Response to Ofcom's consultation

"Supporting the UK's wireless future - Spectrum management strategy 2020"

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Date: 26 February 2021

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Introduction

About Innovation Lambda

Innovation Lambda is a consulting firm specialising in connectivity founded in 2020 and based in London.

We provide consulting services in the Information and Communications Technology (ICT) and in the Telecommunications, Media and Technology (TMT) sectors to support companies, policy makers and regulators to unleash innovative and sustainable products and services.

Innovation Lambda's position about spectrum policy

Innovation Lambda believes that wide adoption of spectrum sharing techniques is essential to avoid the impending wireless spectrum crunch, ensure both continued spectrum access to current users and, at the same time, foster new innovative uses. We believe that this perspective is in line with Ofcom's commitment to see spectrum used in the most economically efficient manner.

The existing static models used for allocating spectrum on a national scale are often inefficient and unable to handle the explosion of wireless data traffic. Indeed, different areas of the country have different social and economic dynamics which ultimately translate into different spectrum requirements. In this context, it is of paramount importance to develop regulations that provide enough flexibility without hindering economies of scale.

We believe that it is important to enable shared access to bands unless it is clear that this is not possible. We believe that sharing improves the efficiency of use and therefore increases the contribution to the country's GDP. Also, as geolocation databases, artificial intelligence and other tools become more capable, and the business models clearer, new and more effective forms of sharing will open up over the coming years.

The growing number of dynamic spectrum management frameworks that have been developed around the world testifies that these sharing approaches provide several benefits. First of all, these frameworks demonstrate that advanced sharing can be successfully implemented thanks to advancement in the technology. Secondly, that different spectrum licensing approaches can coexist in the same band. Lastly, that these frameworks can enable more effective utilisation of spectrum on a local basis.

Overall, we believe that Ofcom should consider shifting the narrative about spectrum management from "whether spectrum can be shared" to "how spectrum will be shared". This shift in narrative could apply to any spectrum band and can have a particular impact on IMT identified bands, which can rely on large economies of scale.

Responses to questions

Innovation Lambda welcomes the chance to comment on the spectrum management strategy and thanks Ofcom for consulting[1]. In this section we provide comments to the consultation by responding to the questions asked by Ofcom.

Response 1

Innovation Lambda supports Ofcom's vision on spectrum management and believes that the overall approach to the review is balanced and in continuity with the positions taken by the regulator over the recent years.

[1] https://www.ofcom.org.uk/consultations-and-statements/category-1/supporting-uk-wireless-future

We are pleased with the forward-looking approach depicted in the document and we believe that the "Technology Futures" report is a great additional piece of work that allows the reader to better appreciated the breadth and depth of Ofcom's effort.

We observe that the principles presented in the consultation document are applicable to any spectrum band and we were pleased to see that Ofcom openly discussed both the opportunities and the challenges/trade-offs of enabling innovative uses versus ensuring continued access to current users.

We were also pleased to see the consultation document making numerous references to the international scene. We believe that Ofcom's approach to promote international harmonisation whilst retaining flexibility where possible is sound.

Lastly, the one principle that we believe Ofcom underplayed is 'use-it-or-share-it'. Although it appears that this principle is somehow taken into consideration, we believe that it could have been discussed more openly. The European Commission has recently published[2] its "draft Opinion on Spectrum Sharing – Pioneer initiatives and bands". The draft opinion discusses options for the promotion of spectrum sharing, the identification of key pioneer initiatives and bands, and a roadmap for increased spectrum sharing, making direct mention to the 'use-it-or-share-it' principle.

Response 2

Innovation Lambda agrees with the trends identified by Ofcom.

We would also like to highlight the importance that 'reducing environmental impact' will have in the plans of governments in the UK and around the world in the coming years. With this expectation, we believe that the use of low-power communication services might not be as a determining factor as it might seem. Indeed, many additional factors such as network topology and device obsolescence ultimately contribute whether services have a lower environmental impact. It is therefore not straightforward to expect that by having reduced powers, the network will be more environmentally friendly. We believe that whilst encouraging low power communication through spectrum policy can be useful, Ofcom should adopt a holistic view to ensure the environmental impact of new services aligns with the government's goals.

Response 3

Artificial Intelligence / Machine Learning

Innovation Lambda expects that advanced techniques such as Artificial Intelligence will have a growing impact on wireless communications and therefore on spectrum management, whether directly or indirectly.

For example, we expect that new interference and propagation models developed using these techniques will become predominant in the market as they will likely outperform the ones largely used today, which are based on closed-form expressions.

One potential issue that we encourage Ofcom to consider is that these techniques might be available on the market as "black boxes" developed by entities with a commercial interest to not disclose the details of the algorithms. As these techniques might have impact on policy decisions, it becomes important that the regulator has a deep understanding of these techniques and that has the means to benchmark them publicly.

[2] https://rspg-spectrum.eu/public-consultations/

Self-configuring networks

Innovation Lambda believes that in self-configuring and self-optimising networks software will be key from a technical point of view and, even more importantly, for product differentiation. There will likely be impacts on spectrum management too. Our expectation is that companies such as the ones already providing DSA-related services will likely develop thin-layer spectrum-agnostic software that will improve spectrum use efficiency.

Automated spectrum management tools

Automated tools such as geolocation databases have demonstrated to work very well[3] and Innovation Lambda foresees that their use will greatly increase in the years to come not only to coordinate access to shared bands, but also to optimise spectrum use within licensed bands (e.g., by mobile or satellite operators).

These tools are currently being considered by several other countries. For example, the regulator of the Kingdom of Saudi Arabia, CITC, has recently published a public consultation on its "Spectrum Outlook for Commercial and Innovative Use 2021-2023"[4].

From a policy point of view, we see no reason why these tools could not be used in other bands as they are useful everywhere there is a partial occupancy of the band. In Response 7 we present some suggestions to make the geolocation database market sustainable.

We observe that current sharing frameworks using geolocation databases assume that primary users are not aware of other users in the band. From a technical point of view, this assumption makes sense when the equipment used by primary users is old. However, we argue that in many cases recently developed equipment is already spectrum aware and that in the near future self-optimising networks will be able to make use of all the knowledge they can collect, including about spectrum activity. This means that in the future automatic coordination could be considerably improved as we expect that future spectrum sharing frameworks will incentivise coordination among users, including with primary users.

Blockchain

The case for blockchain in spectrum management has been discussed in a number of academic papers and it naturally raises considerable interest. Innovation Lambda is interested in this topic too, but we observe that in most of the cases described in literature the conditions to make this technology required to solve spectrum management problems are not satisfied[5]. Indeed, the single most important feature of blockchain is that users cannot reliably trust each other (and therefore all decisions are published on distributed unmodifiable ledgers). In the case of spectrum management, all spectrum users are either directly or indirectly entrusted by a central entity, the regulator. The regulator already has several instruments to ensure that spectrum is accessed and used according to rules, and it is not clear what blockchain could do that other instruments cannot[6].

That said, there could be cases where short term light licences or access to licence-exempt spectrum could be logged on a blockchain so that the regulator does not need to be involved. The actual benefits of such approach to

[3] The single most important functionality of these tools is to protect the incumbents. To date no episode of real harmful interference has been recognised by any regulator in the world that has adopted sharing frameworks based on geolocation databases.

[4] https://www.citc.gov.sa/en/new/publicConsultation/Pages/144201.aspx

[5] Wüst, Karl, and Arthur Gervais. "Do you need a Blockchain?" IACR Cryptology ePrint Archive 2017 (2017): 375.

[6] Innovation Lambda has heard academic voices claiming that blockchain could ultimately make the role of the regulator obsolete. We believe that this is point of view does not take into consideration all the functions that a national spectrum regulator does.

the ecosystem are yet to be demonstrated commercially, and our understanding is that this use of blockchain would have more to do with smart contracts than with spectrum management.

Terahertz spectrum

Considering that technology is pushing the boundaries of what can be achievable, Innovation Lambda expects that Terahertz spectrum will have some (initially limited) commercial applications within the next decade (such as intersatellite communication using visible light).

In time, we expect that the use of Terahertz spectrum will become more widespread. From a spectrum policy point of view, we believe that, given their propagation characteristics, terrestrial applications using this portion spectrum will unlikely require spectrum licences.

6G technology

With 5G equipment just recently started to be deployed, the market is keen to start the discussions about the next iteration of 3GPP innovation called 6G. As usual at this stage, the expectations for the new technology generation are very high and we expect a consolidation of the requirements within the next couple of years.

From a spectrum management point of view, Innovation Lambda expects that most of the 6G spectrum required for consumer application will not need additional spectrum as a considerable amount can be made available by refarming the spectrum currently used by 3G, 4G and 5G.

Response 4

In 2019 Policy Impact Partners and the Dynamic Spectrum Alliance, published a report on spectrum sharing[7]. The study found significant interest among public sector officials and industry players in exploring new approaches to spectrum sharing in different frequency bands, including those identified for IMT. The analysis conducted in three populous economies in very different regions of the world ¬– Colombia, Malaysia and South Africa – found that IMT spectrum could be exploited further than currently is and stakeholders recognised that more efficient use of this spectrum could help close the digital divide between urban and rural areas.

Innovation Lambda believes that similar considerations could apply to the UK market. We believe that the increase demand for localised spectrum is a consequence of this need for more flexibility to access spectrum, particularly in the bands where the economies of scale that the 3GPP ecosystem brings can be leveraged.

We agree with Ofcom's approach to balance the use of nationwide licences (with coverage obligations) with the opportunity to enable localised access to spectrum to other users. Indeed, notwithstanding the low number of TV Whitespace (TVWS) deployments to date, the TVWS framework has enabled users to locally access the band without risk of interference to incumbent users.

We recognise that there is not a one-size fits-all in issuing licences based on geography size. Indeed, as economic and social dynamics might vary significantly in different areas of the country, Ofcom should pursue a flexible spectrum management strategy benefits from economies of scale of national and international markets, but that can deliver upon the local requirements. The recent proposal on 26 GHz presented at a techUK meeting[8] depicts ways to assign spectrum differently based on the different conditions that different areas of the country might have. We agree with the principles set in that proposal and we encourage Ofcom to consider its adoption more widely to other spectrum bands.

[7] Policy Impact Partners, "Enhancing Connectivity through Spectrum Sharing", September 2019 – Source.
[8] https://www.techuk.org/resource/a-new-approach-to-spectrum-licensing-the-26-ghz-band.html

In the document it is noted that the strategy does not affect the decisions made in relation to the 700 MHz and 3.6-3.8 GHz bands. Whilst we understand the rationale for this decision at this point in time, we observe that the approach does not seem to align with the spirit of the proposal presented in the document.

Indeed, Innovation Lambda cannot help but observe that the rules for coexistence set in the TVWS framework could (still) be modified to allow opportunistic use of mobile spectrum (not necessarily licence-exempt, as set for manually configurable white space devices[9]) whilst protecting the upcoming nationwide mobile services in the 700 MHz band, which will presumably take some time to be deployed across the territory. Similarly, Local Access Licences could apply to the whole 3.4-3.8 GHz band.

We believe that Localised Access Licences are a good tool to increase spectrum use efficiency and we would like to provide a couple of suggestions to improve it further.

The first suggestion is to review the process to allow shorter term use of spectrum possible. This would help certain applications (e.g., TV production) to make use of mobile spectrum for a couple of days or weeks.

The second suggestion is to automate as much as possible the Licence Access Licence application process. This would significantly facilitate use of spectrum which requires short term licences, but also allow Ofcom to reduce the overhead of managing the presumably increasing volume of licence applications.

Finally, we observe that in the case of home entertainment, most of the traffic is and will most likely be carried over Wi-Fi and we believe that Ofcom should ensure that enough licence-exempt spectrum is available allow the consumer market to grow. According to the report recently published by the Wi-Fi Alliance[10], the economic value of Wi-Fi in the UK is over £70 billion, and it is expected to grow by almost 10% by 2025.

Response 5

We agree with the barriers identified for innovation in new wireless technologies and we believe that there are two factors that can help reduce these barriers.

The first is favouring international spectrum harmonisation. Simply put, the greater the market for equipment vendors, the easier will be for new players to find enough financial resources and product differentiation to enter the market.

The second is simplifying equipment certification process. The more the UK diverges from European practices, the higher the costs and the longer it will take for equipment vendors to target the UK market[11]. We therefore recommend Ofcom (and the UK government) to align with already established practices as much as possible and only gradually introduce UK-specific certification where absolutely necessary.

Response 6

Innovation Lambda lauds Ofcom's engagement with private and public sector organisations in the UK through a series of workshops. We are also pleased with Ofcom's engagement with funding and venture capital bodies as we recognise that the telecoms market is often considered too difficult to navigate by those entities, thus reducing the availability of capital for innovation.

[9] https://www.ofcom.org.uk/consultations-and-statements/category-2/manually-configurable-wsds
[10] https://www.wi-fi.org/news-events/newsroom/wi-fi-global-economic-value-to-reach-5-trillion-in-2025
[11] We share the same concerns expressed by Craig Melson from techUK as reported by PolicyTracker on February 2021 in the news article titled "Brexit change to radio equipment certification mark riles device makers" – Source.

We believe that stakeholders would find it useful to have access to the information collected by Ofcom's remote spectrum monitoring systems – although we recognise that commercial confidentiality and security issues might require caution.

We observe that the 24th of September 2019 appears to be the date of the last update to the UK Spectrum Map. We cannot confirm whether that is indeed the case and what other spectrum activity might have taken place since that date, but we believe that an important step to improve the quality of the spectrum information would be to develop a system automatically updates the map (and associated metadata) whenever there is a change – or at the very least indicate the most recent change in the UK Spectrum Map. In terms of keeping stakeholders informed, we welcome Ofcom's proposal to publish a Spectrum Roadmap.

We also propose Ofcom to provide on their website an analytics dashboard depicting some key data – which is at the moment only published in file format[12].

In terms of usability of the Ofcom website, we would like to see more advanced filtering capabilities for the Consultations and Statements page[13]. For example, it is currently not possible to find all the responses to the consultations made by an entity.

Finally, we fully endorse the development of Application Programming Interfaces (APIs) to Ofcom's access spectrum management data.

Response 7

Innovation Lambda agrees with Ofcom on the proposed approach to make spectrum available for innovation when its future is uncertain. In particular, at the early stages of innovation we believe that test & trial licences and light licences should provide enough basic flexibility. Afterwards, the Local & Shared Access Licences can play an additional and important role for commercial operations together with other more traditional licensing approaches (including licence-exemption, obviously). Indeed, we observe that not all business cases require exclusive access to spectrum and that, in general, the higher the frequency and the less noisy the user in the band are, the lower the barrier (in terms of process and coordination) to access spectrum becomes.

We are very familiar with the opportunities and challenges of automated spectrum management tools and geolocation databases[14] and we believe that especially in bands with a developed equipment ecosystem (such as the ones based on the 3GPP standards), these tools might prove very successful.

We also recognise that automated spectrum management tools might result in additional costs and that it is very important to find ways to make use of these tools not only beneficial to spectrum users (and regulator), but financially sustainable. In particular, rules should allow enough diversification in the way these services are developed and provided. If this does not happen, then it will be difficult for these tools' operators to ultimately develop sustainable business cases[15].

[12] For example, the information about licences (currently published here) could be presented through graphs to make the information more accessible to every citizen.
[13] https://www.ofcom.org.uk/consultations-and-statements
[14] For more information about automatic frequency coordination, please see the report "Automated Frequency Coordination – An established tool for modern spectrum management", Dynamic Spectrum Alliance. March 2019 – Source.
[15] Note that if the only service that can be provided by geolocation databases is device connectivity, then the only realistic business model is to charge a fee per device connected, which becomes financially sustainable only if the number of devices connected is very high (indicatively tens of thousands or more). This constraint means that geolocation databases are not sustainable until enough devices are connected, and it is the role of the regulator to ensure that policies do not accidentally affect emerging ecosystems.

One simple example of rules that can facilitate service differentiation is to not define the details of the calculations which determine the way priority users are protected. This way, it would be possible for some tools to differentiate themselves from the others for example by the amount of spectrum made available for secondary users.

Without provision for differentiation, the market will unlikely be able to sustain costs of geolocation databases. If this happens, it might be better to have the regulator to manage these automated systems (whether directly or through a third party). Nevertheless, we believe that such approach would not be optimal in the long term. Besides operational and costs challenges, this solution would stifle innovation as a regulator would unlikely be able to continuously innovate the tools and provide additional value-added services.

Ultimately, having multiple parties to provide these tools can greatly increase innovation, and there are a few things that we recommend Ofcom to consider in order to make automated spectrum management tools successful:

1. Allow third parties to run these systems and do not constraint the architecture and network topology of the solution.
2. Set minimum protection criteria that spectrum users need to have but allow the database operators to provide different degrees of protection.
    - For example, some database operators might be able to use more accurate clutter information, 3-D protection models, or antenna patterns, and therefore be able to allow more users to operate at a higher price. Other operators might instead adopt simpler models but have lower fees.
3. Enable these tools on different bands and streamline the geolocation database certification process
    - The certification process should be based on the certification of functionalities.
    - As some functionalities will be common across different bands, those do not need to be tested again.
    - When a new band is added to the list, the operators can simply certify the functionalities that are specific to that band and not certified yet.
    - Encouraging region-wide certification recognition programmes.

We finally observe that these systems can only be as accurate as the data that they have. For this reason, the discussion in Section 5 of the consultation document is particularly relevant.

Response 8

Innovation Lambda would like to comment on some parts of the consultation text before Question 8.

In Paragraph 7.17 Ofcom claims that the administrative process for spectrum trades is straightforward.

We observe that one problem with the process to obtain a Local Access Licence (which is under of the spectrum trading regulatory framework) is that the prospective applicant does not have a simple (and automatic) way to know whether spectrum is available before submitting the application.

We propose Ofcom to enable a map-based tool (maybe through third parties) that allows citizens and businesses to check the availability of spectrum in a particular location (or area). We understand that availability does not mean that the licence application will be approved, but we believe that tools like this one would greatly improve the process. A further improvement could be to have the application form to be created directly from this map tool.

From a technical point of view, these tools could be built on API enabled by Ofcom (see paragraph 7.19). We understand that Ofcom might not want to make this tool public in order to facilitate only genuine applications. In this case, the tool (and API) could be designed to be accessible only to registered entities[16].

We finally observe that if the processes for spectrum trading and spectrum leasing were to be automated, in time we might see an increase of spectrum leasing. We agree with Ofcom that in principle leasing is expected to occur somewhat more rarely. However, we believe that the line between trading and leasing, although very clear from a legal point of view, will likely become more blurred from an operational point of view – hence it is important to not introduce unnecessary process obstacles.

In Paragraph 7.27 Ofcom says, "[…] it is conceivable that some of the technologies outlined in Annex 6 could in the future open up new possibilities in market design, for example to automate spectrum trading and determination of pricing". Innovation Lambda believes that automated spectrum management tools could be used in the determination of spectrum pricing too. For example, the price for a local licence could be determined by the radio technology used and by characteristics of the area covered (including for example the number of people covered by the service).

As it is recognised that security of investment has a great dependency on the security of retaining spectrum, we encourage Ofcom to publish a framework for the determination of notice periods, so to provide current and prospective spectrum users with the necessary knowledge to continue their operation in the band and at the same time to evaluate access to other bands.

We agree that automated spectrum management tools can support spectrum management. However, we observe that this is not necessarily true only for spectrum sharing frameworks, although clearly this is where these tools can bring the highest benefits. We also agree that there are additional costs to consider when discussing the appropriateness of using automated spectrum management tools. In Response 7 we provided some considerations.

We agree that key to efficient use of spectrum is to minimise out-of-band emissions and improve receivers' performance. At the same time, we encourage Ofcom to keep a balanced approach when evaluating expected performance of devices based not only on the latest standards (which take time to update), but also on what currently available on the market and the device life cycle.

We are interested in learning more about the way Ofcom intends to use pricing to incentivise better interference rejection capabilities and differential protection. Whilst the principle is sound from a spectrum efficiency point of view, we are slightly concerned that in practice setting the prices would require careful evaluation of many factors whose effects might not be easy to map. Also, if differences in pricing are noticeable, there might be profound consequences for the ecosystem (and possibly some of those unexpected). On the other hand, if differences are too low, then the effect of this measure would disappear.

One additional comment about differential pricing is that as part of this investigation Ofcom should consider pricing advantages if the operator adopts technologies that allow their radios to be more spectrum usage aware. For example, if radios adopt "listen before talk" protocols or can periodically communicate to Ofcom statistics about the way they used spectrum.

[16] In their recent consultation (see footnote 4), CITC mentions explicitly mentions this use case. In Section 3.2 they say, "[…] Importantly, databases can also make it simpler and quicker for users to access spectrum, for example they could automate their request process such that their network planning tool automatically sends requests to the CITC database, which in turn automatically processes them and returns responses, all in a matter of seconds and 17 without any human intervention."

Finally, we strongly agree with the intent to increase realism in coexistence analysis. However, we recognise the complexity, cost and the time needed to periodically update realistic coexistence studies. Ultimately, we believe that in the case of spectrum sharing (especially when automated tools are involved) it is important to set up frameworks which can be periodically reviewed and tuned. This means that sharing can be enabled with some reasonably conservative assumptions which can be tuned as more precise data and coexistence studies are available. To this aim, we observe that the TVWS framework was set with this precise intent. Although as of today Ofcom has not performed major revisions to the TVWS framework, we observe that the FCC continuously improved the framework over the years. Most notably, FCC's recent updates provide flexibility for TVWS to be used for the Internet of Things. Also, the FCC is also taking into consideration whether different propagation methods should be adopted for the protection of the incumbents.

Response 9

No.

Response 10

Innovation Lambda agrees with Ofcom and foresees that the use of automatic tools for spectrum sharing in various IMT identified bands will become more and more important in the next decades.

Response 11

No.

Consultation questions

Question 1: Do you have comments on the overall approach to the review?

Question 2: Have we captured the major trends that are likely to impact spectrum management over the next ten years?

Question 3: Could any of the future technologies we have identified in Annex 6, or any others, have disruptive implications for how spectrum is managed in the future? When might those implications emerge?

Question 4: Do you agree that there is likely to be greater demand for local access to spectrum in the future? Do you agree with our proposal to consider further options for localised spectrum access when authorising new access to spectrum?

Question 5: Do you agree with the actual and perceived barriers identified for innovation in new wireless technologies, and our proposed ways of tackling those?

Question 6: Do you agree with Ofcom's proposals to improve our outreach and reporting activities, and spectrum information tools?

a) Are there additional ways that Ofcom could better engage with existing and future users and providers of wireless communications?

b) Please explain any specific areas where you believe more or better provision of information could provide value to stakeholders

Question 7: Do you agree that it is important to make more spectrum available for innovation before its long-term use is certain? Do you have any comments about our proposed approach to doing this?

Question 8: Do you agree that it is important to encourage spectrum users to be 'good neighbours' to ensure more efficient use of the spectrum? Do you agree with our proposals to:

a) increase realism in coexistence analysis at a national and international level?

b) encourage spectrum users to be more resilient to interference?

c) ensure an efficient balance between the level of interference protection given to one service and the flexibility for others to transmit?

Do you have any comments on which of these will be the most important?

Question 9: Are there any other issues or potential future challenges that should be considered as part of this strategy?

Question 10: Do you agree that continued use of our existing spectrum management tools (as set out in sections 4-7) will be relevant and important for promoting our objectives in the future, in light of future trends?

Question 11: Is there anything else we should be considering doing, or doing differently, to promote our objectives?