License Exempt Spectrum for Short Range Devices

Usage, Benefits and Policies
Contents
Executive Summary ........................................................................................................... 2
License Exempt Short Range Communications ............................................................ 4
Technologies and Standards ............................................................................................ 4
  Standards ....................................................................................................................... 5
  Regulatory ..................................................................................................................... 5
  Technical Standards ....................................................................................................... 5
The economics perspective of SRDs ............................................................................... 6
The broader societal perspective ..................................................................................... 7
  Diversity and Innovation ............................................................................................... 7
  Freedom of Choice ......................................................................................................... 7
Considerations for the future ........................................................................................... 8
  Open Spectrum Regulations ......................................................................................... 8
  Better Compliance Requirements ................................................................................. 9
  More License Exempt spectrum .................................................................................. 10
Appendix .......................................................................................................................... 12
The economics perspective ............................................................................................. 12
  Bluetooth ..................................................................................................................... 12
  Wi-Fi ............................................................................................................................... 12
  ZigBee ............................................................................................................................ 13
  Bespoke designs ............................................................................................................ 14

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Executive Summary

This document argues that making more license exempt spectrum available would benefit the European economy and society. It describes the many uses and benefits of license exempt short range radio equipment – frequently referred to as SRDs – which provides a large share of untethered connectedness for a wide variety of purposes ranging from professional broadband networking to medical devices and sensors for remote monitoring of homes.

The economic value contained in and generated by SRD equipment is huge. A key example is Wi-Fi: from inconspicuous beginnings as a cable replacement it has grown into the world’s most frequently used medium for short range data transfer. Using available figures for the installed base of such equipment and applying multipliers for the value of associated services and user benefits suggests that the annual economic value of SRD equipment exceeds 100B€ per year.

The societal value of this class of equipment is broad as well as various: it ranges from freedom of choice to driving innovation, from freedom of usage to providing new services. Freedom of choice enhances the quality of life for people of any age, occupation or status. This should be contrasted to service provider offered products that are necessarily less varied in function and frequently costly to use.

Because of the very large economic value and quality of life factors associated with the use of license exempt radio equipment, additional spectrum would offer major benefits for the European economy. Care has to be taken in designating additional spectrum as well as in regulatory requirements that affect users as well as market access. The current trends of emphasizing the importance of (spectrum for) cellular services and “spectrum efficiency” could deny market access to many, user friendly types of wireless products with low spectrum load and good spectrum sharing properties. Such trends could kill the goose with the golden eggs.
License Exempt Short Range Communications

From the perspective of the typical user (and ignoring non-civilian use and a few details), the radio world presents a dichotomy: licensed spectrum use on a commercial basis and license exempt use on a private, non-commercial basis. Both types of use have great economic value but there is a major difference: the concentration of revenues on the one hand and the riches of diversity of widely available short range equipment – including equipment formally known as “Short Range Devices” or SRDs – on the other hand.

SRDs are used for a wide variety of applications and functions, ranging from Wi-Fi used for broadband data transfer at gigabit rates to ultra low rate wireless sensor links used in smart home applications. Driven by the digitalization of all aspects of life and the emergence and ubiquity of the smartphone, SRD’s, notably Wi-Fi, now account for 70% to 80% of the world’s wireless data transfers. In the coming years, SRDs are poised to become the nerves of all smart homes and buildings as fuel prices remain high and “green = good” remains dominant in the public mind.

SRDs are also used for medical purposes and assisted living. These span a wide range of functions from miniature diagnostic equipment to remote diagnosis and intensive care equipment. Assisted living – or eHealth – applications include hearing aids but also remote monitoring and support of people and their living quarters which allows them to retain their freedom and general quality of life. Given the diverse types of connectivity needed in these applications and assisted living situations, the coincident use of multiple SRD technologies is the rule rather than the exception. This testifies to the resilience of these technologies.

The concepts “Internet of Things” (IoT) and machine to machine communications (M2M) have been around for more than 20 years\(^1\) and form a growing sector in the information economy; it deals with devices talking to each other – light switches with lights, traffic lights with cars and electricity meters with the electricity network, to name a few things. The spread of IoT into the private domain is driven by the emergence of two unrelated developments: low cost wireless sensors and cloud computing: both reduce and simplify data collection and processing. Coupling sensors to the cloud requires wireless connectivity and, in view of the large scale of use, it is likely that industry standards such as ZigBee and Bluetooth will be the main types of SRD in this sector. The density of devices in IoT applications varies widely – from the high density in the factory or processing plant to the low density of smart grid data collection. This requires an equally wide range of technical properties and regulatory allowance.

Technologies and Standards

The range of wireless means is as large as the range of applications of SRDs. In addition to Wi-Fi for broadband connectivity, Bluetooth and ZigBee are widely used as well with the focus of latter being in low bandwidth, power efficient monitoring and control functions. These three major technologies are not the whole story. There are many products on the market that rely

\(^1\) See e.g. http://www.vs.inf.ethz.ch/publ/papers/Internet-of-things.pdf (Informatik- Spektrum 33 (2)
on bespoke designs for transmitters and receivers that have to operate under constraints not accommodated by these standards. Examples are hearing aids and medical/assisted listening devices that use ultra low power/very small size transceivers.

Standards

Deployment of SRDs is subject to regulatory and technical standards. The former are de facto mandatory in nature and serve to protect market players from each other. The latter are voluntary in nature and serve to create large markets and their associated “eco systems” of suppliers, vendors, application developers and service providers.

Regulatory

Over time, a whole range of frequency bands for SRDs has become available\(^2\) ranging from 7.6MHz to 246GHz; only 105MHz of this range is available for SRDs below 5GHz. Even within rather narrow frequency bands such as the 863-870MHz there are regulatory constraints on RF power and duty cycle that vary by an order of magnitude. This confusing state of affairs reflects the ad-hoc process through which SRD regulations have grown over time.

The European Telecommunications Standards Institute (ETSI) has developed a series of “harmonised standards” for SRDs that reflect the above regulatory complexity. These harmonised standards have legal status and apply throughout the EU. They specify minimum technical requirements that equipment must meet to offer (presumed) compliance with the essential requirements formulated by Europe’s top regulatory authority\(^3\), the European Commission. In the case of radio equipment the relevant document is the Radio Equipment Directive.\(^4\)

Technical Standards

Before the emergence of broadly accepted technical standards for short range wireless applications developed by the wireless industry, SRDs tended to be implemented as bespoke designs created and tailored for a given purpose, application or form-fit. Although the role of bespoke designs remains important – notably in medical applications and small form factor/high efficiency products, the role of technical standards is growing rapidly, due, in part, to the significant cost reductions possible through standardized designs and components.

Whereas regulatory standards impose limitations, technical standards specify capabilities that manufacturers can and do choose from. Technical standards exemplified by IEEE standards 802.11 (Wi-Fi) and 802.15 (Bluetooth and ZigBee) owe their success in wireless markets because they provide the technical basis for large eco-systems consisting of chip suppliers, equipment vendors, application developers and a variety of service providers providing various forms of support for users. The IEEE standards tend to provide supersets

\(^2\) See e.g. ERC Recommendation REC 70-03 and Commission Implementing Decision 2013/752/EU
\(^3\) See Radio Equipment Directive 2014/53/EU
\(^4\) Alternatively, expert opinion may be invoked to decide if a product complies with the intent of such a standard even if it does not comply with the letter of that standard
of technology which contain many functions and features. The commercial counterparts of the above gremia like the Wi-Fi Alliance, the Bluetooth Sig and the ZigBee Alliance, focus on selecting subsets from the supersets and so reduce the development burden while at the same time increasing the potential market size through compatibility testing and or performance validation.

The rate of adoption of a new technology depends heavily on the growth of the supporting eco system. In other words, no eco system, no market. On the other hand, over time, the breadth of applications supported by the eco-system tends to widen in one way or another. Thus we see Wi-Fi as low power/high bandwidth option in smart phones, Bluetooth in hearing aids and Assisted Listening Devices and ZigBee in smart grid data collection applications.

The economics perspective of SRDs
License exempt equipment, including SRDs, used to be a sort of economic backwater that was of little interest or value. The regulatory status of the spectrum they use reflects that: the conditions of use include “no generation of interference and no protection from interference”. The backwater proved valuable as a playground where inventors could try out their designs without the need for a long and costly spectrum designation process. This was demonstrated by the FCC in the late 1980’s when they opened up three bands until then designated for non-radio applications – ISM bands at 912MHz, 2.4GHz and 5.8GHz – for wireless communications applications. That action enabled IEEE to establish Committee P802.11 charged with the development of wireless LAN technologies – which became Wi-Fi. Before long this was example was followed by Committee P802.15 for Personal Area Networks which standardized the bespoke Ericsson design called “Bluetooth”.

Thus a whole new industry was born in a spectrum sandbox. And it still sits there although it has outgrown the ISM sandbox.

Table 1 provides some insight into the numbers of the main short range equipment technologies. The Appendix provides more details.

The figures refer to worldwide estimates and projections; given the relative size of the EU economy, about 1/3rd of the values apply to EU markets. This puts the currently installed base in the EU of all types of short range equipment using the 2.4GHz band at well over 5 billion devices. Double digit growth rates suggest a doubling in 5 to 7 years.

The economic value of a technology has two major components: the value of the installed base the value generated by services provided to the users and the value generated by the usage of that technology.

Using available figures for device volumes and applying a multiplication factor of 3 for technology related services and the same value for user benefits we get a generated economic value of approximately 100B€ per year over all license exempt equipment used in the EU.
Table 1: License Exempt devices – economic values (EU)

<table>
<thead>
<tr>
<th>License Exempt technology</th>
<th>Value of installed base</th>
<th>Value of associated services/yr</th>
<th>Value of generated benefits/yr</th>
<th>Growth rate/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bluetooth</td>
<td>3B€</td>
<td>9B€</td>
<td>9B€</td>
<td>18%</td>
</tr>
<tr>
<td>Wi-Fi</td>
<td>10B€</td>
<td>30B€</td>
<td>30B€</td>
<td>18%</td>
</tr>
<tr>
<td>ZigBee</td>
<td>1B€</td>
<td>3B€</td>
<td>3B€</td>
<td>&gt;20%</td>
</tr>
<tr>
<td>Bespoke</td>
<td>2B€</td>
<td>6B€</td>
<td>6B€</td>
<td>~5%</td>
</tr>
<tr>
<td>Total</td>
<td>21B€</td>
<td>48B€</td>
<td>48B€</td>
<td></td>
</tr>
</tbody>
</table>

This is a fraction of the 2.8% of GDP for all communications expenditures or ~515.2 B€ of which more than half or ~250B€ is cellular services revenue (source: Eurostat).

The broader societal perspective

Over the last 15 to 20 years, license exempt wireless technologies have become a major factor in the EU and other developed economies. The benefits of these technologies extend beyond the purely economic domain and it is worth contrasting these technologies in this respect with cellular technologies.

Diversity and Innovation

Over time, license exempt wireless technologies have developed that fill a wide range of market segments and market niches. Generally speaking the economic benefits of high volumes are paid for in reduced flexibility of function or usage. A case in point is the cellular industry: the enormous investments required for cellular infrastructure effectively prevent that cellular systems develop the same richness of functionality and diversity as license exempt technologies.

The availability of license exempt spectrum assures that entrepreneurs who see a market opportunity are not prevented from exploiting that through lack of freely available spectrum. Thus both technical and functional innovation is encouraged. The same is not in the cellular domain. Here customer retention and cash flow are the main drivers and the direction is towards monopolization rather than innovation. Note that this is true everywhere: innovation and market dominance do not go together.

Freedom of Choice

The importance of freedom of choice is hard to exaggerate: it is a key factor in the perceived quality of life for people of any age and any occupation or status and it plays a major role in all business sectors – including B2B and B2C transactions. Freedom of choice allows manufacturers to build any type of product and at the lowest possible cost – within the applicable legal and regulatory framework. Similarly, freedom of choice maximizes the benefits for his/her expenditures as perceived by the consumer. This extends into the domain of wireless communications: without license exempt equipment freely available on the market, users would be forced to make do – and pay for – services offered by cellular systems operators.
The corollary of diversity and innovation is freedom of choice for the user/consumer. The reverse is also true – without freedom of choice, innovation has no perspective of potential reward. Thus a distinguishing property of technologies designed for use in license exempt spectrum is that they offer freedom of choice for consumers as well as for businesses.

Notably smaller businesses benefit from the freedom of choice as it allows them to match communications cost with financial resources. The emergence of Wi-Fi and Bluetooth as well as more recently ZigBee, illustrates of the importance of freedom of choice as a factor in the growth and adoption of new technologies. The emergence of the personal computer is another powerful illustration of the importance of this factor. The PC killed its creator (IBM) thanks to the killer app called “spreadsheet” which offered users the freedom to do their own thing rather than having to fit the mold of a mainframe application.

The drive towards maximizing customer retention and cash flow in the cellular domain reduces freedom of choice to the freedom to choose from a small set of options packaged as different services.

Considerations for the future

The emergence of license exempt wireless technologies was enabled by changes in the regulatory domain that opened new types of spectrum usage. Their growth was and is facilitated by the emergence of voluntary industry standards that enabled the growth of ecosystems that rapidly broadened the market share of these technologies. The key factors here are the openness of the enabling regulation and the freedom of choice embedded in voluntary technical standards. Given the economic and societal importance of license exempt wireless technologies it is necessary that these factors continue their beneficial roles.

Open Spectrum Regulations

The largest market for license exempt wireless technologies is the United States and the role of its industry in developing these technologies is even more dominant. Both facts are a direct consequence of the FCC’s policy of minimal restrictions in its spectrum regulations. For license exempt spectrum the FCC’s technical requirements are largely limited to maximizing RF power output and spurious emissions. There are no other restrictions or requirements in the FCC’s rules that apply to “unlicensed spectrum”.

This should be contrasted with the situation in Europe with the 2.4GHz band as example – see Table 2.
### Parameter Comparison

<table>
<thead>
<tr>
<th>Parameter</th>
<th>FCC Part 15 $247</th>
<th>ETSI 300 238</th>
<th>ETSI 300 440</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF power</td>
<td>1 watt</td>
<td>100mW</td>
<td>10mW</td>
</tr>
<tr>
<td>Tx Spurious</td>
<td>.08microwatt</td>
<td>1microwatt</td>
<td>1microwatt</td>
</tr>
<tr>
<td>Antenna gain</td>
<td>Above 6dB, 1 dB</td>
<td>db for dB reduction of power output with antenna gain 3)</td>
<td>db for dB reduction of power output with antenna gain 3)</td>
</tr>
<tr>
<td>Tx modes</td>
<td>FHSS or digital modulation</td>
<td>FHSS or other modulation, timing restrictions</td>
<td>FHSS or other modulation</td>
</tr>
<tr>
<td>Rx Spurious</td>
<td>20nanowatt</td>
<td>20nanowatt</td>
<td>20nanowatt</td>
</tr>
<tr>
<td>Rx Selectivity 1)</td>
<td>-</td>
<td>under consideration</td>
<td>under consideration</td>
</tr>
<tr>
<td>Rx Blocking 1)</td>
<td>-</td>
<td>under consideration</td>
<td>under consideration</td>
</tr>
<tr>
<td>Medium Utilization 2)</td>
<td>-</td>
<td>&lt;10% if no LBT</td>
<td>-</td>
</tr>
<tr>
<td>Listen Before Talk</td>
<td>-</td>
<td>optional</td>
<td>optional</td>
</tr>
</tbody>
</table>

Table 2: Comparison of FCC and ETSI compliance requirements for 2.4GHz equipment

1) These parameters will become mandatory as part of the EC’s Radio Equipment Directive to include receiver parameters in all harmonised standards.

2) This parameter is the product of duty cycle and radiated RF power level

3) This restriction discourages the use of more spectrum efficient directional antennas

Clearly, the EC’s compliance requirements are more restrictive than those of the FCC. The operational impact of these restrictions is important because it limits new solutions to communications needs. On the other hand the larger degree of freedom in the US has not lead to problems in practice: most Wi-Fi products are shipped with transmitters that deliver ~100mW RF power. In other words, the European restrictions serve no practical purpose but they do freeze the status quo and limit freedom of choice.

The EC’s Radio Equipment Directive includes “efficient use of spectrum” as an essential requirement that has to be accounted for in each harmonised standard by parameters such as Receiver Selectivity and Blocking. The purpose is laudable but in the implementation at committee level, radio orthodoxy tends to take precedence over practical relevance. The reason is that in a shared, license exempt frequency band there are many factors that affect spectrum usage and there are equally many ways to optimize such usage at the systems level – without resorting to orthodox receiver requirements that drive up costs for all concerned. The result of this process could be regulatory requirements that limit the ability of EU industry to compete with its US and Chinese counterparts in the EU and other markets. That is not what the Commission had in mind.

**Better Compliance Requirements**

The preceding section shows that the EU’s radio regulations and associated standards are more restrictive than those of the FCC and other Administrations. This difference could possibly be justified if the restrictions could be shown to provide certain benefits such as avoiding over-use of a spectrum band. Economic literature provides many examples of the
notion of “tragedy of the commons” – the overuse of shared resources because too many users are greedy enough not to worry about their fair share.

A recent Dutch report ⁵ shows a possibly real case of such a tragedy of the 2.4GHz commons: too many users with gear that is too aggressive in acquiring spectrum access. Do we have here an example of failure of the market? The policy of “let the market do what the markets does best” may be right in some cases, when a prisoners dilemma plays a role, such a policy fails. Markets need some form of regulation but agreement on what to regulate and what to leave to market players is a difficult question that has not been answered successfully.

The regulation that is in place imposes limits of RF power and unwanted emissions and, since a few years, it requires polite spectrum access for high duty cycle gear like Wi-Fi. It imposes detailed requirements on LBT (listen-before-talk) and other access techniques but there is no word about other factors that play a major role in medium access such as channel choice and contention window settings that scale with channel load. Setting specific technical requirements for such parameters is not the task of the regulator or even the ETSI standards – the constant technical evolution requires permanent revisions of the harmonised standards and the technical knowledge required is a potential barrier. The solution is to generalize the requirements.

Traffic regulation provides an interesting example of how a broad goal like road safety can be achieved without fixing a lot of technical detail. It includes not only speed limits but also requires vehicles to stay in a lane, adjusting their speed to traffic flow, etc. This suggests that 2.4GHz regulation should include not only basics like RF power restrictions but also should encourage good frequency selection and adaptation to spectrum load, e.g. in the case of Wi-Fi through beacon rate and contention window size. Such behaviour does not need complex rules and parameters to be effective and therefore it is easily verified – in the laboratory as well as in the field. Although the benefit of such “behaviour requirements” is clear, implementing such a regulation may not come easily due, in part, to the inertia of the gremia involved.

More License Exempt spectrum
The currently available bands for SRD use provide a total of less than 105MHz or about 2% of the spectrum below 5GHz. Above 5GHz there are some 600MHz of spectrum available for wireless access system and intelligent transport systems but that category lies outside the scope of this paper. For cellular communications, more than 10 times as much spectrum – between 400MHz to 3.8GHz – has been designated and/or auctioned.

The three most important designations for SRDs are grouped at 863-875MHz, 915-921 MHz and 2400-2483.5MHz; together these make up 101.5MHz out of the above total. 83.5MHz is shared with ISM applications. As noted above, Wi-Fi, Bluetooth and ZigBee technologies, together with host of bespoke solutions operate in the 2.4GHz band because that band was

⁵ See http://www.agentschaptelecom.nl/sites/default/files/research_license_exempt_spectrum_netherlands_-_v1.0.pdf
easily accessible and provided few restrictions – originally this was also true in the EU. The economic and societal importance of these technologies suggests that making more frequencies available would increase the benefits of all concerned. In fact, the 2.3GHz band, recently designated for use by LTE-TDD, would have been an interesting possibility. Future re-designations of spectrum below 5GHz should consider making more spectrum available for license exempt use rather than creating more opportunities for cellular operators to make revenue from a common resource.
Appendix

The economics perspective

License exempt equipment, including SRDs, used to be a sort of economic backwater that was of little interest or value. That lowly status enabled the promotion of the backwater into a playground where inventors could play around with new ideas and technologies. That probably was the thinking at the FCC in the late 1980’s when they opened up three bands until then designated for non-radio applications – the ISM bands at 912MHz, 2.4GHz and 5.8GHz – for wireless communications applications. That action enabled IEEE to establish Committee P802.11 charged with the development of wireless LAN technologies. Before long followed P802.15 for Personal Area Networks which standardized the bespoke Ericsson design called “Bluetooth”. A whole new industry was born – in a spectrum sandbox. And although grown a lot, the baby still sits there.

The following provides some insight into the figures of the main short range equipment technologies. The figures refer to worldwide estimates and projections; given the relative size of the EU economy, about 1/3rd of the values apply to EU markets. This puts the currently installed base in the EU of all types of short range equipment using the 2.4GHz band at well over 5 billion devices. Double digit growth rates suggest a doubling in 5 to 7 years.

Bluetooth

According to the IHS Report “Bluetooth Market Analysis” of August 2014 the worldwide installed base of Bluetooth chipsets and devices exceeds 10 billion devices. Shipments in 2013 were 2.4 billion growing to 4.7 billion in 2018, a growth rate of 18%. At 2€ per embedded device, this represents a value of 38€ for devices and a multiple of that in terms of services in the EU market.

Since 2011, Bluetooth encompasses two flavors: classic Bluetooth and Bluetooth Low Energy. The attach rate of both flavors is growing in all market segments – smart phones, tablets, mobile PC, TV’s sets, etc. More than half of the growth in volume is taken up by the increasing attach rates for mobile phones. Decreasing form factors and decreasing power consumption combined with improved throughput assures a long life and a broadening range of applications for Bluetooth technology.

Wi-Fi

Wi-Fi devices span a wide range of performance, size and power consumption. These reflect the diverse applications this technology is used – including 97% of the world’s internet access on smartphones and tablets. In addition to large scale consumer use, Wi-Fi is increasingly used in businesses, schools and hospitals as part of their wireless infrastructure. Wi-Fi attached to cable or DSL networks is increasingly used as public access facility. The Wi-Fi Alliance estimated in 2014 that the installed base exceeds 4 billion devices. By far the largest share is single band, 2.4GHz technology. The implication is that the installed base of 2.4GHz capable Wi-Fi devices will grow to well over 6 billion devices that carry more than 60% of the world’s
wireless data. At a typical cost of 5€ per embedded device this represents a value of 10B€ for devices and a multiple of that in terms of services for the EU market.

Unlike Bluetooth, Wi-Fi feels the competition of the cellular industry. The share of the cellular wireless data is increasing, driven by lower fees and higher data rates. It is more than likely that the expansion of 3G into 4G and now 5G is driven by the realization in the cellular world that Wi-Fi could become a serious threat to cellular revenues. Looking at the Wi-Fi technology explains some of that concern: data rates in the Gb/s range, reasonable power consumption and low cost. The other part of the explanation is the emergence of the packetized IP protocol as the main carrier of data, regardless content. Voice, video and simple internet access all use the IP protocol as basis. Wi-Fi was designed from the ground up to be IP compatible, for the cellular world IP has proven a complex and expansive nut to crack – only 4G networks can transport IP with reasonable efficiency.

Providing Wi-Fi levels of capacity with licensed spectrum requires major cell size reduction and therefore vast outlays in infrastructure – which in the case of Wi-Fi are borne by the user or network owner. That business model motivates the emergence of “unlicensed LTE” – LTE operating in license exempt spectrum but still tied closely to the operator’s macrocell network. That keeps the user tied to the cellular service provider – and that keeps the monthly fees flowing to the operators. That goal is the driving force behind the stories of the “coming spectrum crunch” and the need for “1000X capacity”.

From an economics point of view the choice between LTE-U and Wi-Fi is a choice between de facto monopolies and open markets. The most probable long term perspective is that both technologies will co-exist in the market – provided suitable ways of sharing spectrum can be developed. So far this is not the case.

ZigBee
Wi-Fi delivers high speed data capabilities and Bluetooth delivers medium rate, short range data transfer capabilities. ZigBee covers low rate data transfers medium distances. Fuelled by the Internet of Things including smart grid applications, ZigBee is the rapidly growing third of the main technologies used for wireless data applications. The technology provides robust multi-channel operation as defined by the IEEE 802.15.4 standard.

According to ABI Market Research(November 2013) annual 802.15.4 device shipments are set to grow from 206 million today to over 730 million in 2019. ZigBee-enabled devices, currently accounting for 74% of all 802.15.4 shipments, are set to continue leading the way throughout this time, reaching over 350 million annual shipments by 2019. In particular, ZigBee will see strong growth in the home automation market, where the share of total ZigBee shipments will rise from around 9% today to 28% in 2019”.

Although there are concerns about congestion of the 2.4GHz license exempt band, the reality is that in most locations, most of the time the performance and capacity of short range equipment is adequate for most users. Therefore, this frequency band will remain heavily used and for the foreseeable future.
If we assume that in the near future, the smart home/smart energy market will penetrate 50% of the households and if we further assume 10 devices per home, the market volume for ZigBee devices is in the range of 150M devices. At 20€ per ZigBee enabled device or -function the market value is in the range of 1B€ for devices and a multiple of that in terms of services in the EU market.

Bespoke designs
The price paid for the main benefit of high volumes – low cost per function – is the narrowing of the application space. Even as the above technologies evolve, driven by the technologists in the standards gremia, the application space remains limited. Therefore, there remains a market for bespoke designs that fill niches not covered efficiently by the mainstream high volume technologies. As noted above, medical and health related applications typically motivate the development of bespoke designs that focus on specific combinations of parameters for power consumption, transmission speed, ranger size and reliability.

If we assume that 5% of the population will require some form of wireless medical device, the market for such wireless enabled medical devices is in the range of 20M in the EU. At 100€ a piece the market value is in the range of 4B€ for devices and a multiple of that in terms of services in the EU market.