

22nd June 2015

Response to:

Public Sector Spectrum Release: Award of the 2.3 and 3.4 GHz spectrum bands

In response to your consultation, I recommend that OFCOM delays the award of the 2.3GHz spectrum in its entirety. Your testing on interference to 2.4GHz band products indicated the risk of interference, which justifies further testing. I believe that the mitigation suggestions proposed by OFCOM are either impractical or not yet technically possible. More work is required before it is safe to deem that we are at a point where devices in the 2.3GHz and 2.4GHz bands can coexist.

In addition, I do not believe that OFCOM has balanced the overall value of the 2.3GHz and 2.4GHz spectrum. In the remainder of this submission I provide some independent inputs into that valuation, which suggests that the commercial and societal value of keeping the 2.4GHz spectrum clear of interference is several orders of magnitude greater than the value of the 2.3GHz licence. At some point in the future it may make perfect sense to allocate the 2.3GHz spectrum to LTE. Today it does not.

Hence I recommend that OFCOM:

- Delays the 2.3GHz auction in its entirety until more research has been done into the issues of interference.
- Understands the technical innovations needed to mitigate interference and plan any auction schedule to align with these.
- Understands how to accommodate the large number of legacy devices which might be affected by LTE operating at 2.3GHz.
- Make manufacturers in every sector actively aware of the consequences to their business, including potential support costs.

Why LTE should wait for 2.3GHz

OFCOM has fallen into the role of refereeing the battle going between mobile network operators, who want more spectrum and the ongoing survival of the 2.4GHz band. The 2.4GHz spectrum is unlicensed, and used by the wireless standards in most consumer devices, including Bluetooth, Wi-Fi, ZigBee and others. If mobile phones start to use frequencies close to 2.4GHz, it will degrade the performance of these products. Internet access may slow down, audio bars and Sonos systems may get noisy, hearing aids will perform poorly, the response of smart home systems could get sluggish or stop. Everything that uses the 2.4GHz band may work less well and have a reduced range, to the point where they're no longer compelling devices. If that happens, users will stop buying products, businesses may close, investors will lose their money and the current Internet of Things bubble will be firmly burst.

There are a lot of "mays" in that. That's because we can't be sure. To their credit, OFCOM have commissioned some tests which show that here is a problem, but they didn't test enough, or new enough products to determine the true extent of the problem. OFCOM's response is to say that manufacturers need to redesign their products to be more resistant to interference. However, that adds cost, the technology is not yet available for small products and it can't be retrofitted to the billions of existing products already on the market. For that reason I believe any

auction should be delayed to give the industry time to test and see if it can develop solutions. Otherwise the costs could be enormous.

OFCOM has a responsibility to "further the interests of consumers in relevant markets". I interpret that as any market which uses spectrum. However, their consultation appears purely to further the interests of the mobile operators. At no point does it consider the relative value to consumers of providing more LTE spectrum versus the loss of value in reducing the performance of products which use the 2.4GHz band. In the consultation document it is stated that "Ofcom has a duty to secure the optimal use of radio spectrum. This will usually be the **highest value use in financial terms**. We therefore have a preference for allowing market based mechanisms - such as an auction - to determine the outcome of an award". This fits poorly with unlicensed spectrum, for which OFCOM cannot gain revenue. However, I believe they have a responsibility to balance the safeguarding public and societal value, as well as providing an assessment of the true costs.

OFCOM have carried out consultations and have performed limited technical testing which, in their words, has "identified potential risk". The reaction to the testing and concerns expressed by standards groups has been to reply that companies need to find mitigation strategies. The suggestions in the consultation document for solving the problems are:

- Adding filters to the products
- Moving to use the unlicensed 5.1GHz spectrum,
- Replacing the wireless connection on smart TVs and games consoles with a cable, or
- Telling customers to move their devices by a metre or more.

These become more ridiculous as you go down the list. The final one harks back to the era when you had to hang out of the window with your TV aerial to get a signal.

The facetious nature of these mitigations suggests that the requests for more investigation by affected industry areas and users, particularly work involving real life measurements, are very necessary. I am concerned that OFCOM's responses show a lack of understanding of the many of the application areas in which 2.4GHz is used, the societal value of which far exceeds their expected license revenue. To illustrate this value I have highlighted a few application areas.

Medical Equipment

A growing amount of health devices are using 2.4GHz, ranging from approved clinical devices to personal health and fitness devices. OFCOM's reaction to representations from their manufacturers is that "Licence exempt bands are not suitable for the deployment of safety critical devices because the frequencies can offer no protection from interference caused by other users". This takes a very limited view, writing off much of the industry. The vast majority of these devices are not safety-critical; they are used for monitoring and control of long term chronic conditions, for assisted living, and increasingly for prevention in the form of health and fitness devices. Few of these will be able to apply any of OFCOM's suggested mitigations, because:

- They are too small to use any filters currently available
- They use Bluetooth, which does not operate in the 5.1GHz band,
- Patients use them *because* they don't have a cable, and
- They work wherever a patient is, not where OFCOM wants them to be.

The way that non-critical devices have been excluded from consideration implies a lack of understanding about the value of data. One of the biggest benefits to telecare is the collection of regular patient data to monitor the state of a disease

or condition. Whereas critical monitors are important and need a reliable, real-time connection, they serve a tiny percentage of those who could benefit from connected devices. As the DALLAS project and the NHS' Whole System Demonstrator illustrated, regular monitoring and feedback can play a very important part in care management. Providing regular data to help doctors, carers and to patients themselves helps them manage their conditions better and live safely at home, saving money and improving the quality of their life. In 2012, the Department of Health estimated that [telecare could save the NHS £1.2 billion](#) over the following five years, largely helped by this sort of device. That's equivalent to around £400 million per year. To put that in perspective, OFCOM's reserve price for the 2.3GHz auction is £20 million per year – 5% of the potential savings for the NHS. It is also worth pointing out that any changes to clinically approved products would take around five years to get to market, so the very earliest that a 2.3GHz auction should be considered from the viewpoint of medical products is 2020.

Impact on the UK Smart Metering Programme

The UK is embarking on a Smart Metering programme, which will involve 28 million homes being fitted with an electricity meter, in home display, comms hub and where appropriate a gas meter. All four devices communicate with each other using a ZigBee radio operating at 2.4GHz. The meters can't be moved (they're screwed to walls), but the good news is that they are large enough to have filters added. That will add about £50 million to the cost of the programme. However, there are some knock-on effects which will cost a lot more.

Tests show that interference will reduce the range, which is important for sending information from the meters to the in home display every ten seconds. DECC's belief is that range will already be a problem in 25% of UK homes. OFCOM's testing suggested that interference could decrease the effective range of a 2.4GHz device by 30%. Based on DECC's propagation data, it looks more likely that this would increase the potential number of homes where smart meters would not reliably communicate with the IHD by a further 10%, not the 0.25% that OFCOM estimates. DECC is working on using an alternative chunk of unlicensed spectrum at 868MHz, but the work on that is painfully slow. If the number of users who cannot get real-time information falls to this level, it seriously undermines the energy savings that the programme is based on, possibly reducing them by over £1 billion.

That's not the only problem. Redesigning every meter, comms hub and in home display will add another 12-18 months delay to the program, which is already running late. That shortens the window of availability for the GPRS spectrum which the programme currently uses and which will disappear around 2025. (That could happen earlier, as I suspect that Hutchinson – a 3G/4G only network, has little interest in preserving spectrum for 2G once they've completed their acquisition of O2.) If this delay means that the average life of the current GPRS modem in smart meters is going to be only 5-7 years, then it makes no sense to roll them out, rather than moving straight to an LTE modem. However, that will add around \$30 to the BoM for each home. That equates to a further £500 million on the programme cost, with another £500 million for the cost of updating meters which have already been deployed. So licensing out the 2.3GHz spectrum could add over £2 billion to the cost of the UK's smart metering programme.

Distracted Drivers

One of the most obvious usages for Bluetooth over the past fifteen years has been in handsfree solutions for drivers. The premise, which is jointly promoted by automotive manufacturers, phone vendors, network operators and equipment suppliers is that using handsfree allows you to safely make phone calls whilst driving. That argument has permitted drivers to make calls when they're on the

road, with a balance of legislation prohibiting handheld usage mitigated by industry support for integrated hand-free capability in a growing percentage of new cars.

What happens when an LTE phone operating at 2.3GHz is used in the confines of a car? The answer is that we don't know, but it is likely to be one of the most severe interference environments because of the close proximity of phone and Bluetooth radio. If it degrades significantly, drivers will revert to holding phones, increasing the likelihood of accidents. It also has a knock-on effect for the connected car, where Wi-Fi and Bluetooth are the primary method of distributing content around the vehicle. The GSMA suggests that the [global value of these services](#) already exceeds €15 billion per year, which equates to around £600 million for the UK.

Cars have room to add filters, but that's not practical as a legacy retrofit. The automotive industry is a slow-moving, safety conscious one, so it would take three years or more for filtered devices to appear in new models, and around ten years for the current legacy devices to be retired from use. As far as I am aware, automotive manufacturers and service providers were not aware of the issues. They need to be. We also need to test what happens in real vehicles, lest driver distraction returns and people start getting killed.

Consumer Electronics and Wearables

Few people understand just how much wireless has transformed consumer products. From internet access at home, to tablets, toys, smart TVs, games consoles, fitness trackers, smart watches, burglar alarms, smart thermostats and soundbars, all of this innovation relies on Bluetooth, Wi-Fi and ZigBee. They are present in low cost fitness devices costing under £10, through home audio systems in the hundreds of pounds to designer smart watches at £10,000+. If the 2.3GHz spectrum is auctioned, none of these will work as well as they did. The performance that delighted users will diminish and segments of the industry could collapse. It appears that OFCOM had little success in spelling out the potential problem for affected manufacturers, or in soliciting their views. It is important that these issues are made apparent to these manufacturers. Too much of the debate appears to have centred around the needs of the mobile operators, and has not been sufficiently inclusive of manufacturers operating in the 2.4GHz band. In general, these companies do not track regulatory spectrum changes – that is not their business. But it does not mean they should be excluded.

Some of these products could add filters to mitigate interference, but that's not a retrofit for legacy products. So OFCOM's hope is presumably that consumers throw their old products away and buy new, replacement ones. That is a policy which is difficult to support.

Fitting filters works where the product is physically big enough to include a filter, but many wearable products are not. In time filter technology will improve and filters will get smaller, but that's probably at least five years away. Filtering and spectral shaping for the power amplifier stages in 4G phones, base stations and femtocells should also improve, helping reduce the problem. But neither are likely to happen and be deployed before 2020.

Looking at these products also shows up another fallacy in OFCOM's conclusions, questioning their understanding of how technology is being deployed in the unlicensed 2.4GHz band. They make the claim that Wi-Fi products could move to the higher 5.1GHz unlicensed spectrum. Some can, but 5.1GHz comes with some practical issues. The range is less at 5.1GHz, which is why many home routers use 2.4GHz. Many products mitigate this by using MIMO technology with multiple antennas, but that only works if you have room for them, which many products

don't. A more important consideration is that running a radio at 5.1GHz takes more power. For power limited products like smart watches, which struggle to get through a day, that's a show stopper.

The result is that whilst mobile phones support Wi-Fi at 2.4GHz and 5.1GHz, products like the [Apple watch don't](#). They only run at 2.4GHz. So anyone who wants to use one with their Wi-Fi, which is presumably 100% of owners, needs to set their routers to 2.4GHz. This will also set their phones and Apple TVs to 2.4GHz. The fact is that the growth of wearables will force more Wi-Fi traffic to move from 5.1GHz to 2.4GHz – the exact opposite of what OFCOM is expecting. Once again, they need to perform tests with more real products and talk to the manufacturers to understand their roadmaps for unlicensed spectrum usage. The consumer electronics market for wearables has been transformed in the last year and will continue to develop. It should not be nipped in the bud by a premature spectrum auction.

As product performance degrades, it will herald the start of additional support costs as irate consumers contact their equipment suppliers. Across the multiplicity of industries involved, that imposed support cost could equal the costs paid for the licences. It would seem unfair to inflict this on an industry which designed products in good faith. OFCOM should consider passing this support responsibility on to the prospective licence holders. A grant of licence to one company should not financially impact another. However, OFCOM might find that the reserve price of £2.5 million per 5MHz may need to be lowered if consequential support costs are included.

Hearing Aids

Another industry which is moving rapidly to 2.4GHz is hearing aids. Traditionally they've been stand-alone devices, amplifying ambient sound, but in recent years they've started incorporating Bluetooth links to provide a wireless connection to mobile phones. Apple recently launched support for a Bluetooth low energy audio link to hearing aids, and work is taking place on a standard which can be used to connect to phones, TVs and public spaces, replacing the forty year old telecoil standard.

The effect of adding Bluetooth functionality has been startling, increasing sales by around 30%. Hearing aids can suffer from being stigmatised, in much the same way as spectacles and orthodontic braces have been in the past. Like those, they are still viewed by many as an aid of last resort – it's generally accepted that users with hearing loss could benefit from wearing them ten years before they do. It appears that the latest miniature designs which connect to mobile phones may be the change that society needs to remove that stigma.

Because of the minimal space available, there is no way that hearing aids could fit RF filters. Maybe in five years filters will be small enough, but people need these connected hearing aids now. The number needing them will increase. Earlier this year, the World Health Organisation [predicted that some 1.1 billion teenagers and young adults](#) around the world are at risk of hearing loss due to the unsafe use of personal audio devices, including smartphones, and exposure to damaging levels of sound at noisy entertainment venues such as nightclubs, bars and sporting events, according to WHO.

Hearing loss has potentially devastating consequences for physical and mental health, education and employment, which carries a cost for society. In 2014 the Ear Foundation [tried to put a figure on the cost](#). It estimated that hearing loss cost the NHS £450 million each year and that the larger societal cost for the UK could be as high as £30 billion. Given the WHO's predictions, along with the increase in retirement age, those figures will only grow. That alone questions the

economics of the 2.3GHz spectrum, which will kill the progress that has been made in hearing aids and assisted listening devices.

OFCOM has largely disregarded concerns from this market, pointing out that only around 1% of UK users have hearing aids which include Bluetooth. That is because they have only just appeared on the market. In five years they will account for the majority of hearing aids. Once again, this shows a lack of understanding of these markets. It's like making a pronouncement a few months after the original iPhone launch that only 1% of users have bought a smartphone, so they can be ignored. [That's what Nokia did](#), and look what happened to them.

Internet of Things

There is general agreement that the Internet of Things, or at least the growth of internet connected products will be explosive. Numbers vary, but estimates for how many devices will be connected in 2020 range from 30 billion to 1.5 trillion, with a conservative figure sitting around 50 billion. Around half of these will probably employ cellular, but any numbers beyond that are likely to be based on Wi-Fi or Bluetooth, operating at 2.4GHz. The predominant reason for that is cost. If we look at billions of sensors, they are likely to be cheap and battery powered, neither of which can be supported by cellular. Today an LTE modem costs around \$40, even before you add in the contract. That price will fall, but the power consumption won't. Future initiatives like LTE-M will help, but are unlikely to cost less than current GPRS modules, or allow long term battery operation. Nor will we have them before 2020. In order to hit the extra tens of billions, the assumption is that the growth of the IoT will come from short range Bluetooth and Wi-Fi links – Bluetooth where it is battery powered and needs to cost under \$5, and Wi-Fi for smart home devices. That is unless their performance is adversely affected by LTE, in which case all bets are off.

There is a massive amount of investment and development going on within the IoT space, driven by these numbers. [Gartner have predicted](#) that in 2020, global IoT hardware and services will generate income exceeding \$309 billion, with accompanying savings of \$1.9 trillion in global economic value. If we do a rough calculation for the UK, pro-rataing it to our 4% of global GDP, that suggests the IoT value for the UK in 2020 will be £200 billion with savings of £1.3 billion. Half of that can probably be ascribed to cellular implementations, but that still leaves £100 billion of products and £650 billion of services that will rely on continuing usage of the 2.4GHz band. By 2020 technical solutions for interference should be in place, but an early auction could disadvantage the UK by making it more difficult to roll out system deployments, knocking the UK out of the top tier of countries developing the IoT. Last year, in a speech at CeBit, [David Cameron promoted Britain's extraordinary tech and innovation sector](#) announcing £73 million funding for research into the IoT. He emphasised that he saw the Internet of Things as a huge transformative development - a way of boosting productivity, of keeping us healthier, making transport more efficient, reducing energy needs, tackling climate change. OFCOM should be aware that impacting performance of products in the 2.4GHz spectrum could throw this opportunity away.

Conclusion

If the 2.3GHz auction goes ahead it not only risks stopping innovations in short range wireless, but also risks making most of the last decade's innovations unusable, turning the clock back on personal connectivity. OFCOM should take the opportunity to set an example to the world by postponing the auction, working with the industry to highlight the problems, better understand the implications and develop solutions.

Auctioning the 2.3 GHz spectrum may make some money for the mobile operators and the Government coffers, but it will cost the UK economy orders of

magnitude more. In time technology will emerge, both for LTE devices and for devices operating in the 2.4GHz spectrum, which will allow them to coexist, but that is likely to be at least five years away. Until that appears and the legacy products have started to disappear, releasing this spectrum could do immense damage. Without more evidence we don't know how severe that will be, but once the spectrum is auctioned, it will be too late to find out.

The message seems clear:

- Delay the 2.3GHz auction in its entirety until more research has been done into the issues of interference.
- Understand the technical innovations needed to mitigate interference and plan any auction schedule to align with these.
- Understand how to accommodate the large number of legacy devices which might be affected by LTE operating at 2.3GHz.
- Make manufacturers in every sector actively aware of the consequences to their business, including potential support costs.

At some point it may make perfect sense to allocate the spectrum. Today it does not.

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