in a household, namely:

1. whether standardisation across the utility industries occurs
2. what frequency bands might be used to connect meters to a related control panel.

Currently there is no clear standardisation programme across the utility industries and there is no obviously preferred frequency band except insofar as an older standard relating to meter reading rather than smart metering identifies the 868 MHz frequency band.

On the one hand there could be complete standardisation (1) and the 868 MHz band would be selected. Each household would therefore only require one control panel (receiver) to support three meters. In this case the number of receivers

operating in the 868 MHz band would be a third of the values above. If some other frequency band is selected then clearly the number of receivers operating in the 868 MHz band falls to zero.

On the other hand there might be no effective standardisation, for example because wide scale installation commences before any standardisation exercise can be completed. This is likely in which case each household would require a separate control panel (receiver) for each meter and each receiver may or may not use the 868 MHz frequency band. Depending on the outcome of this more variable scenario the number of receivers operating in the 868 MHz frequency band could be the same as the number of meters indicated above. However, there are any number of scenarios between this and the zero option which depend on the degree of standardisation within a utility sector (as opposed to across utilities) and the choices of frequency band made by each fragmented part of the utility supply industry.

6.9 Telemetry

In its broadest sense telemetry simply transfers data from A to B through a standard interface at either end (RS232, Ethernet etc). Applications that might be supported by one or more telemetry links are therefore wide and varied. For simpler radio links carrying serial data, the communication is unidirectional and integrity is maximised by using listen before talk (LBT) and error checking. For more important links, bidirectional communication is used which allows for more sophisticated protocols using redundancy checks and acknowledgements. This increases latency but provides a very robust link.

Wireless telemetry is widely used by utilities and other industries for a variety of applications, typically involving remote monitoring of systems. Safety critical applications such as the monitoring of reservoir water levels or electricity substations tend to use licensed spectrum in the 458 / 463 MHz band, which is specific to the UK. Less critical applications that require long operational range use the licence-exempt 458 MHz band, which is again UK-specific. The 869 MHz band tends to be used for shorter range applications.

Although the potential market might be characterised as very large it appears from companies we contacted that each company satisfies a small niche in terms of client sector or application set. Each company has a view (generally confidential) of their client sector and/or application set market size but absolutely no idea about the overall market size for telemetry. Since telemetry devices are often based on RF modules / chipsets it was suggested that the views of module manufacturers might give a better idea of market size. However, the only module manufacturer who responded to our enquiries had a similar profile to the telemetry companies, namely that of a niche company. We have not therefore been able to gather enough data on which to base a forecast.

6.10 Automotive

It has been noted [17] that “Short Range Devices perform a variety of important functions in modern automobiles. In accordance with information provided by the European Automotive Manufacturers Association (ACEA), the existing passenger car fleet in Europe consists of more than 250 million vehicles. Currently approximately 60 % of these vehicles are equipped with one or more SRDs. Approximately 6 million new vehicles are sold in Europe every year. 80 % of all new vehicles are currently equipped with SRD devices. This percentage is increasing and will reach 100 % in the near future.”

The type of SRD applications used in vehicles listed include:

- remote keyless entry systems
- passive entry systems
- personal car communications systems
- truck-trailer communication systems
- security systems (vehicle alarm systems).

The report [17] further notes “the considerable number of malfunctions of the keyless entry systems” and that increasing use of frequency bands will lead to an increase in malfunctions and that “spectrum in the 873 MHz to 876 MHz provides the potential for a long term solution for automotive Short Range Devices”. However, our research identified very few products for the automotive industry that operate in the already available 863–870 MHz band. The majority of products—especially those associated with vehicle key fobs—operate in the 315 MHz band (North America and Japan) and 434 MHz band (Europe).

Vehicle key fobs

Car key fobs have over time become more sophisticated. Initially they were used to provide wireless identification to turn off the vehicle immobiliser, using LF frequencies, and to provide remote keyless entry, using a unidirectional UHF link, from a distance by the push of a button.

A Passive Keyless Entry / Go system, where sensors initiate communication between the car and key, was introduced in 1999 and is available for more than 200 car models. The driver can enter the car by simply pulling the door handle and to start the engine by simply pressing the ignition button in the dashboard, without the need for taking the car key out of the pocket. The PKE system consists of one or more key fobs, each with an LF receiver and a UHF transmitter while the car has several LF transmitters and a UHF receiving module. The PKE system utilises the LF link for data communication from the car to the key and the UHF link from the key to the car. Also, for the remote keyless system, two-way communication key fobs have been developed that allow the driver, for example, to receive confirmation that the car was locked.

The next developments are expected to be the Connected Key where connectivity to other devices such as mobile phones, PDAs or PCs can be provided using Near Field Communications which work at 13.56 MHz. This will allow the implementation of applications which, for example, provide car related information onto a mobile phone before opening the car or downloading route information from a PC into the in-car navigation system.

While most current implementations use lower frequency bands, future developments are expected to migrate to UHF and it can be noted that Audi and BMW are already using 868 MHz for their car key fobs.

Tyre pressure

Another automotive application that has achieved some prominence recently is the capability to measure tyre pressure while in motion. This is mandated in the US and within Europe EC Regulation 661/2009 [22] which requires all new cars to be equipped accordingly from 2014. EC standardisation mandate M/457 [23] has started the process to arrive at a common method to achieve this and at this stage it is not known what the final method might be. At present there are conflicting signals as to what the final option might be as:

- a current prominent UK supplier has a system based on 433 MHz
- an Italian supplier specializing in this application also uses 433 MHz but specifies 868 MHz as an option
- it is understood that a physical / geometrical method for determining tyre pressure which does not require the use of a wireless link is being implemented already by car manufacturers.

We have not been able to gather enough data on which to base forecasts for automotive applications

7 CONCLUDING REMARKS

We have provided forecasts for most of the SRD applications operating in the 863–870 MHz frequency band. We have not been able to do so for some of the market sectors due to lack of data. This includes the more general sector of telemetry and it has not been possible to address non-specific SRDs as by definition these could be anything.

It is interesting to note from information provided by respondents that, particularly with regard to applications using the high part of the band (and the underlay), the industry still appears to exist in an interim period in moving from 433 MHz to 868 MHz as a preferred frequency. While there are undoubtedly cases where 868 MHz has been chosen from the outset, there are many cases where predominant supply has been, and still is, based on 433 MHz but with 868 MHz being offered as a new option.

Furthermore, also mainly with respect to applications using the high part of the band, a high uncertainty is attributable to the forecasts because alternatives are available and standardisation has not run its course. For example, in the case of smart meters depending on the outcome of standardisation activities all meters might end up using the 868 MHz band or none at all. If there is no standardisation with respect to frequency band then supply may be fragmented with suppliers opting for differing frequency bands.

Uncertainty is compounded by the possibility of convergence between different applications. Currently, application development is fragmented even within very large companies. However, it is not difficult to see that a number of applications could be supported by a single system (requiring one receiver), for example, intruder alarm, home automation, access control and smart metering. For this to become widespread would probably require a wider standardisation effort than is currently going on. We therefore do not think this affects the forecasts for the timescale considered by this study.

A ACRONYMS / ABBREVIATIONS

ACEA	European Automotive Manufacturers' Association
ALD	Assistive Listening Device
CENELEC	European Committee for Electrotechnical Standardisation
CEPT	European Conference of Postal and Telecommunications Administrations
DC	Duty Cycle
DIY	Do It Yourself
EC	European Commission
ECC	Electronic Communications Committee
ECO	European Communications Office
ERC	European Radiocommunications Committee
ERP	Effective or Equivalent Radiated Power
ETSI	European Telecommunications Standards Institute
EU	European Union
FCC	Federal Communications Commission (US)
FM	Frequency Modulation
GPS	Global Positioning System
GSM / GPRS	Global System for Mobile Communications / General Packet Radio Service
HAN	Home Area Network
HF	High Frequency
IT	Information Technology
JFMG	Joint Frequency Management Group
LBT / AFA	Listen Before Talk / Adaptive Frequency Agility
LF	Low Frequency
LPRA	Low Power Radio Association
NB / WB	Narrow Band / Wide Band
PC	Personal Computer
PDA	Personal Digital Assistant
PKE	Passive Keyless Entry
PSTN	Public Switched Telephone Network

RF	Radio Frequency
RFID	Radio Frequency Identification Device
SRD	Short Range Device
SRD / MG	Short Range Device Management Group
UHF	Ultra High Frequency
VHF	Very High Frequency

B REFERENCES

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[2] UK Interface Requirement 2030—Licence-exempt Short Range Devices. 98/34/EC Notification number: 2007/0576/UK. Ofcom, September 2008 (Version 1.4).

[3] Annex 2 (The ECO report on inventory of cases and case studies of interferer to victim interactions [WP2]) of the draft report on the receiver parameters pilot study which is found as Annex A of ECC(09)130.

[4] ECC Report 11—Strategic plans for the future use of the frequency bands 862-870 MHz and 2400–2483.5 MHz for short range devices, Helsinki, May 2002.

[5] Draft ETSI TR 102 546 v1.1.1_2.0.2 (2007-01): “Electromagnetic compatibility and Radio spectrum Matters (ERM); Technical characteristics for Professional Wireless Microphone Systems (PWMS); System Reference Document”.

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[8] Alien Whitepaper: EPCglobal Class 1 Gen 2 RFID Specification.

[9] Verdict report (2010): “How Britain Shops 2010: food and grocery”.

[10] RFID journal article: “Honda UK to track components through the supply chain” http://www.rfidjournal.com/article/articleview/2703/

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[15] http://www.dcsf.gov.uk/rsgateway/DB/SFR/s000843/SFR08_2009.pdf

[16] http://www.hospitalsworldwide.com/countries/uk.php

[17] ETSI TR 102 649-2 v1.2.1 (2010-06), Part 2: Additional spectrum requirements for UHF RFID, non-specific SRDs and specific SRDs.

[18] ETSI EN 300 220-1 v2.3.1 (2009-12). Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Radio equipment to be used in the 25 MHz to 1000 MHz frequency range with power levels ranging up to 500 mW; Part 1: Technical characteristics and test methods.

[19] Social Alarms and Telecare Association, Press Release: “Gordon Brown signals importance of alarms in spending review”.

[20] EN 13757-4:2005. Communication systems for meters and remote reading of meters—Part 4: Wireless meter readout (Radio meter reading for operation in the 868–870 MHz SRD band). CEN/CENELEC.

[21] Office of National Statistics: http://www.statistics.gov.uk/cci/nugget.asp?id=8

[22] EC Regulation 661/2009 (of 13th July 2009) concerning type-approval requirements for the general safety of motor vehicles, their trailers and systems, components and separate technical units intended therefor.

[23] EC standardisation mandate M/457 (21st December 2009) Standardisation mandate to CEN, CENELEC and ETSI in the field of tyre pressure gauges for motor vehicles and tyre pressure management systems (measuring instruments).

C PARAMETERS, ASSUMPTIONS AND CALCULATIONS USED FOR FORECASTS

C.1 Low-band

C.1.1 Wireless Microphones

Parameter Designation	Value	Sources	Comments
Number of wireless microphones sold by one supplier in the UK last year.	5,500	Interview with supplier	One supplier estimates that they have approximately 5-10% of the market and that approximately 50,000 to 60,000 wireless microphones were sold in the UK in the last year (they estimate their sales at approximately 5,000 to 6,000). Another supplier estimated they may have sales of 10,000 a year, although this only covers entry-level. Therefore sounds reasonable they may sell close to 20,000 in total (consistent with figures of first supplier).
Market Share of that supplier	10%	Interview with supplier	See above.
Number of wireless microphones sold in the UK last year	55,000	Calculation	5,500 / 10% This is consistent with PAMA's[18] estimates of a total of ~650,000 wireless microphones sold in Europe in 2009. From our calculation, the UK would represent ~8.5% of the European volume. This is consistent with the percentage of population in the UK in relation to the total population in Europe (61 million / 822 million = 7.4%) plus an adjustment for a supposedly higher penetration in UK in relation to less developed European economies.

[18] The Professional Audio Manufacturers Alliance. Reference found in ETSI TR 102 546 v1.1.1 (2007-02) located at http://www.etsi.org/deliver/etsi_tr/102500_102599/102546/01.01.01_60/tr_102546v010101p.pdf

Number of wireless microphones currently in use in the UK	275,000	Calculation	55,000 / 20% Key assumption made is that consumers upgrade microphones every 5 years. Therefore annual sales represent ~20% of total market. A third supplier noted that there are already 100 000s of wireless microphones out in the market already.
Percentage of wireless microphones using the 863-865 MHz frequency range	50%	Assumption	Assumption made on the basis that consumer applications make up ~70% of market and that ~70% will operate in this range. Based on comments from three suppliers: First supplier: … difficult to get a handle on the users of the 863-865 frequency as all applications can be used in this frequency and while it's mostly non-professionals, many professionals may combine this band with another ... Second supplier: There is a general concern with the overcrowding of the 863-865 MHz band. The professionals who purchase the higher end products will use the lower frequencies and completely avoid 863-865 MHz because of the interference. This 863-865 MHz band is OK for a vicar in a church or more consumer-driven use, but no professional will want to use the band due to overcrowding. Third supplier: There are not currently many wireless microphones and IEMs in this band but they expect the numbers to grow as these applications move from other frequencies to the 863 band. They noted that the professional people won't use the 863-865 MHz band because of interference concerns – more the consumer side that uses applications in this frequency band.

Number of wireless microphones using the 863-865 MHz frequency range in the UK	137,500	Calculation	275,000 x 50%
Growth rate in number of wireless microphones	5%	Assumption	Draft ETSI TR 102 546 (NOTE 1 – page 17): PAMA estimated annual growth after 2006 at 5%. Interviews also predicted steady increase over the years.
Percentage of wireless microphones using the 863-865 MHz frequency range in the future	Conservative: 50% Aggressive: from 50% to 75% (in steps of 5%) between 2010 and 2015	Assumption	Conservative: nothing changes. Aggressive: consumer applications in other bands migrate to 863-865 MHz band. Professional applications increasingly use channels in the 863-865 MHz band.

Forecast for wireless microphones in the 863-865 MHz band:

	2010	2011	2012	2013	2014	2015
Number of wireless microphones currently in use in the UK	275,000					
Annual growth rate	5%	5%	5%	5%	5%	5%
	275,000	288,750	303,188	318,347	334,264	350,977
% in 863-865 MHz (conservative)	50%	50%	50%	50%	50%	50%
Conservative forecast	*137,500*	*144,375*	*151,594*	*159,173*	*167,132*	*175,489*
% in 863-865 MHz (aggressive)	50%	55%	60%	65%	70%	75%
Aggressive forecast	*137,500*	*158,813*	*181,913*	*206,925*	*233,985*	*263,233*

C.1.2 Assistive Listening Devices – ALDs

Parameter Designation	Value	Sources	Comments
Number of people in UK with hearing impairments (in 2003)	9 million	Hear-It report[19]	"The figure generally quoted for prevalence of hearing impairment in the UK is 1 in 7, or approximately 9 million people (RNID, 2003)"
Number of people who would benefit from a hearing aid (in 2003)	8.1 million	Assumption	9 million x 90% Assumption combining the above 9 million with 90% as indicated below: "In England and Wales it is estimated that approximately 8.1 million of the population have a hearing impairment, of whom around 90% have a sensorineural hearing loss and would benefit from a hearing aid" (Hear-It report)
Number of people with a hearing aid prescribed (in 2003)	1.4 million	Hear-It report	"Approximately 1.4 million, or 3.4% of the population, have a hearing aid prescribed, although around 10.4% of the population could benefit (NICE, 2000; Davis, 2003)."
People with hearing impairment without a hearing aid (in 2003)	6.7 million	Calculation	8.1 million – 1.4 million
Percentage of people with hearing impairment without a hearing aid who would benefit from an ALD	50%	Estimate	8% / 16% Based on indication obtained through research that the range that would most benefit from ALDs falls within people with 25 to 40 dB of hearing loss. The Hear-It report estimates that 16.1% of the UK population has a hearing loss > 25 dB and 8.2% has a hearing loss > 35 dB. Since the population of people who have a hearing impairment > 25 dB is 16% and 8% have a hearing loss between 25 dB and 35 dB, this equates to approximately 50% of hearing impaired people who would benefit from an ALD

[19] http://www.ehima.com/members/Hear_It_Report_October_2006.pdf

People who would benefit from an ALD (in 2003)	3.35 million	Calculation	6.7 million x 50%
Population growth rate	0.7%	Estimate	Estimate from the Office for National Statistics
People who would benefit from an ALD (in 2010)	3.52 million	Calculation	3.35 million x (1.007) ^ 7
Percentage of ALD in the 863-865 MHz frequency range (in 2010)	5%	Estimate	25% x 20% Based on estimates that only 1 in 4 people with some form of hearing impairment uses some form of hearing aid device and that the market for Assistive Listening Devices is largely dominated by Infrared and FM based systems (at least 80% in our estimate based on availability of models in vendors' websites)
Number of ALD in the 863-865 MHz frequency range (in 2010) [START]	175,882	Calculation	3,517,638 x 5%
Average growth	0.9%	Estimate	Based on ONS data showing growth in the aging population of 0.88% in 2008.[20]
Number of people who would benefit from an ALD (by 2019)	3,813,042	Calculation	3.52 million x (1.009) ^ 9 Assumes that the number of people who would benefit from an ALD is driven by growth in the aging population
Penetration of ALD in the 863-865 MHz frequency range (by 2019)	10%	Assumption	Assumes a combined effect of increase in take up of ALDs and increase in penetration of SRD based ALDs
Number of ALD in the 863-865 MHz frequency range (in 2019) [CEILING]	381,304	Calculation	3,813,042 x 10%

[20] http://www.statistics.gov.uk/downloads/theme_health/Pop-age-sex14.xls

Forecast for ALDs in the 863-865 MHz band:

Gompertz Series parameters	
Ceiling	381,304
Initial Value	175,882

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Forecast (Conservative)	*175,882*	*186,383*	*197,492*	*209,241*	*221,661*	*234,782*	*248,632*	*263,235*	*278,608*	*294,753*
Growth YoY (Conservative)		6.0%	6.0%	5.9%	5.9%	5.9%	5.9%	5.9%	5.8%	5.8%
Forecast (Aggressive)	*175,882*	*196,756*	*219,943*	*245,608*	*273,843*	*304,550*	*337,062*	*368,439*	*374,986*	*381,304*
Growth YoY (Aggressive)		11.9%	11.8%	11.7%	11.5%	11.2%	10.7%	9.3%	1.8%	1.68%

C.2 Mid-band

C.2.1 RFID use in Manufacturing and Distribution

Parameter Designation	Value	Sources	Comments
Number of returnable containers for a large retailer in a particular retail sector[21]	20 million	Interview with a supplier	The large retailer is used as a proxy as it is the largest user of returnable containers in a particular retail segment. The supplier also informed that another large retailer uses approximately 7 million returnable containers with RFID tags.
Market share of the particular retail sector for that large retailer	30.98%	Verdict: How Britain Shops 2010, p.25, Table 3	
Number of returnable containers in the particular retail sector [A]	64,724,919	Calculation	20 million / 30.98% This assumes the large retailer's use of returnable containers provides a good approximation for all retailers in this particular sector
Estimated penetration of RFID in the retail sector	26%	SeBW report[22]	From SeBW report, page 49: "The most interesting data point refers to the retail sector, where 26% of respondents indicated that they have adopted RFID with 24% of firms already using RFID in their regular business." (based on survey from 2007). We assume this penetration is the same for the particular retail sector of interest
Total estimated number of returnable containers using RFID in the particular retail sector	16,828,479	Calculation	64,724,919 x 26%
Percentage of returnable containers using RFID in 865-868 MHz frequency range	70%	Assumption	Based on the indication that most of the implementations in returnable containers now use Gen2 UHF technology. However, HF using 13.56 MHz and "real time location systems – RTSL" using 433 MHz and 2.4 GHz are also employed.

[21] This particular retail sector contains household goods, food, beverages and tobacco.

[22] http://www.ebusiness-watch.org/studies/special_topics/2007/documents/Study_07-2008_RFID.pdf

Total estimated number of returnable containers using RFID in 865-868 MHz frequency range in the particular retail sector	11,779,935	Calculation	16,828,479 x 70%
Percentage of returnable containers with RFID in the retail sector in relation to total number of returnable containers in the broader distribution sector	50%	Assumption	Assumption made based on ONS statistics for "Distributive and Services trades"[23]. Weight of retail related wholesale trades: Household Goods, Food, beverages and tobacco and other; in relation to Machinery, equipment and supplies and ½ of Wholesale trades of non-agricultural intermediate products, waste and scrap. (2005)
Total estimated number of returnable containers using RFID in 865-868 MHz frequency range [START – DISTRIBUTION]	23,559,871	Calculation	11,779,935 x 2 This calculation enables the extrapolation of the particular retail sector to the distribution sector as a whole
Average economic growth [B]	2.5%	Estimate	Based on IMF estimates for period 2011 to 2015
Penetration of RFID in the retail sector by 2019 [C]	70%	Assumption	Assumption made based on indications of impact on distribution efficiency / business profitability driving penetration. Also assumes diffusion to SMEs.
Penetration of RFID in 865-868 MHz frequency range in the retail sector by 2019 [D]	70%	Assumption	Assumption made based on the expectation that Gen 2 UHF and RTSL will dominate and percentage in the 865-868 MHz will remain the same.
Percentage of returnable containers with RFID in retail in relation to total distribution by 2019 [E]	30%	Assumption	Assumes diffusion to other distribution sectors which will gradually use more returnable containers with RFID technology.
Total r-c using RFID in 865-868 MHz frequency range in 2019 [CEILING – DISTRIBUTION]	132,026,506	Calculation	=64,724,919 x [(1.025)^9] x 70% x 70% / 30% = [A] x [(1+[B])^9] x [C] x [D] / [E] I.e. affected by economic growth, penetration and diffusion effects

[23] http://www.statistics.gov.uk/pdfdir/das0506.pdf

Parameter Designation	Value	Sources	Comments
Number of returnable containers for Honda	350,000	RFID Journal[24]	The article reports figures for 2006 and we assumed that the overall number of returnable containers for Honda did not change (due to the reduction in output in the last two years).
Honda Market Share in the UK	4.30%	Estimate	Estimate based on the market share for Honda in 2006[25]
Estimated number of returnable containers in the automotive industry in the UK [A]	8,139,535	Calculation	350,000 / 4.30%
Percentage of returnable containers in the automotive industry using RFID	50%	Assumption	Desk research indicated that approximately 80% of the top car manufacturers with sales in the UK use returnable containers with RFID in the supply chain
Total estimated number of returnable containers using RFID in the automotive industry	4,069,767	Calculation	8,139,535 x 50%
Percentage of returnable containers in the automotive industry using RFID in the 865-868 MHz range	70%	Assumption	Same assumption as in distribution sector
Total estimated number of returnable containers in the automotive industry using RFID in the 865-868 MHz range	2,848,837	Calculation	4,069,767 * 70%
Percentage of r-c with RFID in the automotive industry in relation to total number of returnable containers in the manufacturing sector	50%	Assumption	Transport manufacturing represents ~35% of the manufacturing sectors likely to use RFID (machinery and equipment, electrical and optical, transport equipment)[26]. Its complex supply chain, justifies a higher estimate for use of returnable containers (Hence, adjustment to 50%).

[24] http://www.rfidjournal.com/article/articleview/2703/

[25] http://www.autoblog.com/2006/06/20/honda-uk-sales-going-strong/

[26] http://www.berr.gov.uk/files/file44332.pdf

Total r-c in the manufacturing sector using RFID in the 865-868 MHz range [START – MANUFACTURING]	5,697,674	Calculation	2,848,837 / 50%
Penetration of RFID in the automotive industry by 2019 [B]	70%	Assumption	Assumes diffusion to smaller manufacturers and higher penetration within large manufacturers.
Penetration of RFID in 865-868 MHz range in automotive industry by 2019 [C]	70%	Assumption	Same assumption as in distribution sector.
Percentage of r-c with RFID in the automotive industry in relation to total number of returnable containers in the manufacturing sector by 2019 [D]	30%	Assumption	Assumes diffusion to other manufacturing sectors which will gradually use more returnable containers with RFID technology.
Total r-c using RFID in 865-868 MHz frequency range in 2019 [CEILING – MANUFACTURING]	13,294,573	Calculation	8,139,535 x 70% x 70% / 30% [A] x [B] x [C] /[D] Economic growth not considered as growth in manufacturing sector is uncertain.

Forecast for returnable containers with RFIDs in the 863-865 MHz band:

Gompertz Series parameters	
Ceiling	145,321,080 = (132,026,506 + 13,294,573)
Initial Value	29,257,545 = (23,559,871 + 5,697,674)

('000)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Forecast (Conservative)	29,257	34,000	39,496	45,859	53,216	61,706	71,479	82,680	95,430	109,753
Growth YoY (Conservative)		16%	16%	16%	16%	16%	16%	16%	15%	15%
Forecast (Aggressive)	29,257	35,804	43,772	53,444	65,136	79,172	95,814	115,006	135,254	143,188
Growth YoY (Aggressive)		22%	22%	22%	22%	22%	21%	20%	18%	6%

C.2.2 RFID use in Individual Items

Parameter Designation	Value	Sources	Comments
Number of tags used by one large UK garment retailer (250 stores)	150 million per year	Supplier	The supplier has run this initiative [item level tagging on clothes] at a UK garment retailer for 2 years. The retailer has used approximately 150 million tags a year – the tags are non-reusable. This retailer has 250 stores in the UK. Each store has approximately 2-3 RFID readers for these tags. These tags and readers use the 866-868 MHz frequency band. This has been a proven business case – improved the bottom line of the business, mostly by improving the ability to count the stock on shelves and to determine what needs to be reordered. Other clothing chains (eg in Portugal, Germany and some in the UK) are also now looking at this approach."
Number of Individual Level Tags (ILTs) per large store	600,000	Calculation	150,000,000 / 250
Number of large garment retail stores in the UK	4,000	Verdict and internet research	From Verdict Report: How Britain Shops 2010: Clothing – M&S, Next, Primark, Asda/George, Debenhams, Matalan, New Look, River Island, Tesco, TK Maxx and Bon Marché have jointly 60.3% of market share in the clothing sector. These retail chains have 3,849 stores according to the latest information available in their individual websites.
Total potential number of RFID ILTs in the UK garment sector [A]	2.4 billion	Calculation	600,000 x 4,000

Percentage of retail stores using RFID ILTs in the UK garment sector	20%	Estimate	Estimation obtained by looking at top UK garment retailers and determining the number that employ RFID technology. This estimate was then compared against interview responses and other forecasts to assess accuracy.
Total estimated number of RFID ILTs in UK garment retail	480,000,000	Calculation	2.4 billion x 20%
Percentage of RFID ILTs in the UK garment retail using RFID in the 865-868 MHz range	70%	Assumption	Based on the indication that most of the implementations in individual level tagging now use Gen2 UHF technology. However, HF using 13.56 MHz was massively used in early implementations.
Total estimated number of RFID ILTs in UK garment retail using 865-868 MHz [START]	336,000,000	Calculation	480 million x 70%
Average economic growth [B]	2.5%	Estimate	Based on IMF estimates for period 2011 to 2015
Penetration of RFID ILTs in the UK garment retail sector by 2019 [C]	50%	Assumption	Assumption made based on indications of positive impact on stock management / business profitability driving penetration. Also assumes diffusion to smaller retail chains.
Penetration of RFID ILTs in 865-868 MHz range in garment retail sector by 2019 [D]	70%	Assumption	Conservative assumption considering that HF tags will continue to be preferred for certain applications.
Total estimated number of RFID ILTs in UK garment retail using 865-868 MHz by 2019 [CEILING]	1 billion	Calculation	2.4 billion x (1.025)^9 x 50% x 70% [A] x (1+[B])^9 x [C] x [D]

Forecast for ILTs in the 865-868 MHz band:

Gompertz Series parameters	
Ceiling	1,049,044,895
Initial Value	336,000,000

('000)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Forecast (Conservative)	*336,000*	*389,876*	*452,039*	*523,562*	*605,500*	*698,684*	*803,155*	*916,254*	*1,022,957*	*1,049,044*
Growth YoY (Conservative)		16%	16%	16%	16%	15%	15%	14%	12%	3%
Forecast (Aggressive)	*336,000*	*410,044*	*499,392*	*606,338*	*732,374*	*875,419*	*1,015,594*	*1,049,044*	*1,049,044*	*1,049,044*
Growth YoY (Aggressive)		22%	22%	21%	21%	20%	16%	3%	0%	0%

Comparison with 3rd party forecasts for UHF RFID:

Reference studies (EUROPEAN level)		Million of tags per year - UHF RFID in band 865 – 868 MHz *(forecasted figures are shown in italics)*								
Source	Issued	2006	2007	2008	2009	2010	2011	2012	2017	2022
ETSI TR 102 649-1 (Logistics only)	April 2007	*190*	*220*	*320*	*450*	*680*	*960*	*1 200*		
YoY growth			16%	45%	41%	51%	41%	25%		
BRIDGE project	February 2007		144					*3 220*	*22 400*	*86 700*
CAGR									47.5%	31%
IDTechEx	2009				680					
Table 5 of ECO study	Nov 2009		475		665					*354 000*

Ovum - UK Level									
	2006	2007	2008	2009	2010	2011	2012	2017	2022
R-Cs [Conservative]					29	34	40	83	
ILTs [Conservative]					336	390	452	916	
Total [Conservative]					***365***	***424***	***492***	***999***	
R-Cs [Aggressive]					29	36	44	115	
ILTs [Aggressive]					336	410	499	1,049	
Total [Aggressive]					***365***	***446***	***534***	***1,164***	

C.3 High-band

C.3.1 Fire alarms

Parameter Designation	Value	Sources	Comments
Number of commercial and industrial properties in England and Wales	1,794,592	Government	The government provides information on the number of commercial properties in England and Wales. This value was obtained from www.communities.gov.uk[27].
Percentage of these properties in England and Wales in the UK	80%	Estimate	This estimate is based on the fact that England and Wales has approximately 89% of the total UK population and 62% of the total UK land area. As a large portion of Scotland is unsuitable for commercial sites, we expect England and Wales to have more than 62% of the properties of interest. We also expect the number of sites to be below 89% as England's population per commercial property is likely to be higher than that for the UK as a whole.
Number of commercial and industrial properties in the UK	2,243,240	Calculation	1,794,592 / 80%
Number of schools and hospitals in the UK	25,816	Government and hospital databases	We assume that "commercial and industrial" properties do not include schools and hospitals. As these are important non-residential users of fire alarms (as identified by industry players), we include them in the forecast. The data on the number of schools was obtained from www.dcsf.gov.uk and the data on the number of hospitals was obtained from www.hospitalsworldwide.com.
Total number of properties	2,269,056	Calculation	2,243,240 + 25,816
Average number of alarms per property	50	Estimate	This estimate is based on discussion with a supplier and other industry participants present at the IFSEC conference. Specifically, these participants indicated that there are typically 40-60 devices in an average sized building.

[27] http://www.communities.gov.uk/documents/planningandbuilding/xls/1179479.xls

Total estimated addressable market [A]	113,452,800	Calculation	2,269,056 x 50
Percentage of properties with some fire alarm system in place	100%	Assumption	Our assumption is based on the regulation that all commercial and industrial properties in the UK are required to have working fire alarms installed in their premises
Estimated number of fire alarms that are wireless	30%	Estimate	This estimate is based on discussion with a supplier and other industry participants at the IFSEC conference.
Estimated percentage of wireless alarms operating in the 868-870 MHz band	30%	Estimate	This estimate is based on discussion with a supplier and other industry participants at the IFSEC conference.
Total number of wireless fire alarms operating in the 868-870 MHz band [START]	10,210,752	Calculation	113,452,800 x 100% x 30% x 30%
Average economic growth [B]	2.5%	Estimate	Based on IMF estimates for period 2011 to 2015
Estimated penetration of wireless fire alarms by 2019 [C]	80%	Estimate	This estimate is based on discussion with a supplier and other industry participants at the IFSEC conference.
Estimated penetration of wireless fire alarms in the 868-870 MHz band by 2019 [D]	100%	Estimate	This estimate is based on discussion with a supplier and other industry participants at the IFSEC conference. Specifically, information gathered indicated that all wireless devices will need to be able to operate at 868-870 from 2011
Total number of wireless fire alarms operating in the 868-870 MHz band by 2019 [CEILING]	113,349,601	Calculation	113,452,800 x (1.025)^9 x 80% x 100% [A] x (1+[B])^9 x [C] x [D] Calculation based on the economic growth (2.5%), the estimated penetration of wireless alarms (80%), the penetration of alarms in the 868-870 MHz band (100%) and the number of years until 2019 (9)

Forecast for fire alarms in the 868-870 MHz band:

Gompertz Series parameters	
Ceiling	113,349,601
Initial Value	10,210,752

('000)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Forecast (Conservative)	*10,210*	*12,740*	*15,887*	*19,799*	*24,654*	*30,667*	*38,093*	*47,224*	*58,375*	*71,822*
Growth YoY (Conservative)		25%	25%	25%	25%	24%	24%	24%	24%	23%
Forecast (Aggressive)	*10,210*	*13,394*	*17,553*	*22,972*	*30,011*	*39,110*	*50,782*	*65,546*	*83,647*	*103,736*
Growth YoY (Aggressive)		31%	31%	31%	31%	30%	30%	29%	28%	24%

C.3.2 Intruder alarms

Parameter Designation	Value	Sources	Comments
Current penetration of alarm systems in residential areas	13%	Interview with a supplier	"Current penetration of alarm systems in the residential market is 12 – 14 %."
Number of residential premises in the UK [A]	26,665,714	ONS	Using ONS data[28] we calculate that there were 26,142,857 households in the UK in 2009. Based on an evaluation of historic growth rates, an increase of 2% was considered to adjust the figure for 2010.
Number of alarm systems in residential areas	3,466,543	Calculation	26,665,714 x 13%
Current market share of wireless systems	30%	Assumption	Assumption based on information obtained during the interviews: the first supplier estimates 25% wireless, another supplier estimates 34-36% wireless
Number of wireless alarm systems in residential areas [START – RESIDENTIAL]	1,039,963	Calculation	3,466,543 x 30% (For the last 4-5 years all new wireless alarm systems can operate in the 868-870 MHz band for harmonization with other European countries)
Average economic growth [B]	2.5%	Estimate	Based on IMF estimates for period 2011 to 2015
Penetration of alarm systems in residential areas by 2019 [C]	30%	Assumption	The first supplier estimates that in 5 years time this penetration will be around 18 to 20%. We projected another 10% growth in penetration for the next 5 years.
Market share of wireless systems by 2019 [D]	70%	Assumption	Based on an expectation of continued growth in penetration. The first supplier estimated a growth of 20% in penetration in the last 5 years.
Number of wireless alarm systems in residential areas by 2019 [CEILING – RESIDENTIAL]	6,993,383	Calculation	26,665,714 x 1.025^9 x 30% x 70% [A] x (1+[B])^9 x [C] x [D]
Current penetration of alarm systems in commercial buildings	80%	Assumption	Assumption based on the broad need for commercial concerns to protect stock and assets.
Number of commercial premises in the UK [A]	2,269,056	Calculation	See calculation in the forecast for fire alarm systems.

[28] http://www.statistics.gov.uk/cci/nugget.asp?id=8

Number of intruder alarm systems in commercial areas	1,815,245	Calculation	2,269,056 x 80%
Current market share of wireless systems	10%	Assumption	Based on indications that current installations in the commercial sector are, in its majority, wired.
Number of wireless intruder systems in commercial areas [START – COMMERCIAL]	181,524	Calculation	1,815,245 x 10%
Average economic growth [B]	2.5%	Estimate	Based on IMF estimates for period 2011 to 2015
Penetration of alarm systems in commercial buildings by 2019 [C]	80%	Assumption	Assumes that alarm systems are broadly available already and that there are no major drivers for further penetration
Market share of wireless systems by 2019 [D]	30%	Assumption	Assumption made considering convenience of wireless where interruption of commercial services needs to be avoided
Number of wireless intruder systems in commercial areas by 2019 [CEILING – COMMERCIAL]	680,098	Calculation	2,269,056 x 1.025^9 x 80% x 30% [A] x (1+[B])^9 x [C] x [D]

Forecast for intruder alarms in the 868-870 MHz band:

Gompertz Series parameters	
Ceiling	7,673,480 = (6,993,383 + 680,098)
Initial Value	1,221,487 = (1,039,963 + 181,524)

('000)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Forecast (Conservative)	1,221	1,496	1,831	2,239	2,734	3,333	4,054	4,910	5,904	6,978
Growth YoY (Conservative)		22%	22%	22%	22%	22%	22%	21%	20%	18%
Forecast (Aggressive)	1,221	1,585	2,054	2,656	3,422	4,386	5,565	6,891	7,617	7,673
Growth YoY (Aggressive)		30%	30%	29%	29%	28%	27%	24%	11%	1%

C.3.3 Remote Controllers

Parameter Designation	Value	Sources	Comments
Number of units sold by one supplier in the UK in a year	500	Interview with supplier	Response provided by supplier during an interview
Estimated UK market share for that supplier	32.5%	Interview with supplier	The supplier stated that their market share was between 30% and 35%
Estimated number of units sold per year	1,538	Calculation	500 / 32.5%
Replacement cycle	5 years	Assumption	Based on replacement cycle of other similar peripheral equipment
Number of units currently in the market	7,692	Calculation	We assume that the current market is simply replacement. Consequently, the number of units in the market is calculated as 1,538.46 x 5
Percentage of units operating in the 868-870 MHz band	25%	Interviews with two suppliers	The first supplier indicated that approximately 50% of the units operate in this band. In comparison, another supplier was of the opinion that none of the units operate in this band. As these are the main industry operators, we took an average of their responses to be the most accurate reflection of market sentiment
Number of units in the market in the 868-870 MHz band	1,923	Calculation	7,692 x 25%
Year-on-year growth of overall market	2.5%	Estimate	Based on IMF estimates for period 2011 to 2015
Percentage of units sold in a year that represents replacement of wired units or new deployments	75%	Estimate	Based on interview responses and the prediction of a 5-year replacement cycle.
Number of additional units in a year	296	Calculation	1,538 x 1.025 x 25% x 75% This is calculated as the number of units sold over the course of the preceding year as well as the % of these units operating in the 868-870 MHz band and the % of units representing replacement of wired units or new deployments. The calculation for 2011 is (1,538*1.025) x 25% x 75%

Forecast for remote controllers in the 868-870 MHz band:

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Units sold in the year [A]	1,538	1,577	1,616	1,657	1,698	1,741	1,784	1,829	1,874	1,921
Percentage of units operating in the 868-870 MHz band [B]		25%	25%	25%	25%	25%	25%	25%	25%	25%
Percentage of units sold representing replacement of wired units or new deployments [C]		75%	75%	75%	75%	75%	75%	75%	75%	75%
Additional units in the year in the 868-870 MHz band [A] x [B] x [C]		296	303	311	318	326	335	343	351	360
Forecast (previous year's forecast + additional units in the year)	*1,923*	*2,219*	*2,522*	*2,832*	*3,151*	*3,477*	*3,812*	*4,155*	*4,506*	*4,866*

C.3.4 Social alarms

Parameter Designation	Value	Sources	Comments
Current addressable market [A]	8,500,000	Office of National Statistics (ONS)	The addressable market comprises the elderly (who we define as over 65) and the disabled. Using ONS data we estimate that the number of individuals over the age of 65 is 4.3 – 4.5 million. ONS data also indicates that the number of disabled people in the UK is approximately 4 million.
Number of individuals currently using social alarms	2,000,000	Interview with a supplier	The supplier estimated that there were currently around 2 million social alarms in use. Data from the Social Alarm and Telecare Association provides verification for this estimate by showing that the number of individuals using social alarms in 2004 was approximately 1.5 million.
Current penetration of social alarms	24%	Calculation	2 million / 8.5 million
Percentage operating in the 868-870 MHz band	90%	Interview with a supplier	The supplier indicated that almost all of the market currently uses the 868-870 MHz band – The supplier is aware of just one company that uses a lower frequency
Current number of social alarms in the 868-870 MHz band [START]	1,800,000	Calculation	2 million x 90%
Average growth [B]	0.9%	Estimate	Based on ONS data showing growth in the aging population of 0.88% in 2008. [29]
Penetration of social alarms by 2019 [C]	60%	Estimate	Based on 2004 population estimates (from ONS), we calculate that penetration in 2004 was 2.5%. Over the past 6 years penetration has increased from 2.5% to 24% and we expect this increase to continue, although at a slower rate.
Penetration of social alarms operating in the 868-870 MHz by 2019 [D]	90%	Estimate	The percentage currently operating in this band is already high (90%) and we have no reason to believe this will change
Number of social alarms operating in the 868-870 MHz band by 2019 [CEILING]	4,975,459	Calculation	8.5 million x 1.009^9 x 60% x 90% [A] x (1+[B])^9 x [C] x [D]

[29] http://www.statistics.gov.uk/downloads/theme_health/Pop-age-sex14.xls

Forecast for social alarms in the 868-870 MHz band:

Gompertz Series parameters	
Ceiling	4,975,459
Initial Value	1,800,000

('000)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Forecast (Conservative)	*1,800*	*2,123*	*2,500*	*2,939*	*3,443*	*4,009*	*4,601*	*4,971*	*4,975*	*4,975*
Growth YoY (Conservative)		*18%*	*18%*	*18%*	*17%*	*16%*	*15%*	*8%*	*0%*	*0%*
Forecast (Aggressive)	*1,800*	*2,370*	*3,096*	*3,977*	*4,850*	*4,975*	*4,975*	*4,975*	*4,975*	*4,975*
Growth YoY (Aggressive)		*32%*	*31%*	*28%*	*22%*	*3%*	*0%*	*0%*	*0%*	*0%*

C.3.5 Smart metering

Parameter Designation	Value	Sources	Comments
Ceiling of smart meters by 2020	47,000,000	Government	The UK government plans to roll-out smart meters to every home by 2020. As per government statements, this equates to approximately 47 million meters in 2020.
Percentage of smart meters operating in the 868-870 MHz band	100%	Landys+Gyr (Public domain)	Discussions with industry experts within Ovum indicate that there is a definite movement towards standardization – our expectation is thus that all smart meters that will be rolled out over the next 10 years will use the same frequency. Two main frequency bands could be used for smart meter deployment: the 2.4 GHz and 868-870 MHz bands. If the 2.4 GHz band is selected, the forecast for smart meters in the 868-870 MHz band will be zero. If it is decided that the 868-870 MHz band will be used, we predict that 100% of all smart meters will use this band. Currently Landys+Gyr, who use the 868-870 MHz band, have a partnership with British Gas to provide smart meters within the UK. We assume 100% of smart meters will use this 868-870 MHz band but note that the reader should be aware of the alternatives.
Number of smart meters in the UK in 2012	2,019,945	British Gas (Public domain)	British Gas plans to install 2 million meters by 2012. While British Gas is one of three providers discussing the roll out smart meters (the others are npower and Scottish and Southern Electric), it is the only one currently teamed up with a provider (Landys+Gyr) and in a position to supply a significant number of smart meters by 2012. We therefore estimate that the number of smart meters in 2012 will be slightly higher than 2 million.

Number of smart meters in the UK in 2010 [START]	800,000	Estimate	Smart meters were only introduced towards the end of 2008 and are still in the pilot phase. We estimate that approximately 3% of households currently have a single smart meter. This estimate is based on the number of smart meters expected in 2012 and the fact that mass roll-out of smart meters is only expected to commence in 2013, peaking at 47 million in 2020. The calculation is based on 47 million meters x 3% x 50% (as it is estimated that each house will have roughly 2 meters)

Forecast for smart meters:

Gompertz Series parameters	
Ceiling	47,000,000
Initial Value	800,000

('000)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Forecast (Conservative)	*800*	*1,272*	*2,019*	*3,199*	*5,051*	*7,941*	*12,404*	*19,167*	*29,006*	*41,562*
Growth YoY (Conservative)		59%	59%	58%	58%	57%	56%	55%	51%	43%
Forecast (Aggressive)	*800*	*1,465*	*2,672*	*4,846*	*8,708*	*15,410*	*26,464*	*41,799*	*47,000*	*47,000*
Growth YoY (Aggressive)		83%	82%	81%	80%	77%	72%	58%	12%	0%

C.4 Use of the Gompertz Curve

The Gompertz Curve is an S-shaped curve that is used for time series data where growth is slowest at the start and end of a time period and more rapid in the middle period. This curve has proved to be a good fit for a number of applications; for example, mobile phone penetration where growth is initially slow (as costs are high), then increases rapidly as demand rises and costs fall, and then slows down as the market becomes saturated.

The Gompertz Curve is based on the following function:

$$y(t) = ae^{be^{ct}}$$

The constants ‘b’ and ‘c’ are negative values. As the variable‘t’ grows, y(t) tends to ‘a’, the asymptote (in our case, the Ceiling value).

When t = 0, i.e. in the intercept with the y bar (in our case, the Initial Value), the function is simplified as follows:

$$y(0) = ae^{b}$$

Therefore, we calculate the constant ‘b’ from the values entered for the Initial Value and for the Ceiling as follows:

$$b = -\ln(\frac{Ceiling}{Initial\_value})$$

The growth slope of the Gompertz curve changes with the changes in t. We identify the value of the constant ‘c’, from our input Growth_factor as follows:

$$c = \ln(1 + \frac{\ln(Growth\_factor + 1)}{b})$$

We calculate the series of values in the curve by using the value of the previous element of the series as the ‘Initial_value’ of the next element in the series.