Title: European Electronic Communications Code Spectrum Impact Assessment
IA No: N/A
RPC Reference No: N/A
Lead department or agency: DCMS
Other departments or agencies: N/A

Impact Assessment (IA)

Date: 08/05/2019
Stage: Consultation
Source of intervention: European Directive
Type of measure: Secondary Legislation
Contact for enquiries:
eecc@culture.gov.uk

Summary: Intervention and Options

RPC Opinion: Not required at consultation stage

Cost of Preferred (or more likely) Option

Total Net Present Social Value	Business Net Present Value	Net cost to business per year (EANDCB in 2016 prices)	One-In, Three-Out	Business Impact Target Status
£3,472.4m	-£2,312.6m	£0.1m	N/A	0.5

What is the problem under consideration? Why is government intervention necessary?

Spectrum is a valuable national asset and its value should be maximised for the economy through its efficient and effective use. The European Electronic Communications Code Directive (EECC), which the Government intends to transpose fully into UK law, contains a number of spectrum management articles which intend to increase utilisation and promote effective use. Two articles are the subject of this Impact Assessment. The first relates to the enforcement of spectrum licence conditions, the second to the release of high-frequency spectrum for mobile.

What are the policy objectives and the intended effects?

Government seeks to transpose the EECC text into UK legislation to meet its broader objectives of efficient and effective spectrum use and to support the future 'market expansion' model for mobile as set out in the Future Telecoms Infrastructure Review (FTIR). Government anticipates that the articles in question (Articles 47 and 54) will increase spectrum utilisation and promote efficient use, enable improved mobile coverage, support innovation, and help to facilitate 5G roll-out in the UK.

What policy options have been considered, including any alternatives to regulation? Please justify preferred option (further details in Evidence Base)

Option 1: Do nothing - *do not transpose the text into UK legislation*

Option 2 (preferred option):

- Article 47 and Recital 122: transposition of the Article and Recital which state that spectrum licence enforcement conditions must include 'use it or lose it' conditions in **future mobile spectrum licences**.
- Article 54: To allow the use of the 26.5-27.5 GHz of the 26 GHz band for mobile, subject to market demand and the absence of significant constraints and the need to protect essential defence functions.

Option 3:

- Article 47 and Recital 122: transposition of the Article and Recital which states that spectrum licence enforcement conditions must include 'use it or lose it' in all **future radio spectrum band licences**.
- Article 54: To allow the use of 26.5 - 27.5 GHz of the 26 GHz band for mobile and subsequently also make the rest of the 26 GHz band (24.25-26.5 GHz) available for mobile, subject to market demand, the absence of significant constraints and the need to protect essential defence functions.

Will the policy be reviewed? It will be reviewed. **If applicable, set review date:** 2025/2026

Does transposition go beyond minimum EU requirements?		No		
Are any of these organisations in scope?	**Micro** Yes	**Small** Yes	**Medium** Yes	**Large** Yes
What is the CO_2 equivalent change in greenhouse gas emissions? (Million tonnes CO_2 equivalent)		**Traded:** N/A	**Non-traded:** N/A	

I have read the Impact Assessment and I am satisfied that, given the available evidence, it represents a reasonable view of the likely costs, benefits and impact of the leading options.

Signed by the responsible :		Date:	

Summary: Analysis & Evidence Policy Option 1

Description: Do nothing

FULL ECONOMIC ASSESSMENT

Price Base Year	PV Base Year	Time Period Years	Net Benefit (Present Value (PV)) (£m)		
2016	**2017**	**15 years**	**Low:** Optional	**High:** Optional	**Best Estimate: 0.0**

COSTS (£m)	Total Transition (Constant Price) Years		Average Annual (excl. Transition) (Constant Price)	Total Cost (Present Value)
Low	Optional		Optional	**Optional**
High	Optional		Optional	**Optional**
Best Estimate	**...**		**0.0**	**0.0**

Description and scale of key monetised costs by 'main affected groups'

Ofcom has stated that it will make available the 26.5-27.5 GHz band subject to market demand. Whilst Government seeks the timely release of spectrum for future 5G challenges and to ensure efficient use; Ofcom has not indicated specific plans for the 26 GHz band. Therefore, based on this uncertainty, this option assesses the scenario in which this band is made available after the EECC December 2020 deadline. We assume that Ofcom will make the band available in 2022 (in a Best Estimate scenario), in 2021 (in a Low Estimate scenario) or in 2023 (in a High Estimate scenario) based on the administrative and technical preparation required for releasing and allocating the band. In this option, under all estimates, costs will be borne principally by the Ministry of Defence (MoD), who would have to either share or clear their use of 26.5-27.5 GHz. Ofcom will also bear the cost of preparing and making the spectrum available. If industry decides to acquire access to spectrum licences, they will bear the associated costs of this acquisition and any associated capex and opex with deploying the spectrum (for example, through a small cell network).

Other key non-monetised costs by 'main affected groups'

- Article 47 and Recital 122 - Government's objective is to ensure that spectrum is used efficiently and effectively and thus not under-utilised. By doing nothing, we are not actively ensuring that the scarce resource is used efficiently. Therefore, by including licence conditions to enforce spectrum utilisation, as explored in the other options, this barrier to new players entering the market would be addressed.
- Article 54 - As the United Kingdom will make this band available for mobile later than other countries (Italy, the USA and South Korea have already auctioned the band) there may be non-monetised costs in terms of foregone benefits for the UK. This will be dependent on availability of 5G equipment in the UK market.

BENEFITS (£m)	Total Transition (Constant Price) Years		Average Annual (excl. Transition) (Constant Price)	Total Benefit (Present Value)
Low	Optional		Optional	**Optional**
High	Optional		Optional	**Optional**
Best Estimate	**...**		0.0	**0.0**

Description and scale of key monetised benefits by 'main affected groups'

Article 54 - The benefits accrued from the increase in GDP will begin four years after the 26.5-27.5 GHz release. According to a paper by the GSMA[1] manufacturing and utilities industries are expected to be the largest beneficiary of 5G services which make use of mmWave spectrum (such as the 26.5-27.5 GHz band). It states that mmWave spectrum will be beneficial for the following use cases: virtual reality and meetings, remote object manipulation, industrial automation, next generation transport connectivity, quick deployment/temporary connectivity and high-speed broadband in the home and office.

Other key non-monetised benefits by 'main affected groups'

[1] GSMA (2018), Study on the Socio-Economic Benefits of 5G Services Provided in mmWave Bands. Available online at: https://www.gsma.com/spectrum/wp-content/uploads/2018/12/5G-mmWave-benefits.pdf

According to the same paper by GSMA, additional potential benefits include increased access and availability to more advanced healthcare and education, reduced pollution, increased efficiency in transportation, and enhanced public safety response capabilities.	
Key assumptions/sensitivities/risks **Discount rate** Whilst equipment and technology for 5G is available to service providers, commercial 5G roll-out is not expected until Q4 2019. It is therefore difficult to establish the costs and benefits, and thus the validity of the GSMA and stakeholders forecasted assumptions. To account for this risk, we have reduced the benefits presented in the GSMA paper by a significant proportion by applying optimism bias in line with the Green Book to the capex and opex provided by industry consultants, according to different options and estimates. However, as this option is our base assumption the benefits detailed in Option 2 and 3 are the additional monetary benefits. By doing nothing, for both articles, the full benefits of market efficiency are not realised.	**3.5%**

BUSINESS ASSESSMENT (Option 1)

Direct impact on business (Equivalent Annual) £m:			**Score for Business Impact Target (qualifying provisions only) £m:**
Costs:	**Benefits:**	**Net:**	
0.0	**0.0**	**0.0**	**0.0**

Summary: Analysis & Evidence Policy Option 2

Description: Transposing the minimum requirements of the directive into UK legislation (hereafter referred to as Option 2) - Preferred option

FULL ECONOMIC ASSESSMENT

Price Base Year	PV Base Year	Time Period Years	Net Benefit (Present Value (PV)) (£m)		
2016	**2017**	**15 years**	**Low:** -13,332.4	**High:** 19,731.6	**Best Estimate: 3,720.5**

COSTS (£m)	**Total Transition** (Constant Price) Years		**Average Annual** (excl. Transition) (Constant Price)	**Total Cost** (Present Value)
Low	1.1		2,101.7	**25,584.3**
High	1.4		3,304.8	**40,225.6**
Best Estimate	**1.3**		**3,060.9**	**37,253.3**

Description and scale of key monetised costs by 'main affected groups'

- Article 47 and Recital 122 - Ofcom must enforce adherence with mobile spectrum licence conditions on a 'use it or lose it' basis. As Ofcom already possesses power to revoke a licence, we would theoretically expect there to be continued adherence to the conditions of their licence; thus no significant monetary impact on businesses through spectrum revocation. Instead, there would be greater efficiency of spectrum, either through MNOs or through third parties accessing the underutilised spectrum. As we expect some spectrum to be traded, following the release of Ofcom's spectrum sharing proposals, the cost to business will be compensated by potential commercial revenue streams, resulting in non-quantifiable impact.
- Article 54 - The 26.5-27.5 GHz band shall be made available for mobile by the 2020 EECC deadline subject to the need to protect essential defence functions and the absence of significant constraints within the band and on the assumption that there is market demand. Costs will be incurred principally by the Ministry of Defence, which will have to either share or clear the 26.5-27.5 GHz band to make it available for 5G services. Ofcom will also bear the cost of preparing and conducting spectrum licencing. If industry decides to acquire access to spectrum licences, they will bear the associated costs of this acquisition and any associated capex and opex to deploy small cells.

There are also likely to be some familiarisation costs as businesses understand and transpose the articles.

Other key non-monetised costs by 'main affected groups'

- Article 54 - As only 1 GHz of the 26 GHz band will be made available for mobile, as opposed to the whole band (24.25-27.5 GHz) as explored in Option 3, there would be less spectrum made available for mobile services and thus less revenue generated through its efficient use.

BENEFITS (£m)	**Total Transition** (Constant Price) Years		**Average Annual** (excl. Transition) (Constant Price)	**Total Benefit** (Present Value)
Low	0.0		2,307.5	**26,893.2**
High	0.0		4,176.8	**45,315.9**
Best Estimate	**0.0**		3,656.9	**40,973.9**

Description and scale of key monetised benefits by 'main affected groups'

The benefits accrued from the increase in GDP will begin four years after the 26.5-27.5 GHz release. According to a paper by GSMA[2] manufacturing and utilities are expected to be the largest beneficiary of 5G services which make use of mmWave spectrum. MmWave spectrum will be beneficial for the following use cases: virtual reality and meetings, remote object manipulation, industrial automation, next generation transport connectivity, quick deployment/temporary connectivity and high-speed broadband in the home and office. We have assessed the benefits as the differential in GDP increase between this option and the baseline, considering an earlier realisation of benefits under this scenario (2024 instead of 2026 for the best estimate).

Other key non-monetised benefits by 'main affected groups'

- Article 47 and Recital 122 - both the article and recital will help to encourage industry to fluidly trade and share spectrum, helping to ensure spectrum is fully utilised. Reducing this barrier to entry into the spectrum market will allow new players to invest in infrastructure by making available underutilised spectrum. This new 5G market model has been identified by the Future Telecoms Infrastructure Review (FTIR)[3] as the market expansion model. The latter will fulfill the Government priority to promote efficient investment and innovation in 5G, and ensure that 5G deployment can occur at sufficient pace as new use cases and demand materialise. In a market expansion scenario, the UK would continue to benefit from network competition between multiple national operators. National networks would be supplemented by 'neutral host' infrastructure and private networks to, for example, deliver small cell deployments in urban areas and in-buildings, or to expand rural coverage beyond that delivered by the Mobile Network Operators (MNOs), or to serve new micro-markets such as industry 'verticals' (the potential markets to support the next generation of wireless technology).
- Article 54 - According to the aforementioned paper by GSMA, by allowing the use of the 26 GHz band, additional potential benefits could include increased access and availability to more advanced healthcare and education, reduced pollution, increased efficiency in transportation, and enhanced public safety response capabilities.

Key assumptions/sensitivities/risks	**Discount rate**	**3.5%**
Whilst equipment and technology for 5G is available to service providers, commercial 5G roll-out is not expected until Q4 2019. It is therefore difficult to establish the costs and benefits, and thus the validity of the GSMA and stakeholders' forecasted assumptions. To account for this risk, we have reduced the benefits presented in the GSMA paper by a significant proportion by applying optimism bias in line with the Green Book to the capex and opex provided by industry consultants, according to different options and estimates. This option therefore provides the additional benefits beyond the base option. By allowing use of the 26 GHz band for 5G services and applying 'use it or lose it' conditions to future mobile spectrum licences, the UK spectrum market will benefit from greater efficiency and utilisation.		

BUSINESS ASSESSMENT (Option 2)

Direct impact on business (Equivalent Annual) £m:			**Score for Business Impact Target (qualifying provisions only) £m:**
Costs:	**Benefits:**	**Net:**	
0.1	**0.0**	**0.1**	**0.5**

[2] GSMA (2018), Study on the Socio-Economic Benefits of 5G Services Provided in mmWave Bands. Available online at: https://www.gsma.com/spectrum/wp-content/uploads/2018/12/5G-mmWave-benefits.pdf

[3] DCMS (2018), Future Telecoms Infrastructure Review. Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/732496/Future_Telecoms_Infrastructure_Review.pdf

Summary: Analysis & Evidence Policy Option 3

Description: Alternative approach to transposition

FULL ECONOMIC ASSESSMENT

Price Base Year	PV Base Year	Time Period Years	Net Benefit (Present Value (PV)) (£m)		
2016	**2017**	**15 years**	**Low:** -30,188.5	**High:** 33,933.4	**Best Estimate: 2,536.5**

COSTS (£m)	**Total Transition** (Constant Price) Years		**Average Annual** (excl. Transition) (Constant Price)	**Total Cost** (Present Value)
Low	1.6		4,646.6	**55,221.5**
High	1.9		7,308.0	**86,841.5**
Best Estimate	**1.8**		**6,767.8**	**80,413.2**

Description and scale of key monetised costs by 'main affected groups'

- Article 47 - Ofcom must enforce adherence with spectrum licence conditions on a 'use it or lose it' basis in all future radio spectrum band licences (not just mobile). This would impact not only holders of mobile spectrum licences but all holders of other forms of spectrum licences. However, as we expect some spectrum to be traded, following the release of Ofcom's spectrum sharing proposals, the cost to business will be compensated by monetary benefits, resulting in non-quantifiable impact. We are planning to use consultation to gather data to test this assumption and better understand the impact of this article.
- Article 54 - The 26.5-27.5 GHz frequencies shall be made available by the 2020 deadline subject to the need to protect essential defence functions within the band and on the assumption that there is market demand. Costs will be incurred principally by the Ministry of Defence, which will have to either share or clear the 26.5-27.5 GHz to make it available for 5G services. In 2022 the rest of the 26 GHz band (24.25-26.5 GHz) will be made available. The costs of sharing or clearing this section of the band will be borne by incumbents including companies providing Fixed Links, Satellite receiver Earth stations, Programme Making and Special Event stations (PMSE) and Short Range Devices (SRDs). In both of the processes for making 26.5-27.5 GHz and 24.25-26.5 GHz available for mobile, Ofcom shall bear the cost of preparing and facilitating spectrum licensing. If industry decides to acquire access to spectrum licences, they will bear the associated costs of this acquisition and any associated capex and opex costs necessary to deploy small cells.

There are also likely to be some familiarisation costs as businesses understand and transpose the relevant articles.

Other key non-monetised costs by 'main affected groups'

- Article 54 - As the 26 GHz band is currently being used by various incumbents, there will be a delay in the availability of the band for 5G services.

BENEFITS (£m)	**Total Transition** (Constant Price) Years		**Average Annual** (excl. Transition) (Constant Price)	**Total Benefit** (Present Value)
Low	0.0		4,966.8	**56,653.4**
High	0.0		8,360.9	**89,155.3**
Best Estimate	**0.0**		7,533.5	**82,950.2**

Description and scale of key monetised benefits by 'main affected groups'

The benefits accrued from the increase in GDP will begin four years after the 26.5-27.5 GHz release. We assume the increase in GDP to be equal to option 2 from 2024 to 2025 and to be higher than option 2 from 2026 onwards due to the further release of additional spectrum for 5G services. According to a paper by GSMA[4] manufacturing and utilities is expected to be the largest beneficiary of 5G services which make use of mmWave spectrum. MmWave will be beneficial for the following use cases: virtual reality and meetings, remote object manipulation, industrial automation, next generation transport connectivity, quick deployment/temporary

[4] GSMA (2018), Study on the Socio-Economic Benefits of 5G Services Provided in mmWave Bands. Available online at: https://www.gsma.com/spectrum/wp-content/uploads/2018/12/5G-mmWave-benefits.pdf

connectivity and high-speed broadband in the home and office. We have assessed the benefits as the differential in GDP increase between this option and the baseline, considering an earlier realisation of benefits under this scenario (2024 instead of 2026 for the best estimate) and an incremental percentage increase with respect to option 2 from 2026 onwards.

Other key non-monetised benefits by 'main affected groups'

- Article 47 and Recital 122 - This article and recital will help to encourage industry to utilise their use of spectrum and to use it efficiently - by fluidly trading and sharing spectrum. Reducing the barrier to entry in the spectrum market will allow new players to invest in infrastructure by making available underutilised spectrum. This new 5G market model has been identified by the Future Telecoms Infrastructure Review (FTIR)[5] as the market expansion model. The latter will fulfill the Government priority to promote efficient investment and innovation in 5G, and ensure that 5G deployment can occur at sufficient pace as new use cases and demand materialise. In a market expansion scenario, the UK would continue to benefit from network competition between multiple national operators. National networks would be supplemented by 'neutral host' infrastructure and private networks to, for example, deliver small cell deployments in urban areas and in-buildings, or to expand rural coverage beyond that delivered by the MNOs, or to serve new micro-markets such as industry 'verticals' (the potential markets to support the next generation of wireless technology).
- Article 54 - According to the same paper by GSMA, additional potential benefits include increased access and availability to more advanced healthcare and education, reduced pollution, increased efficiency in transportation, and enhanced public safety response capabilities.

Key assumptions/sensitivities/risks	**Discount rate**	**3.5%**
As the technology discussed in this Impact Assessment is still largely not available in the market, it is difficult to establish whether the benefits and costs forecasted by GSMA and stakeholders will be in line with the actual future costs and benefits. We have accounted for this risk by reducing the benefits presented in the GSMA paper by a significant proportion and by applying optimism bias in line with the Green Book to the capex and opex provided by industry consultees, according to different options and estimates.		

BUSINESS ASSESSMENT (Option 3)

Direct impact on business (Equivalent Annual) £m:			**Score for Business Impact Target (qualifying provisions only) £m:**
Costs:	**Benefits:**	**Net:**	
£0.2	**£0.0**	**£0.2**	**0.8**

[5] DCMS (2018) Future Telecoms Infrastructure Review. Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/732496/Future_Telecoms_Infrastructure_Review.pdf

Evidence Base

Problem under consideration and rationale for intervention

1. Spectrum is a critical national asset and the Government wants to maximise the economic and social value for the UK from its use. Spectrum underpins our daily lives, allowing us to use our mobile phones, watch TV, as well as enabling diverse industries to flourish. In a report published in November 2012, Analysys Mason[6] estimated that spectrum related technologies contributed £52 billion to the economy in 2011. This is estimated to have risen twofold since[7]. It is therefore crucial that spectrum is managed and awarded efficiently.

2. Ofcom, as the national regulatory authority, has a statutory function to manage radio spectrum and ensure that its use is optimal. Under measures introduced by the Digital Economy Act 2017, the Government can set out its strategic priorities in relation to spectrum management, which Ofcom must take account of in exercising its regulatory functions. The Government published its Statement of Strategic Priorities in draft on 15 February.[8] This sets out that the Government's key objectives are to ensure the efficient use of spectrum (including preventing under-utilisation of spectrum), improve mobile coverage to meet demands, encourage innovation and investment in new 5G services to meet future demands, and promote competition in mobile markets.

3. Three spectrum bands have been identified and harmonised at an international level to support the next generation of mobile technology, 5G. These are:
    - 700 MHz - ideal for wide area coverage
    - 3.4 - 3.8 GHz - ideal for capacity uplift in congested areas
    - 26 GHz - ideal for providing high throughput rates and very low latency

4. Ofcom has recently set out its plans to auction the 700 MHz and 3.6 - 3.8 GHz bands on a national basis, and the Government hopes Ofcom will continue to focus on making available the remaining 5G spectrum bands. Ofcom initiated work to make 26 GHz available for 5G in summer 2017 with the publication of a Call for Input. However, it has yet to set out a definitive plan for how it will make the band available for mobile.

5. Previous mobile spectrum bands have been licenced on a national basis to the UK's MNOs. These operators differentiate themselves from their rivals in terms of different measures of network quality (e.g. speed, data and coverage), alongside other factors such as price and brand. Services are delivered through a market-based network competition model. This competitive market structure has driven investment in previous mobile generations. For example, since the spectrum auction in 2013, the MNOs have rolled out 4G coverage at a relatively rapid pace, such that 91% of the UK's landmass now has 4G coverage from at least one MNO, up from 79% in 2017.

6. Despite this progress, there remain areas where mobile connectivity must be improved. The Government is committed to extending geographic coverage to 95% of the UK by 2022. It is also committed to being a world leader in 5G to take early advantage of the benefits from this new technology. We have also set a target that the majority of the population will be covered by a 5G signal by 2027.

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[6] DCMS (2012), Impact of radio spectrum on the UK economy and factors influencing future spectrum demand. Available online at: https://www.gov.uk/government/publications/impact-of-radio-spectrum-on-the-uk-economy-and-factors-influencing-future-spectrum-demand

[7] GSMA (2018), Study on the Socio-Economic Benefits of 5G Services Provided in mmWave Bands. Available online at: https://www.gsma.com/spectrum/wp-content/uploads/2018/12/5G-mmWave-benefits.pdf

[8] DCMS (2018), Public consultation on the Statement of Strategic Priorities. Available online at: https://www.gov.uk/government/consultations/public-consultation-on-the-statement-of-strategic-priorities

7. In July 2018 the Government published the Future Telecoms Infrastructure Review (FTIR) which sets out the Government's assessment of the policies and market conditions required to underpin investment and innovation in the UK's mobile industry. It set out that whilst the national MNOs will be crucial to the future of mobile in the UK, that 5G also creates the potential for market expansion with new infrastructure and service players. The review identified four priority areas:

    - Make it easier and cheaper to deploy mobile infrastructure and support market expansion;
    - Support the growth of infrastructure models that promote competition and investment in network densification and extension;
    - Fund beneficial use cases through the Government's 5G Testbeds and Trials Programme that helps de-risk business models for 5G; and
    - Promote new, innovative 5G services from existing and new players, through the release of additional spectrum.

8. The fourth priority area - spectrum - is particularly relevant for this Impact Assessment. Increasing demand for mobile data can be addressed, in part, by the use of higher frequency spectrum, which enables the provision of higher bandwidth services. In the short to medium-term, demand for capacity is likely to be concentrated in highly populated areas. In addition, the characteristics of spectrum propagation are such that the higher the frequency, the less far it travels (although this could be partially mitigated by 5G technological advancements). This means that, as higher frequencies are used, deployments are likely to be increasingly localised and targeted at areas of higher demand. There is therefore a possibility of higher frequency spectrum being under-utilised without the introduction of flexible, shared spectrum models.

9. The National Infrastructure Commission recognised this challenge in its study Connected Future[9], noting that "Auctioning spectrum licences in large, national scale blocks, at these very high frequencies, risks a significant share of the radio spectrum lying fallow in large parts of the country where it is not profitable for operators … deploying the dense networks described above may not be profitable for the major operators in these areas, yet the spectrum will still be inaccessible to other users."

10. That is why the FTIR noted that we should consider whether more flexible, shared spectrum models can maintain network competition between MNOs while also increasing access to spectrum to support new investment models that could address specific connectivity challenges, including:
    - Community or small provider solutions (e.g. fixed wireless access) to meet the needs of local, often rural, areas;
    - Wholesale-only providers to address urban hot-spots and not-spots (indoors and outdoors) through small cell networks; and
    - Private networks to support innovation in the industrial internet of things, including wireless automation and robotics.

11. In December 2018, Ofcom released its consultation 'Enabling opportunities for innovation' which sets out its plan for spectrum sharing, alongside the upcoming mobile spectrum auctions (700 MHz and 3.6-3.8 GHz). Ofcom have suggested a range of options to facilitate sharing:
    - The ability to directly acquire local licences in three bands (1.8GHz, 2.3GHz, 3.8-4.2GHz).
    - The ability to request leased access to spectrum used by MNOs including 3.4-3.8GHz.
    - A longer term study to look at the use of Dynamic Spectrum Access.

12. Government welcomes Ofcom's continued analysis on spectrum sharing methods, including the focus on moving towards a Dynamic Spectrum Access system. Government therefore believes

[9]National Infrastructure Commission (2017), Connected Future. Available online: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/577906/CONNECTED_FUTURE_ACCESSIBLE.pdf

that Ofcom's approach towards a more fluid spectrum management system works in parallel with the EECC articles explored in this impact assessment.

Market failures

Common Good

13. Radio spectrum has many characteristics of a common (or club) good. From the perspective of its business users the radio spectrum is both rival in consumption, i.e. with more users there are fewer spectrum bands available, and excludable, some business users can be excluded from spectrum consumption as the licensees are guaranteed exclusive access by the regulator[10]. However the degree of both rivalry and excludability might change according to how spectrum is managed. The exclusivity granted to licensees by regulators was originally meant to protect band users against signal interferences; however sometimes it also protects licence holders from competition[11]. Table 1 below gives an overview of how spectrum might be classified according to different exclusivity rights and technology including how different spectrum arrangements can define spectrum as a private, common or club good.

Table 1: Spectrum as economic commodity under different regimes

	Available technology	
Exclusivity rights: (decreasing)	**Original technology**	**Dynamic spectrum access**
Licenced spectrum – full rights	Private good	Private good
Licenced spectrum - easements[12]	Private good	Club good / Public good
Unlicensed spectrum	Common / Open access good	Public good

14. Spectrum management policies, including spectrum ownership and usage rights, are critical to successfully implementing spectrum market trading mechanisms - such as buying, selling, leasing - as they increase transparency and predictability in the market. Using and trading spectrum is impossible without clearly defining rights and obligations to potential users, as is the case for all types of common good (such as land, fishing rights and others). However, spectrum management policies differ by each spectrum band depending on their type of usage. For some bands, exclusivity has been deemed a necessary feature of rival spectrum usage, and in this case spectrum is traded as a private good with clearly defined rights and obligations attached. This is a common characteristic across bands in high demand such as for broadcasting or cellular services.

15. In other cases, usually in bands with lower demand or that are under consideration for experimental use to identify potential uses, spectrum is classed as a common good, with access to frequency bands being non exclusive. Users of this band might be both licenced and unlicenced users, that have to often adhere to specific codes of conduct and technical standards, while not retain any exclusive rights of usage outside highly specified cases. A rigid licence

[10] ACMA (2007), The Economics of Spectrum Management: A Review. Available online at: https://www.acma.gov.au/-/media/mediacomms/Research-library-reports-old/pdf/Economics-of-spectrum-management-pdf.pdf?la=en

[11] Goggin, I. (2007), Spectrum Management and the Achievement of Policy Goals - An Independant Regulator's Perspective", in (ed.), Utilising the Airwaves, OFCOM.

[12] Spectrum is owned but subject to an easement that any and all users that do not meaningfully interfere with the owner's right to spectrum could not be excluded from using the spectrum.

regime encourages the use of spectrum as a private good, while more flexible arrangements can lead to other characterisation such as a common or club good (excludable but non rivalrous use - open to a list of users that can utilise it under certain conditions, most importantly non-interference with other users).

16. As spectrum is a scarce resource[13], a free-market pricing mechanism would not, on its own, remove demand pressures, but would make sure that spectrum is valued according to its degree of economic scarcity. Government aims to ensure resources are fully utilised and thus maximise social welfare. For 'technologists', scarcity is both a regulatory and a technical issue. So the problem is related not only to adequate pricing, but also to designing the right technological instruments to provide instant, interference-free access to any idle (not used) bandwidth. Historically, and as suggested in this Impact Assessment, spectrum scarcity can be managed with technical responses such as using higher frequency bands, increasing technical efficiency (eg. data compression, smaller bandwidths, spectrum reuse) and developing spectrum sharing technology[14].

The UK mobile market structure

17. The cellular network infrastructure market has many of the characteristics of a natural monopoly: high fixed costs and high barriers to entry. The provision of cellular infrastructure requires the construction and maintenance of a large, extensive, and diverse network – with high fixed capital costs. Despite this, in the UK there are four nationwide MNOs offering cellular services through their own network. These are, in order of retail subscriber market share: O2 UK (part of Telefonica Spain), EE (part of BT Group), Vodafone UK (part of the Vodafone Group), and Hutchison 3G UK (part of the CK Hutchison group). There are several smaller sized operators that offer retail cellular services but use wholesale access to MNOs infrastructure (termed MVNOs: Mobile Virtual Network Operators).

18. The presence of four national cellular networks, combined with a planned release, indicates a largely well-functioning and competitive market, with a choice of services for consumers available at a reasonable price[15]. This is in contrast with the state of the fixed broadband infrastructure market, in which the majority of customers are served by a single network (BT Group), with only Virgin Media having a competing presence in large parts of the country. The reasons behind the better functioning of the mobile market are various but two stand out: the absence of a former state monopoly for the provision of mobile services (such as in the broadband market) and the higher importance of operating over capital expenses in the mobile over the fixed broadband market; the mobile market is less capital-intensive than the fixed broadband market, lowering the barriers to market entry[16] (in fixed broadband, each subscriber has a unique line dedicated to them, while in mobile the access network is not dedicated to individual subscribers - lowering the costs in turn).

19. As set out in the FTIR, 5G creates an opportunity for an expansion of the market – in the range of consumer and industry 'use cases', in the type of mobile services provided, and in the number of wireless operators. There is therefore a role for policy and spectrum management in creating the conditions that help support new entrants to grow a competitive mobile market, and to support investment and innovation.

[13] Noam, E. M. (1995), Taking the Next Step Beyond Spectrum Auctions: Open Spectrum Access. IEEE Communications Magazine, 33(12), 66-73.
[14] Hatfield, D. N. (2005), Spectrum Management Reform and the Notion of the 'Spectrum Commons. Southern African Journal of Information and Communication, 4(Spring), 1-12.
[15] The UK compares favourably for mobile broadband prices in comparison to other European states, see more at: http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=50376
[16] GSMA, Comparison of fixed and mobile cost structures. Available at: https://www.gsma.com/publicpolicy/wp-content/uploads/2012/09/Tax-Comparison-of-fixed-and-mobile-cost-structures.pdf

The current legal framework

20. The UK mobile industry is underpinned by two Acts: the Wireless Telegraphy Act 2006 (WT Act) and the Communications Act 2003. The WT Act consolidates enactments about wireless telegraphy and spectrum issues. The Communications Act implements European Decisions into UK legislation.

21. Ofcom's statutory duties derive from both European and domestic legislation. European legislation, reflected in both the WT Act and Communications Act, includes provisions from Directives (including the Framework Directive and Authorisation Directive) and is set to be replaced by the EECC in December 2020. The EECC, when transposed into UK legislation, will introduce new provisions which Ofcom, Government and industry will have to adhere to.

Why are we Transposing the EECC?

22. The EECC was adopted by the EU Council on 4 December 2018 and was published in the Official Journal of the European Union on 17 December 2018. The EECC Directive will have a two year transposition deadline, meaning that the EECC must be transposed into UK law by 20 December 2020. The implementation period (IP) means the UK remains subject to the rights and obligations under the Treaties of the EU, which include transposing EU Directives. The transposition deadline for the EECC falls within the IP, therefore the EECC must be transposed into UK law. At the end of the IP, the body of UK law will be amended to correct deficiencies arising from EU Exit. At that point, further legislation will be needed to remove any provisions that are inoperable or redundant given that the UK will no longer be subject to EU rights and obligations.

What does the EECC mean for spectrum management

23. The EECC seeks to establish coherent management of spectrum across the EU. To achieve this, it introduces greater prescription to the spectrum management framework for the benefit of EU Member States and neighbouring European countries. Whilst the UK currently has most of the provisions already in place, the EECC includes requirements on Member States to release spectrum for 5G and amendments to current regulation on spectrum authorisations and specifically licence conditions. The two main articles/policies subject to this impact assessment are:

    - Article 47 and Recital 122: Article 47 introduces new conditions to be attached to rights of use of spectrum in an effort to "ensure optimal and the most effective and efficient use of radio spectrum". This includes a 'use it or lose it' concept which allows competent authorities to enforce spectrum licence conditions - such as 'level of use' - on a 'use it or lose it', or 'use it or share it' basis. We anticipate this will be applied to all mobile spectrum bands licenced in future, as outlined in our preferred option below. This will minimise the amount of spectrum lying fallow and enable new entrants into the market whilst supporting competition and innovation among current users. Alongside the benefits of quality and speed of services to consumers, there is opportunity for new revenue streams for existing spectrum licence holders through leasing and sharing. Government's ambition is to ensure fluid and open access to spectrum, offering greater consumer choice and diversity in the market.

    - Article 54: Article 54 allows the use of at least 1 GHz of the 26 GHz band (24.25-27.5 GHz) and "sufficiently large blocks" of 3.4-3.8 GHz for 5G mobile services. Whilst the UK -

via Ofcom - has set out its proposals for the 3.4-3.8 GHz band, it continues to assess the market demand for the 26 GHz band for 5G services. The article requires competent authorities to make available (at least) 1 GHz within the 26 GHz band, subject to the need to protect defence functions and providing there is evidence of market demand. As the options below set out, Government has identified 26.5-27.5 GHz as the section of the band to be first made available, before making available the rest of the band. This band will support the roll-out of 5G and ensure harmonisation across Europe.

The European Electronic Communications Code Directive (EECC)

24. As markets and technologies change, the EU updates existing telecoms legislation on a periodic basis. The European Commission first proposed the EECC in September 2016 as part of the its Digital Single Market Strategy. The EECC is a recast of four existing directives that together make up the current EU regulatory framework for electronic communications, which were originally adopted in 2002 and updated in 2009. The four existing Directives, updated and merged into the EECC are:

    - The **Framework Directive 2002/21/EC** establishes a harmonised framework for regulation of electronic communications networks and services and lays down the objectives of national regulators, such as Ofcom. This Directive also set out the framework for assessing SMP in telecoms markets.
    - The **Access Directive 2002/19/EC** harmonises regulation of access to, and interconnection of, electronic communications networks and associated facilities and to promote competition, interoperability and consumer benefits. This Directive empowers regulators to impose access and interconnection obligations and, under certain circumstances, to impose as a last resort the functional separation of a vertically integrated operator (for example, BT and Openreach).
    - The **Authorisation Directive 2002/20/EC** introduces a general authorisation system for electronic communications networks and services by removing the need for individual electronic communications operator licences.
    - The **Universal Service Directive 2002/22/EC** sets out end-users' rights relating to the availability, affordability and accessibility of electronic communications networks and services.

25. The existing framework comprising of the four directives above established a number of longstanding key principles that are consistent with UK Government policy. Indeed, the original 2002 EU framework was closely based on the UK's regulatory approach.
    These six principles are:

    - *Technology neutrality* - Regulation should not discriminate against or in favour of a particular type of technology.
    - *Competition* - Competitive markets should be the main driver of investment and consumer choice. Regulation should be consistent with the principles of european competition law.
    - Member States should make *efficient and effective use of spectrum* for electronic communications services.
    - *Regulation free from interference from commercial interests* - Member States should have an independent national regulator (Ofcom in the UK).
    - *Removing barriers to the single market* - The framework forbids any kind of licensing regime required to operate a service or network. It promotes interoperability and gives operators a right to request network access and interconnection in any EU Member State.

- *A flexible and deregulatory framework* - Market regulation should only be imposed where necessary and proportionate to support competition or to protect consumers. It should be removed when no longer needed.

Headline Changes

26. The EECC broadly aligns with the principles of the current EU telecoms regulatory framework, with a few key differences:

    - Increased focus on investment in fibre and 5G networks: There are new regulatory tools to incentivise investment and increased harmonisation of spectrum management rules.
    - Over the top (OTT) communication services (eg WhatsApp) are brought into scope of telecoms regulation.
    - Increased emphasis on promoting infrastructure competition and investment in very high capacity networks.

Policy Objective

Description of options considered

Article 47 and Recital 122

27. As highlighted above, Article 47 sets out the basic premise for the need for licence conditions to "ensure optimal and the most effective and efficient use of radio spectrum", thereby setting, at a minimum, a 'level of use' for licence holders to meet. The recital reinforces this concept by introducing a 'use it or lose it' policy. Put simply, a licence holder must meet the level of use of spectrum set in the licence conditions, otherwise the Competent Authority will enforce the use it or lose it clause. Government supports spectrum sharing or leasing in place of losing or revoking licences and therefore, whist the Recital is not legally binding, Government plans to transposethe concept into UK legislation.

28. The 'use it or lose it' policy could encourage MNOs and other spectrum licensees to actively share (lease or trade) spectrum. As set out above, spectrum sharing could provide opportunities for both current and new players. With the release of additional spectrum, spectrum sharing models could promote new innovative 5G services; improve rural and indoor coverage; maintain network competition between MNOs; and could spur innovation in industrial internet of things, wireless automation and robotics.

29. Whilst Article 47 outlines how licence conditions should set out requirements such as the level of use and that it could be fulfilled through trading and leasing; the supporting Recital (122) explicitly outlines Member States' power to apply a 'use it or lose it' clause including penalties and thresholds of use[17]. The parameters for determining this will be considered during the next phase of consultation.

Options for preliminary assessment

[17] Article 47 and Recital 122 can be found in Annex A and Annex B retrospectively.

- **Do nothing** - maintain the status-quo and do not transpose Article 47 and Recital 122 into UK Legislation.

- **Option 2 [preferred option]** - transpose Article 47 and Recital 122 with enforcement conditions that enable competent authorities to include 'use it or lose it' conditions into mobile spectrum licences in future.

- **Option 3** - transpose Article 47 and Recital 122 with enforcement conditions that enable competent authorities to include 'use it or lose it' conditions into all future radio spectrum licences.

Preferred option

30. At this stage, the Government's preferred option is option 2 - requiring Ofcom to enforce adherence to level of use on a 'use it or lose it' basis. Mobile bands are currently issued on a national basis - and Ofcom provisionally intends to award the 700 MHz and 3.6-3.8 GHz on the same basis. It has also set out its plans to introduce shared access to spectrum for mobile. We are supportive of Ofcom's proposals and would envisage the new system working in tandem with the Article and Recital.

Article 54

31. The European Commission identified the following bands for 5G services within Europe: 700 MHz, 3.6-3.8 GHz and 26 GHz band. To this end, Article 54 obliges Member States to allow the use of the 3.6-3.8 GHz band and take all appropriate measures to make available at least 1 GHz of the 26 GHz band (24.25-27.5 GHz) by the defined deadline of 31 December 2020, as long as there is clear market demand and no significant constraints to migrating existing users. Ofcom are set to auction 700 MHz and 3.6-3.8 GHz in Spring 2020[18] but has not yet set out its plans for releasing 26 GHz.

32. Different frequency bands have different characteristics, with lower frequencies providing better wide area coverage and building penetration and higher frequencies offering better capacity, but over shorter distances. A mixture of high and low frequency bands are therefore needed by mobile operators to provide a range of services. In Ofcom's consultation for 700 MHz and 3.6-3.8 GHz, it recognises the importance of the mmWave (26 GHz band) as it is "likely to play an important role in the future of 5G, for example for targeted deployments of small cells to support the delivery of services that require very high throughput rates and very low latency".[19]

33. When Government released its 5G Strategy update[20] in December 2017 it highlighted its plan to make the 26.5-27.5 GHz band available for 5G mobile, subject to the need to protect essential defence functions within the band. The UK will continue to explore the benefits of allocating the whole band (24.25-27.5 GHz) for 5G mobile. Ofcom is contributing to national and international technical co-existence studies to understand the impact on existing users[21] and any technical and regulatory measures, including the option to progressively clear 24.25-26.5 GHz on a geographic basis, with regard to the bandwidth required to support 5G.

[18] Ofcom (2018), Award of the 700 MHz and 3.6-3.8 GHz spectrum bands. Available online at: https://www.ofcom.org.uk/__data/assets/pdf_file/0019/130726/Award-of-the-700-MHz-and-3.6-3.8-GHz-spectrum-bands.pdf

[19]https://www.ofcom.org.uk/__data/assets/pdf_file/0019/130726/Award-of-the-700-MHz-and-3.6-3.8-GHz-spectrum-bands.pdf

[20]DCMS (2017), Next Generation Mobile Technologies: An update to the 5G strategy for the UK. Available online at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/677598/Next_Generation_Mobile_Technologies__An_Update_to_the_5G_Strategy_for_the_UK_Final_Version_with_Citation.pdf

[21] Fixed Links, Satellite Receiver Earth stations, Programme Making and Special Events (PMSE) applications and Short Range Devices (SRDs). There is also a harmonisation for automotive radars until 1 January 2022

34. The upper section (26.5 - 27.5 GHz) is currently used on a light, geographic basis by MoD[22]. Discussions between Government, Ofcom and MoD have explored whether MoD could share the spectrum with mobile in order to meet the requirements of the EECC whilst protecting national defence functions currently provided and planned for in the future by MoD. MoD has confirmed that its use is unlikely to overlap geographically with civil demand therefore minimising any harmful interference.

35. The 26 GHz band will be able to provide very high bandwidth and low latency services for mobile services in densely populated areas such as stadiums and shopping malls, homes or businesses. It could also enable fixed wireless access (FWA), and provide signal on public transport such as trains. Stakeholder consultation highlighted some applications of 5G deployments (including mmWave) such as Mobile Augmented Reality, smart- homes and manufacturing, healthcare advances, and autonomous vehicles.[23]

36. The 26 GHz band propagates signal at a fairly short range but with high capacity and is therefore an important agenda item at the WRC-19. The international momentum behind this band (including its release in European counterparts including Italy), identifies the band as a pioneer band for the roll-out and success of 5G services.

Options for preliminary assessment

- **Do nothing** - maintain the status-quo and do not transpose Article 47 and Recital 122 into UK Legislation.

- **Option 2[preferred option]** - transpose text as is and focus on making available 26.5-27.5 GHz, subject to market demand and the need to protect essential defence functions within the band.

- **Advanced transposition** - transpose the text, clarifying that 26.5-27.5 GHz will be made available for 5G use before making available the rest of the 26 GHz band (24.25-26.5 GHz) for 5G, subject to market demand and the need to protect essential defence functions within the band.

Preferred option

37. Government's preferred option, as outlined above, is to transpose the text as is and make available 26.5-27.5 GHz for mobile. A decision will need to be taken as to how the spectrum is made available. Within our preferred option, there appear to be two suboptions - 1) to clear the band entirely, or 2) make it available for sharing. Whilst the economic analysis conducted for this preliminary impact assessment is based on suboption 1 (clear the band entirely) and therefore provides a conservative estimate of the costs of making the band available, we will continue to analyse the cost of making the band available on a shared basis. Government will use the public consultation to examine the demand for the band and the spectrum sharing options, including sharing the upper band (26.5-27.5 GHz) with the current incumbents, Ministry of Defence.

Economic Analysis

Establishing the baseline (status quo)

38. Following conversations with Ofcom we have established that the most reasonable baseline would be to assume that:

[22] This report does not specify the detailed use of the band by MoD for national defence reasons. However, the analysis has been conducted based on figures provided to DCMS by MoD.
[23] Qualcomm (17 Dec 2018), Final response to DCMS 26 GHz enquiry

- **Article 47 and Recital 122** - Ofcom does not take action on unused or under-utilised spectrum
- **Article 54** - Ofcom will make available a portion of the 26 GHz depending on market demand. The auction will not however meet the 2020 deadline established by the EECC.

Article 47 and Recital 122

39. DCMS has built a model that estimates the costs and benefits related to the auction of mmWave under different options and estimates (Art 54). It was not possible to quantify the impact of Article 47 and Recital 122 at this stage, as data on this policy are currently not available and few counterfactual examples exist currently worldwide. DCMS anticipates costs and benefits to have a minimal non quantifiable *net direct impac*t to industry, albeit considerable *indirect impacts* which are analysed below. Costs incurred by companies for sharing or vacating a spectrum band and their subsequent foregone revenues will be realised revenues for the company/ies acquiring the band. Furthermore, as the new spectrum band owners might make better use of the newly acquired spectrum bands, they might generate revenues greater than the initial costs incurred, creating value for the industry[24]. We aim to gather more evidence through public consultation to inform this analysis of the direct and indirect impact of Article 47 and Recital 122.

40. Options 2 and 3 will ensure that companies are well informed when bidding at spectrum auctions that adherence to licence conditions will be enforced on a 'use it or lose it' basis, thereby meeting the Government's objective of making the spectrum market more fluid. This will promote innovation and investment in new 5G services and ensure efficient spectrum utilisation.

41. The key non-monetised benefit of this article and recital would be to significantly reduce barriers of entry and increase the number of players in the 5G market. We expect the effect should be one of market creation and expansion, in line with the government's targets for the mobile market as outlined in the FTIR[25], and we expect it to have a somewhat similar deregulatory impact as in the case of other markets; such as the electricity and gas markets. It will promote efficient investment and innovation in 5G, and ensure that 5G deployment can occur at sufficient pace as new use cases and demand materialise. In a market expansion scenario, the UK would continue to benefit from network competition between multiple national operators. National networks would be supplemented by 'neutral host' infrastructure and private networks to, for example, deliver small cell deployments in urban areas and in-buildings, or to expand rural coverage beyond that delivered by the MNOs, or to serve new micro-markets such as industry 'verticals'.

42. Government envisages that the fluidity of the mobile radio spectrum bands as a result of the 'use it or lose it' sharing principle will lead to benefits of competition. Benefits will include greater consumer choice and diversity in markets, including further innovation and access into the market. A more detailed analysis of the benefits of enabling a secondary spectrum market is provided below.

Benefits of a secondary spectrum market

43. Increasing the efficiency of spectrum allocations can lead to enhanced efficiency and dynamic use of spectrum resources. Allocation of spectrum to different applications through regulatory intervention is typically static, i.e. the domestic and international negotiations required for spectrum regulation run for several years before making spectrum available for use. Hence changes in market conditions, such as changing data traffic demand, emerging applications, user preferences, and new technologies over time[26] can lead to inefficient use of spectrum resources

[24] This is only an hypothesis and we will test it at consultation.
[25] DCMS (2018), Future Telecoms Infrastructure Review. Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/732496/Future_Telecoms_Infrastructure_Review.pdf
[26] Wireless data services are carried over electromagnetic spectrum, with parts of the spectrum being reserved for specific applications to avoid interference, e.g. broadcasting, mobile calls, FM/AM radio etc. Some use cases, such

in the short-term; spectrum use cases can change rapidly due to technology changes and spectrum owners are not incentivised to lease or sell their spectrum to more efficient users. The secondary market for spectrum can facilitate a dynamic allocation of spectrum by adapting to such market changes over time and geographic scales, with market actors trading spectrum when more efficient and thus profitable use cases are identified.

44. Expanding the spectrum market could also lead to better competitive outcomes by further encouraging the wholesale market in mobile. There is existing evidence[27] that wholesale and neutral-host operating models[28] in mobile can be beneficial in terms of cost savings, such as through network co-location[29]. According to EY[30], 33% of all cellular radio towers in the UK were owned by wholesale providers as of 2015, reselling access to all four major MNOs in the UK, reducing the number of radio towers required to provide mobile coverage in the country and decreasing total costs. In some cases this may encourage entry into the market of new players that could otherwise face higher barriers to entry in the form of high capital costs for deploying their own infrastructure, or the requirement to wait for a series of spectrum auctions to take place to secure the required spectrum assets before offering mobile services.

45. Therefore, fostering sharing of spectrum and infrastructure, combined with spectrum trading and leasing, in the UK secondary spectrum market can enhance the mobile industry and its competitiveness. Specifically, it can:
    - Promote efficient use of spectrum through revocation of existing rights in case of non-use or non-compliance with licence conditions;
    - Set minimum technology performance levels;
    - Incentivise existing users to free unused spectrum and improve the protection of unlicenced band users;
    - Provide transparency and regulatory predictability, boosting investor confidence and competition.

Modelling Assumptions

46. The model built by DCMS has focused mainly on Article 54. For this reason the main costs and benefits are related to the auction of mmWave under different options and estimates. Article 47 and Recital 122 have been taken into consideration as the main factors for enhanced competition, but they are not the main focus of this model. Both articles and the recital will have familiarisation costs for the businesses and transposition costs for Ofcom and Government.

47. We had to make assumptions on behaviours of operators, the Government and regulators which we will explore further and refine post-consultation.

Auction timings

48. For the Do Nothing option we will assume the following:

    - **Best Estimate scenario** - Ofcom will auction 26.5-27.5 GHz in 2022;
    - **Low Estimate scenario** - Ofcom will auction 26.5-27.5 GHz in 2021;
    - **High Estimate scenario** - Ofcom will auction 26.5-27.5 GHz in 2023.

as 4G data services on mobile, are in high demand and therefore produce higher data traffic - necessitating in turn more spectrum to operate efficiently.

[27] EY (2015), European Wireless Infrastructure Association Report. Available at: https://ewia.org/wp-content/uploads/2017/10/EU-Tower-Sector_EY-White-Paper.pdf

[28] Wholesale and neutral hosts in mobile refer to the ownership of passive infrastructure such as radio towers by wholesale-only firms which then rent out access to interested MNOs.

[29] Co-location refers to providing a number of services and asset rental to multiple telecom operators over the same infrastructure. This can lead to multiple MNOs using the same radio towers for providing services, decreasing costs in the process.

[30] Ibid

49. For Option 2, Ofcom will meet the EECC prescribed 2020 deadline, making available 1 GHz by 2020. We anticipate focus on the 26.5-27.5 GHz band whilst considering the need to protect national defence and ensuring market demand.

50. For Option 3 Ofcom will make available 26.5-27.5 GHz by 2020, as with Option 2, and then the rest of the 26 GHz band by 2022, hence two award processes will occur.

Summary of costs and benefits

51. Table 2 below summarises costs and benefits analysed in this impact assessment. More information on how the costs and benefits have been calculated and their size is provided in the paragraphs below.

- **Option 2**:
  i. The *direct costs* are familiarisation costs as operators, DCMS and Ofcom get ready to transpose Article 47, 54 and Recital 122 and a cost for MoD to share or clear the 26.5-27.5GHz;
  ii. The *indirect costs* are related to the prices paid by operators to acquire the spectrum band and to deploy the infrastructure needed;
  iii. The *benefits* have been translated to a GDP increase.

- **Option 3:**
  i. The *direct costs* are familiarisation costs as operators, DCMS and Ofcom get ready to transpose Article 47, 54 and Recital 122 and a cost for MoD and businesses to share or clear the 26GHz;
  ii. The *indirect costs* are related to the prices paid by operators to acquire the spectrum band and to deploy the infrastructure needed;
  iii. The *benefits* have been translated to a GDP increase.

Table 2: Summary of costs and benefits

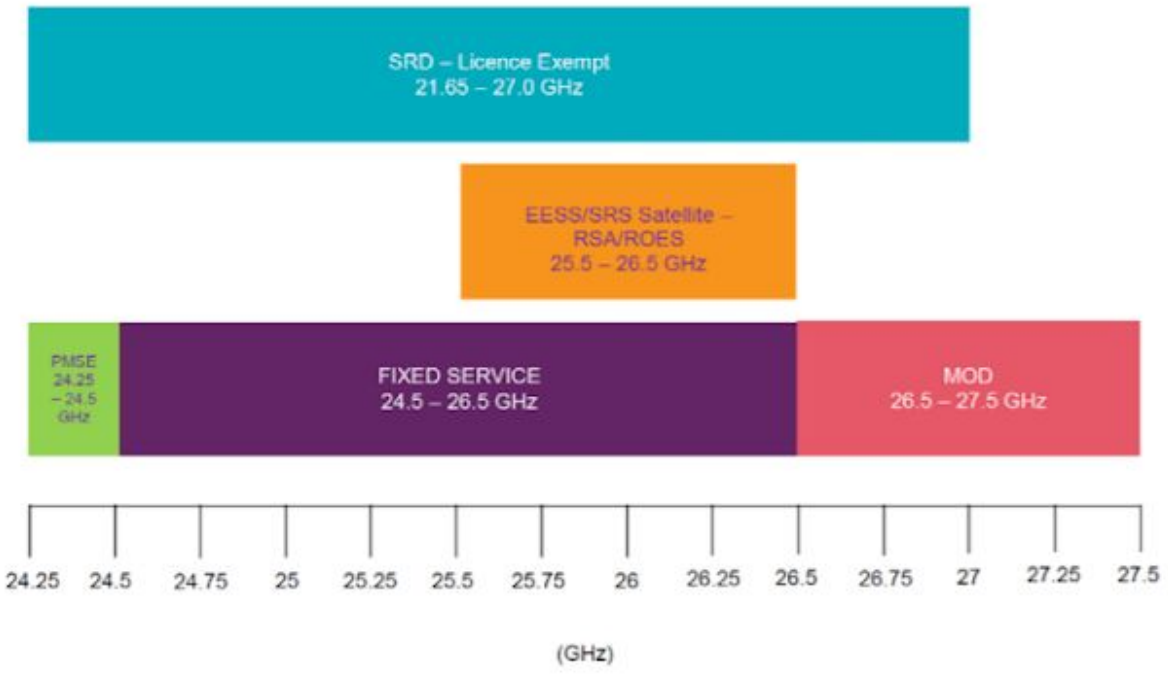
Direct or Indirect	Cost or Benefit	Who	Option 2	Option 3
Direct	Cost	Business	Familiarisation Cost	- Familiarisation cost - Sharing or clearing the 26GHz, which is not MoD owned
		MoD	Sharing or clearing 26.5-27.5 GHz	Sharing or clearing 26.5-27.5 GHz
		DCMS and Ofcom	Implementation costs	Implementation costs
	Benefit	Business	None	None
		Other	None	None
Indirect	Cost	Business	- Auction costs - Deploying small cells	- Auction costs - Deploying small cells
	Benefit	Business	GDP benefits	GDP benefits
		Other	GDP benefits	GDP benefits

Cost of clearing the 26 GHz band - Direct cost

52. In the model we assume that the licence holders in the 26 GHz band face the cost of clearing the band. Due to a lack of data available, we opted for a conservative analysis and the model therefore assumes that licence holders will have to clear the bands rather than sharing. In this instance, clearing will cost more than sharing the band and this difference will be analysed further during consultation.

53. In the UK, the 26 GHz band is used by and is currently available for fixed links, Satellite receiver Earth stations, Programme Making and Special Event stations (PMSE), Short Range Devices (SRDs) and for military uses by the Ministry of Defence (MoD). Figure 1 below shows where, in frequency terms, these authorisations are currently available[31].

Figure 1: UK Authorisations / Grants of RSA for ROES / Permissions for Use



Source: Ofcom (2017) "5G spectrum access at 26 GHz and update on bands above 30 GHz". Available online from: https://www.ofcom.org.uk/__data/assets/pdf_file/0014/104702/5G-spectrum-access-at-26-GHz.pdf

54. The MoD currently grants permissions for defence use of frequencies in the upper 1 GHz of the 26 GHz band. However, the MoD have confirmed that the band is lightly used and could therefore be made available for deployment of 5G on a shared basis.

55. The lower 2.25 GHz of the band is made available for civil use by Ofcom. There are a number of applications that are or can be currently authorised to use the band in the UK. These are Fixed Links, Satellite Receiver Earth stations, Programme Making and Special Events (PMSE) applications, and Short Range Devices (SRDs). Below we quote the high level overview set out by Ofcom[32] for each of these uses:

[31]Ofcom (2017), 5G spectrum access at 26 GHz and update on bands above 30 GHz. Available online from: https://www.ofcom.org.uk/__data/assets/pdf_file/0014/104702/5G-spectrum-access-at-26-GHz.pdf

[32] Ofcom (2017), 5G spectrum access at 26 GHz and update on bands above 30 GHz. Available online from: https://www.ofcom.org.uk/__data/assets/pdf_file/0014/104702/5G-spectrum-access-at-26-GHz.pdf

- **Fixed Links** - These are point to point wireless links that carry a mixture of low, medium to high capacity data traffic between specific geographic locations. They are individually assigned and licenced on a "first come first served" basis and used for a variety of applications, such as backhaul for mobile network operators, fixed networks, utilities, emergency service traffic, TV broadcast distribution, and by several other private and public entities. Within the lower 26 GHz band fixed links are the main use of the band with around 2,800 licences currently on issue across the whole of the UK. Figure 2 contains a map showing the geographic distribution of these links in the UK.
- **Earth Exploration Satellite Service Earth Stations** - Satellite Earth stations in this band are used for receiving Earth observation data, for example satellite imagery and climate data, from Earth exploration satellite systems. The UK currently has one satellite Earth station (receive only) located in Harwell.
- **Programme Making and Special Events (PMSE)** - Typical applications are temporary point to point and portable video links. This band is lightly used.
- **Short Range Devices (SRDs)** - A short-range device is a radio-frequency transmitter device used for the transmission of information. Short-range devices are low-power transmitters with a useful range of few hundred metres, they do not require a licence from its user. Applications for short-range wireless devices include power meters and other remote instrumentation, radio frequency identification applications[33], radio-controlled models, fire, security and social alarms, vehicle radars, wireless microphones, traffic signs and signals (including control signals), remote garage door openers and car keys, barcode readers, motion detection, and many others[34].

Figure 2: 24.5 GHz to 26.5 GHz Fixed links in the UK (June 2017)

Source: Ofcom (2017), 5G spectrum access at 26 GHz and update on bands above 30 GHz. Available online from: https://www.ofcom.org.uk/__data/assets/pdf_file/0014/104702/5G-spectrum-access-at-26-GHz.pdf

[33] Radio-frequency identification (RFID) uses electromagnetic fields to automatically identify and track tags attached to objects, for example an RFID tag attached to an automobile during production can be used to track its progress through the assembly line

[34] Ofcom (2018), IR 2030 – UK Interface Requirements 2030. Available online at: https://www.ofcom.org.uk/__data/assets/pdf_file/0028/84970/ir-2030.pdf

56. In the Do Nothing option we assume Ofcom will ask the MoD to clear the 26.5-27.5 GHz by 2022 (Best estimate), or 2021 (Low estimate), or 2023 (High estimate). The MoD have provided a cost estimation of £0.1-16m to clear the relevant band.

57. In Option 2 we expect the MoD to clear the 26.5-27.5 GHz by 2020. The only difference with respect to the baseline will be an earlier cost for MoD, hence a higher cost present value.

58. Option 3 will have the same cost for MoD in 2020 as option 2, with the additional cost in 2022 of clearing applications that are currently authorised to use the lower 2.25 GHz band in the UK. Companies owning the licences in this band will incur this direct cost by 2022, they will also face a foregone revenue cost as they might be asked to vacate this band before their licences have expired. We have consulted with industry and they cannot currently estimate how much this cost is likely to be and whether part of it will have to be borne by the Government (in case companies are requested to vacate their band before the expiration of their licences). We will use consultation to further explore this potential cost and who should bear it. For the purpose of this model we have assumed this cost to industry to be double the MoD clearance cost, i.e. £0.2-32m.

Familiarisation costs - Direct costs

59. There will likely be some familiarisation costs as operators get ready to transpose Article 47, 54 and Recital 122. This includes reading the regulations and planning how to meet them. It is hard to estimate the potential time it will take to do this, but a broad assumption could be that:

    - **Option 2** - 5% of non-technician staff at telecommunication companies[35] (around 4,400 employees) will spend ten hours each reading and implementing the articles and recital;
    - **Option 3** - 5% of non-technician staff at telecommunication companies[36] (around 4,400 employees) will spend fourteen hours each reading and implementing the articles and recital.

60. The median hourly pay for Private, Information Technology and Telecommunications Professionals in the Annual Survey of Hours and Earning[37] was £21.90 in 2016, we have also uplifted the familiarisation costs by 30% to include overheads[38]. Consequently, the overall familiarisation cost is estimated at approximately, in a best estimate scenario, £1.3m for option 2 and £1.8m for option 3.

Auction costs - Indirect costs

61. If the band is auctioned, the auction costs for businesses, which in turn are Government revenues, have been calculated by comparing the mmWave auction prices paid in Italy (£135m[39]), the USA (£116m[40]) and South Korea (£140m[41]). The Italian auction price has been given a

[35] This broader category does also include companies operating satellites and fixed links.
[36] This broader category does also include companies operating satellites and fixed links.
[37] ONS (2018), Employee earnings in the UK: 2018. Available online: https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/earningsandworkinghours/bulletins/annualsurveyofhoursandearnings/2018
[38] OECD (2005), International Standard Cost Model Manual. Available online at: https://www.oecd.org/regreform/regulatory-policy/34227698.pdf
[39] Telegeography (2018), Italian 5G auction passes EUR4bn. Available online at: https://www.telegeography.com/products/commsupdate/articles/2018/09/21/italian-5g-auction-passes-eur4bn/ The number from the website has been converted from USD to GBP by using an olympic average of the Bank of England average annual exchange rate from 2014-2018, the average has been used in order to avoid yearly exchange rate fluctuations.
[40] FCC (2018), 28 GHz Dashboard. Available online at: https://auctiondata.fcc.gov/public/projects/auction101. The number from the website has been converted from USD to GBP by using an olympic average of the Bank of England average annual exchange rate from 2014-2018, the average has been used in order to avoid yearly exchange rate fluctuations.
[41] Telegeography (2018), MSIT announces results of 5G spectrum auction. Available online at: https://www.telegeography.com/products/commsupdate/articles/2018/06/19/msit-announces-results-of-5g-spectrum-auction/. The number from the website has been converted from USD to GBP by using an olympic average of the

higher weight as the Italian spectrum market bears closest similarity to that in the UK. We estimate the auction cost for the UK to be £135m. This will be refined in our final analysis when more auctions at a European and global level will have taken place. The auction cost is an indirect cost to businesses:

- **Option 2** - the auction cost will be incurred once in 2020, but it will be offset by a benefit of not incurring the cost later in 2022 (best estimate), or in 2021 (low estimate), or in 2023 (high estimate), as in the do nothing option this cost still applies but at a later stage depending on the estimate;
- **Option 3** - same as option 2, with the addition of the industry incurring the same auction cost also in 2022.

Cost of deploying small cells - Indirect costs

62. The Government has introduced recent reforms to planning policy and the Electronic Communications Code (ECC) to make it easier and cheaper to build mobile networks. Measures to date have largely focused on macro cells; however, 5G, in the longer-term, is likely to require greater deployment of small cells. A small cell is a radio access point with low radio frequency (RF) power output, footprint and range. It is operator-controlled, and can be deployed indoors or outdoors, and in licenced, shared or unlicensed spectrum.

63. Small cells complement macro networks - improving coverage, adding capacity, and supporting new services and user experiences. There are various types of small cell, with varying range, power level and form factor, according to use case. The smallest units are for indoor residential use; the largest are urban or rural outdoor picocells[42] [43].

64. 5G, in the longer-term, is likely to see a much greater deployment of small cells. These will be useful to provide extra capacity in specific outdoor locations with high demand, for example city centres, transport hubs and sports stadia. We are also likely to see the growth of small cells indoors to support new 5G-enabled services like factory automation. Spectrum at very high frequencies (mmWave spectrum) can provide much higher data throughput, but will cover much smaller areas and cannot penetrate through walls[44]. 5G deployments in these bands will likely require the deployment of small cells. A paper by the Small Cell Forum claims that in high-population areas, mmWave networks will closely follow existing small cell footprints, i.e. the deployment of mmWave small cells are likely to be used to increase the capacity of existing networks.

65. As small cells are a new technology that is still being trialled, it has proven difficult to find reasonable estimates for their operating and capital expenditure (opex and capex). Based on the estimates provided by Frontier Economics and discussed with industry consultants we have produced the following cost estimation for capex and opex (see table 3 and 4 below)[45]:

Table 3: Capex costs (£bn) for deploying small cells for single, 2 and 4 network/s

Bank of England average annual exchange rate from 2014-2018, the average has been used in order to avoid yearly exchange rate fluctuations.

[42] Small Cell Forum (2018), What is a small cell. Available online at: https://www.smallcellforum.org/what-is-a-small-cell/

[43] A picocell is a small mobile phone base station managed by the network operator to improve coverage.

[44] DCMS (2018), Future Telecoms Infrastructure Review. See online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/732496/Future_Telecoms_Infrastructure_Review.pdf

[45] Frontier Economics (2018), UK MOBILE MARKET DYNAMICS. Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/728816/Frontier_report_on_Mobile_Market_Dynamics.pdf. Please to note we do not claim these costs to be exact and we will use consultation to further refine these with the industry. These costs include an optimism bias of 44% in line with the Government Green Book.

Capex (£bn)	4 Networks	2 Networks	Single network
Dense urban small cells	0.60	0.30	0.22
Urban small cells	12.47	6.24	4.58
Suburban small cells	5.98	2.99	2.20
Village small cells	0.35	0.18	0.13
Road small cells	1.16	0.58	0.42
Total Small cells	20.56	10.28	7.55

Source: Frontier Economics

Table 4: Opex costs (£bn) for deploying small cells for single, 2 and 4 network/s

Opex (£bn/year)	4 Networks	2 Networks	Single network
Dense urban small cells	0.20	0.10	0.07
Urban small cells	4.19	2.10	1.41
Suburban small cells	2.01	1.01	0.68
Village small cells	0.12	0.06	0.04
Road small cells	0.39	0.19	0.13
Total Small cells	6.91	3.46	2.33

Source: Frontier Economics

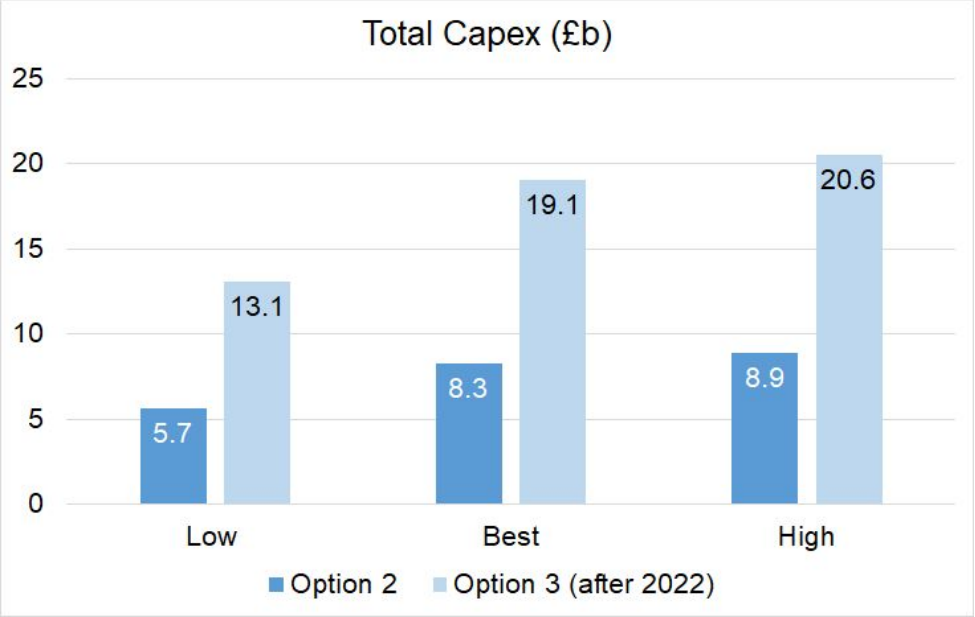
66. There is considerable uncertainty over the business case for multiple small cell networks. Stakeholders appear divided about the return on investment of establishing multiple, and capital-intensive, networks of small cells, potentially opting for a wholesale model instead. Therefore while we would expect each MNO to establish it own small cell network, in our analysis we have to take in consideration the highly likely outcome of MNOs instead opting for alternative investment approaches. Therefore, for options 1 and 2 we have assumed an average of costs in between a single network and two networks. This assumption is based on the number of small cell networks being between 1 and 2 instead of the more ambitious 4 networks. Total capex was divided equally across four years, the first year being when the relevant spectrum auction takes place, i.e. for option 2 investment starts after the spectrum auction in2020 and continues until 2023, while similarly for option 1 from 2022-2025 (best estimate), 2021-2024 (low estimate), 2023-2026 (high estimate). Similarly for opex we have assumed an average of costs in between a single network and two networks. For opex we had an annual cost, hence we have assumed this cost to start one year after the first capex expenditure and then to continue for the years considered[46]. Capex and opex costs for option 1 have been then subtracted from capex and opex costs for option 2, in order to calculate the impact of this option over the baseline.

67. For option 3 we have assumed, in line with article 47 and recital 122, that there will be enhanced competition with respect to the current 5G market. For this reason we have assumed that option 3 will be aligned to option 2 up until 2022 and then the market structure will change to accommodate 4 networks. This forms the more ambitious scenario as discussed above. Capex and opex have been adjusted accordingly post 2022.

[46] We have assumed Opex and Capex to be constant across the years, we aim to refine this assumption during consultation.

68. We have also assumed that in a best estimate scenario small cells are going to be deployed in dense urban, urban and suburban areas. In a low estimate scenario we have assumed that small cells will only be deployed in dense urban and urban areas. In a high estimate scenario, we have assumed small cells will be deployed in all areas (see tables 3 and 4 below). These scenarios reflect the different potential extents of the networks; from the more commercially viable dense urban areas to the less commercially attractive rural areas.

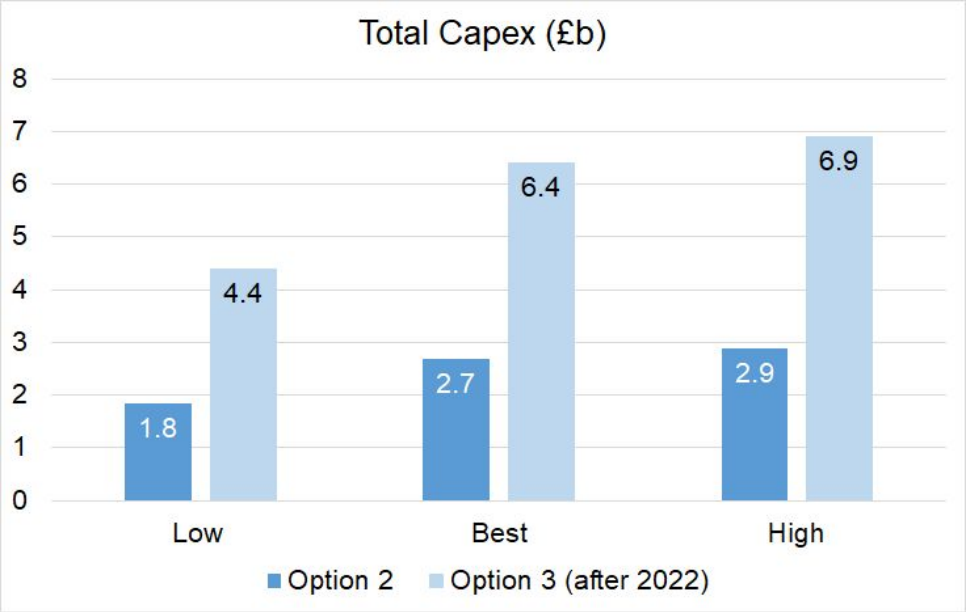
Figure 3: Total Capex costs (£bn) for deploying small cells for option 2 and 3 in a low best and high estimate scenario



Source: DCMS and Frontier Economics for DCMS[47]

Figure 4: Annual Opex costs (£bn) for deploying small cells for option 2 and 3 in a low best and high estimate scenario

[47] Ibid



Source: DCMS and Frontier Economics for DCMS[48]

Implementation costs - Direct costs to Government and Ofcom

69. According to the European Commission Impact Assessment on the EECC[49], each Member State competent authority will employ 25 full time employees (FTEs) in order to transpose the EECC[50]. We have taken this number and divided it for the number of existing directives recast into the EECC (four directives) and assumed that six employees (three from DCMS and three from Ofcom) will work on transposing each directive. Hence three FTEs from DCMS and three from Ofcom will work on transposing the spectrum aspects of the EECC. We have then taken the median pay for an Ofcom[51] and a DCMS[52] employee and multiplied it by three. We have subsequently carried this annual cost from 2020 to 2026, when we assume these policies will be reviewed. We have also uplifted the transposition costs by 30% to include overheads[53]. We have assumed option 3 to be 50% more costly for government and Ofcom with respect to the European Commission forecast, as it is going to go beyond option 2. These costs in a best estimate scenario are £0.3m in option 2 and £0.4m in option 3.

Benefits for mmWave - Indirect Quantitative Benefits

70. The benefits described below are reliant on making the 26 GHz band available, they won't be realised if the mmWave band is not available for businesses to invest and trial new technologies in. The benefits following the auction of part of the 26 GHz have been sourced from the "Study on

[48] Ibid
[49] European Commission (2016), COMMISSION STAFF WORKING DOCUMENT IMPACT ASSESSMENT accompanying the document Proposals for a Directive of the European Parliament and of the Council establishing the European Electronic Communications Code (Recast) and a Regulation of the European Parliament and of the Council establishing the Body of European Regulators for Electronic Communications. Online at: https://ec.europa.eu/digital-single-market/en/news/proposed-directive-establishing-european-electronic-communications-code
[50] We have also consulted Ofcom on the transposition cost and they have agreed that the European Commission proposed number is in line with the expected transposition cost.
[51] Ofcom (2018), The Office of Communications Annual Report & Accounts. Online at: https://www.ofcom.org.uk/__data/assets/pdf_file/0021/115185/annual-report-1718-interactive.pdf
[52] Institute for Government (2018), Civil service pay. Available online at: https://www.instituteforgovernment.org.uk/explainers/civil-service-pay
[53] OECD (2005), International Standard Cost Model Manual. Available online at: https://www.oecd.org/regreform/regulatory-policy/34227698.pdf

Socio-Economic Benefits of 5G Services Provided in mmWave Bands" produced by GSMA in December 2018[54].

71. We have consulted with industry experts and they have confirmed that the GSMA numbers are the most adequate to predict the benefits resulting from the auction of the 26 GHz. A key assumption of the paper is that there is a lag of three/four years between mmWave auctions and benefits realisation (i.e. if the auction takes place in 2019/2020, benefits are realised in 2024), we have kept this assumption constant with a four year lag for each scenario in our analysis.

72. This GSMA paper predicts that by 2034 the economic impact of mmWave spectrum globally will be of £393.27bn[55] and will be distributed across five main use cases, ordered by decreasing contribution to GDP:
    - Industrial automation (23% of the total);
    - Remote object manipulation (18% of the total);
    - Virtual reality and meetings (16% of the total);
    - High-speed broadband in the home and office (15% of the total);
    - Next generation transport connectivity (14% of the total);
    - Other (11% of the total)[56];
    - Quick deployment/temporary connectivity (3% of the total).

73. The paper estimates the impact of mmWave 5G on five consolidated sectors of the economy, ordered by largest to smallest beneficiary:
    - Manufacturing and utilities (38% of the total);
    - Professional and financial services (25% of the total);
    - Public services (17% of the total);
    - ICT and trade (14% of the total);
    - Agriculture and mining (6% of the total).

74. Of the five sectors, manufacturing and utilities is expected to be the largest beneficiary of 5G services which make use of mmWave spectrum. This is primarily due to the relatively large size of the sector in the global economy and the strong role expected to be played by industrial automation and remote object manipulation in this sector.

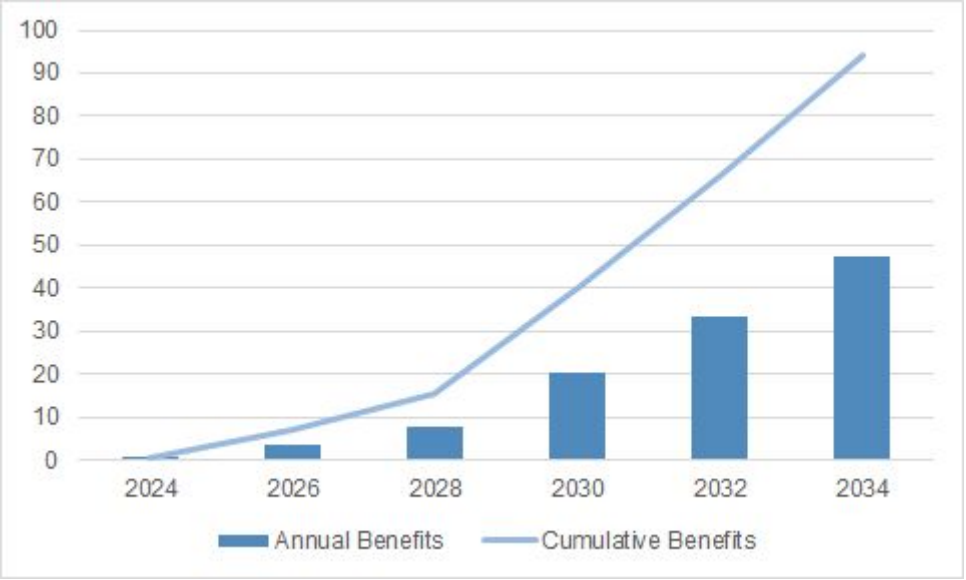
75. The GSMA paper provides a geographical breakdown of mmWave GDP contributions (see figure 5). The trend in figure 5 has been used as the benefits trend within our model. The paper assumes that Europe is an early adopter of mmWave; however in a do nothing scenario the United Kingdom might belong to 'later adopters', because of late auction timings.

Figure 5: MmWave contribution to EU GDP from 2024 to 2034 (£bn)

[54] GSMA (2018), Study on Socio-Economic Benefits of 5G Services Provided in mmWave Bands. Available online at: https://www.gsma.com/spectrum/wp-content/uploads/2018/12/5G-mmWave-benefits.pdf

[55] The number from the paper has been converted from USD to GBP by using an olympic average of the Bank of England average annual exchange rate from 2014-2018, the average has been used in order to avoid yearly exchange rate fluctuations.

[56] The category other has been excluded in our analysis as we deemed the category too general, to ensure it will be realised in the UK.



Source: GSMA Intelligence (historic and forecast to 2025), TMG (forecast to 2034), DCMS own analysis.

76. The European region will benefit from a £93.97bn[57] cumulative increase in GDP by 2034 as a result of mmWave 5G. This is driven primarily by the UK, France and Germany. The UK will reap 13% of total European increase in GDP, equivalent to £12.22bn by 2034. As with the global figure, the manufacturing and utilities sector is expected to contribute the largest share of the overall cumulative GDP contribution (32%).

77. Our analysis has focused on adapting the GSMA paper results to the United Kingdom market and to the assumptions underpinning our options. The paper assumes multiple (more than one) small cell networks materialising in the UK and the whole of the 26 GHz band becoming available. These assumptions are assumed to be closer to the proposed option 3 than option 2, in which latter option only 1 GHz in the band will be made available.

78. With the above assumptions in mind, we produced estimated shares of benefits realisation and modelled these as the different likely scenarios .

79. The high estimate in option 3, the most optimistic scenario modelled, is 89% of the GSMA paper total benefits starting in 2026, four years after the second 26 GHz spectrum auction takes place. The 89% share was produced after removing an 11% share of the benefits which were assigned to minor mmWave relevant applications in the GSMA paper (described as other). This was done both due to the lack of clarity on what these applications are likely to be and the uncertainty over whether these are relevant for the UK market, as well to provide a more conservative benefits estimate in our analysis. In the case of the high estimate for options 2, we estimate, after discussing with industry experts, that as less spectrum will be made available 10% fewer benefits will be realised. This brings down the total benefits realisation share for option 2 to 79% in a high estimate scenario.

80. In order to calculate best and low estimates, we reduced the benefits realisation share based on the proportion of the total network investment (costs) that will take place as a share of the total required investment to achieve multiple small cell networks across the UK. The investment shares in the low and best estimates are the same across both options, with the caveat that the high estimate is not 100% but 89% for option 3 and 79% for option 2. For example the formula used to calculate the proportion of best benefits estimates in option 2 is *100 : best costs estimate / total costs = 79 : X*. This formula will ensure consistency across high, best and low estimates.

[57] The number from the paper has been converted from USD to GBP by using an olympic average of the Bank of England average annual exchange rate from 2014-2018, the average has been used in order to avoid yearly exchange rate fluctuations.

81. Following the calculation above, the proportions of benefits realisation as a share of total benefits provided by the GSMA are:

- **For Option 2**
  i. **Best** - 79% of the total benefits in the GSMA paper;
  ii. **Low** - 73% of the total benefits in the GSMA paper;
  iii. **High** - 50% of the total benefits in the GSMA paper.

- **For Option 3** - Same as option 2 in 2024-2025 and after 2026
  i. **Best** - 89% of the total benefits in the GSMA paper;
  ii. **Low** - 82% of the total benefits in the GSMA paper;
  iii. **High** - 57% of the total benefits in the GSMA paper.

82. We have subsequently net the benefits of options 2 and 3 against the benefits in option 1, the results are in table 5a below. Table 5b provides the Present Value for net benefits for all options.

Table 5: Option 2 and 3 mmWave gross cumulative GDP contribution to the economy (£m)

Option	Estimate	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
2	Low	45	204	250	477	522	1,295	1,340	2,135	2,181	3,044	3,090
	Best	66	364	662	1,060	1,457	2,649	3,842	5,067	6,292	7,617	8,941
	High	71	393	786	1,465	1,966	3,610	4,968	7,506	8,900	11,581	13,082
3	Low	45	204	307	569	707	1,617	1,858	2,897	3,245	4,467	4,930
	Best	66	364	746	1,194	1,725	3,119	4,596	6,178	7,843	9,692	11,624
	High	71	393	877	1,610	2,255	4,117	5,783	8,705	10,574	10,820	15,977

Sources: DCMS own analysis based on the headline GSMA numbers, 2018 prices

Table 5b: Present value of net benefits for options 2 and 3 (£m, 2016 prices)

Option	Estimate	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
2	Low	-0.3	1,274	134	37	177	34	567	32	545	30	522
	Best	-0.3	1,857	1,984	242	312	302	875	845	839	811	847
	High	-2,459	2,004	2,147	2,133	534	380	1,206	927	1,738	922	1,714
3	Low	-2,304	39	134	2,165	206	104	668	171	712	230	782

	Best	-4,861	-3,187	251	3,345	3,284	404	1,022	1,047	1,083	1,102	1,182
	High	-7,705	-5,006	-3,123	3,669	3,741	3,548	1,366	1,181	2,002	1,237	2,076

Sources: DCMS own analysis based on the headline GSMA numbers, 2016 prices

83. Benefits start in 2024 due to the lag between auction and benefits realisation. Benefits for option 3 are higher than in option 3 after 2026 as in 2022 the additional bands of the 26 GHz will be auctioned.

84. For the purposes of the NPV calculation, all benefits have been presented relative to Option 1. The benefits have also been converted to UK figures using a five year average of Bank of England exchange rates[58] and the UK share of European GDP from the GSMA paper (13%).

Benefits for mmWave - Qualitative (Non-monetised) Benefits[59]

85. Beyond the quantitative impacts discussed in the previous section, the GSMA paper also emphasises the social impacts of mmWave 5G technology and services. This section will report the benefits highlighted by the GSMA paper. We assume that what is reported below, at least partially, overlaps with the quantified benefits. However, as the benefits presented in the GSMA paper focus on increase in GDP, it is hard to discern how much of the below benefits have been quantified. Government will have to conduct further in-depth analysis post-consultation, to ensure the below benefits are considered.

86. As mmWave 5G technologies are incorporated across verticals, we envisage impacts such as increased access to education and healthcare expertise, increased independence, and shorter commute times, among many other benefits. The GSMA paper considers five sectors which are arguably among the most likely to experience qualitative improvements from mmWave 5G and the higher broadband capacities and lower latencies that it enables. Potential benefits within each sector are identified, including the relevant use cases and specific examples of improvements to the society well-being. The five sectors are:
    - Healthcare
    - Transportation
    - Education
    - Public safety
    - Industry (manufacturing, mining, and construction).

[58] HMRC (2019), HMRC foreign exchange rates: yearly averages and spot rates. Available online at: https://www.gov.uk/government/publications/exchange-rates-for-customs-and-vat-yearly

[59] The benefits quoted from the GSMA paper have been sourced from:
- NGMN Alliance (2015), NGMN 5G White Paper. Available online at: https://www.ngmn.org/fileadmin/ngmn/content/images/news/ngmn_news/NGMN_5G_White_Paper_V1_0.pdf
- SNS Research (2017), The 5G Wireless Ecosystem: 2017 – 2030: Technologies, Applications, Verticals, Strategies & Forecasts. Available online at: https://www.researchandmarkets.com/reports/4115751/the-5g-wireless-ecosystem-2017-2030
- Ericsson (2018), The guide to capturing the 5G industry digitalization business potential. Available online at: https://www.ericsson.com/en/networks/trending/insights-and-reports/5g-challenges-the-guide-to-capturing-5g-iot-business-potential
- DotEcon Ltd. and Axon Partners Group (2018), Study on Implications of 5G Deployment on Future Business Models. Available online at: https://berec.europa.eu/eng/document_register/subject_matter/berec/reports/8008-study-on-implications-of-5g-deployment-on-future-business-models
- 5G Americas (2017), 5G Services & Use Cases. Available online at: http://www.5gamericas.org/files/3215/1190/8811/5G_Services_and_Use_Cases.pdf

Optimism bias and sensitivity analysis

87. An optimism bias of 44% has been applied to the costs associated with the various policy options. This is based on the suggested upper bound optimism bias for standard civil engineering projects included in HM Treasury Green Book guidance[60]. We have applied a 10% sensitivity analysis in order to calculate low and high estimates, when only central estimates for costs and benefits were available.

Small and Micro Business Assessment (SaMBA)

88. We do not expect our preferred option to have a direct cost on small and micro businesses, as the companies currently holding and interested in participating in auctions for spectrum licences are not likely to be small or micro businesses. In option 3 some of the companies currently holding a licence in the 26 GHz might be small and micro businesses, hence they will incur costs and foregone revenues when sharing or clearing the band. However, at the same time, small and micro businesses will benefit from the policies analysed as the new 5G market model presented will reduce barriers to entry and enable new players to enter the market at lower cost than currently. Furthermore, we expect small and micro businesses to benefit from the possibility to further automate their functions and reduce their travelling times (see qualitative benefits).

Distributional analysis

89. The costs of this Impact Assessment largely fall on telecoms companies and Government, however we envision that the revenues for telecoms companies will make up for the costs incurred. The benefits of this Impact Assessment focus mainly on increase in GDP, hence it is hard to discern which groups might benefit. We assume that there will be an increased benefit especially for commuters, the environment, disabled people, and healthcare services.

Commuters and environmental benefits

90. Several studies have found that commuters will benefit from 5G-enabled road systems that will reduce traffic congestion, while sensors on the railways will cut unplanned train cancellations[61]. As outlined in the qualitative benefits section, intelligent transportation systems (ITS) will enable lower congestion levels and reduction of commute times for citizens. ITS will lead to more efficient planning of public transportation routes and allocation of resources in order to maximize the benefit and availability of public transportation. Data from consumers, such as mobile devices or wearables, could be leveraged in the public transportation planning process for public transportation projects and routes.

Disabled people

91. Improved connectivity will help disabled people enter the labour market through the prospects of teleworking. The employment rate for disabled people aged 16-64 is statistically lower than for non-disabled people across the UK[62]; in 2017, the employment rate was 52.5% for disabled people[63] compared with 80.4% for non-disabled people[64]. Instead, disabled people were more

[60] HM Treasury (2018), The Green Book. Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/685903/The_Green_Book.pdf

[61] O2 (2018), The value of 5G for cities and communities. Available online at: http://www.mobileuk.org/cms-assets/O2%20Smart%20Cities.pdf

[62] ONS (2018), Employee earnings in the UK: 2018. Available online: https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/earningsandworkinghours/bulletins/annualsurveyofhoursandearnings/2018

[63] People reporting having an Equality Act core and/or work-limiting disability.

[64] Excluding unknowns

likely to be unemployed. There were approximately 397,400 unemployed disabled people aged 16-64 who want and are looking for a job in the UK in 2017, giving an unemployment rate of 8.5%. That compared with an unemployment rate of 3.8% for non-disabled people. Consequently, this policy has the potential to reduce these inequalities.

Risk and Assumptions

92. The technology underpinning the costs and benefits of this Impact Assessment is still being trialled and is largely not available in the market. The analysis has been heavily focused on the GSMA paper explaining the mmWave benefits and subsequent discussions with industry. We have apportioned the benefits to mitigate the risk of overestimating any benefit or cost, however we will make sure to re-assess this analysis once better data is available. We will make use of consultation to further test our analysis and assumptions.

Monitoring and Evaluation

93. As part of this policy, a Post Implementation Review (PIR) will be conducted five to six years after implementation. Some of the research questions that we propose in order to assess impact include:
    - Has the policy been successful in reaching government objectives?
    - Is the rationale for intervention still valid? For instance, whether market failures persist in the spectrum and 5G market.
    - What were the overall impacts on business?
    - Direct and indirect impacts - did the assumed impacts occur and were there others that were not identified both direct and indirect?
    - Small and micro businesses - Did the impact assessment underestimate or overestimate impact on small and micro businesses?
    - Did stakeholders comply, if not, how did Government and Ofcom respond to ensure adherence to the policy?
    - Market structure impacts - was there any impact on the market structures of 5G? Did the 5G market model reflects and expanded market?

94. To successfully answer these questions, we propose monitoring the following (provisional) key indicators though the list is not exhaustive. The consultation phase may also identify alternative indicators and methods of data collection.
    - Direct costs to businesses for clearing or sharing 26 GHz;
    - Foregone revenues for businesses handing in their licences before their expiration date;
    - MmWave refined benefits to the UK market;
    - Potential impact on businesses for Article 47 and Recital 122

DCMS 5G benefits model - Comparison of benefits results with GSMA analysis

95. To compare the 5G benefits estimates provided by GSMA and mobile operators, DCMS analysts have built a more conservative model on 5G benefits. The GSMA paper is the only published evidence on mmWave potential benefits, hence why it has been extensively used in this IA, while the below model does not include mmWave in its analysis. However the model below is useful to give an estimate of the possible benefits over-estimation of the GSMA paper. The below model is based on an Australian government working paper[65] which estimated the costs and benefits that may stem from 5G rollout. Based on this work and consultation with its author, the 5G team have built a model to understand the cost and potential impacts of 5G rollout on UK productivity.

[65] Australian Government (2018), Impacts of 5G on productivity and economic growth. Available online at: https://www.communications.gov.au/departmental-news/impacts-5g-productivity-and-economic-growth

96. Productivity measures output per unit of input. The productivity impact of 5G will stem from how inputs and outputs change as a result of the technology. Technology such as 5G can be expected to improve productivity by:
    - Improving the efficiency of production of existing goods/services;
    - Bringing new services and applications to market (with associated efficiency gains).

97. The model is based on the original Australian model. It uses a common approach (growth accounting) which decomposes economic growth into changes in productivity, inputs and outputs. Typically, this involves an assumption about how different inputs—labour and capital—are used to produce output. By examining the movements in measured inputs and outputs, a residual measure can be calculated, which reflects changes in productivity. All input data is sourced from ONS. The model inputs are:
    - Labour inputs - number of hours worked
    - Capita input - changes in 'capital services', which measures the flow of outputs from an economy's capital stock.
    - Multifactor productivity (MFP) index.

98. The key assumptions of the model are:
    - Model outputs are calculated under a number of scenarios which vary according to the level of total investment cost, roll out of capital and annual growth of gross value added (GVA) due to 5G investment.
    - Consumption of fixed capital: It is assumed the new capital added to the existing stock of productive capital asset depreciates at a rate of 5%. This is based on the geometric depreciation profile used in the original model to subtract year-on-year capital consumption from total new capital added to the economy as a result of the 5G investment.
    - Labour inputs are assumed to remain constant - i.e. to isolate the changes and associated impacts of 5G capital.
    - Higher costs should not be equated with the likelihood of expected returns. A higher cost or greater investment does not mean that the likelihood of 5G generating higher benefits is increased.
    - The model assumes no sunk costs, as the purpose of the analysis is to look at the total costs and associated benefits of 5G (i.e. rather than making government investment decisions).
    - The estimate of the economic benefit is likely to be conservative in that it does not fully take into account the consumer and non-market benefits that are not captured in economic statistics. These include cost and time savings for households arising from 'smarter cities' and the indirect effects from improvements in health services on participation and productivity—both enabled by better mobile telecommunications. The sharing economy (which harnesses household assets for market production) is also likely to increasingly blur the line between productive and household sectors in terms of the drivers of output, innovation and productivity growth.

99. The cost of 5G deployment is hard to quantify, given the uncertainty around 5G investment costs, we have therefore taken a simple approach by looking at a range of key inputs:
    i. capital costs of building a 5G network;
    ii. operational costs;
    iii. spectrum costs;
    iv. transaction costs (i.e. costs to businesses and consumers to upgrade phones/equipment to access 5G).

100. For this analysis, we have modelled (i), (ii) and (iii). We have assumed zero transaction costs, as these would be incurred as part of lifecycle upgrades. For the capital costs, the model uses three cost variables:
    - Low - £6.5bn; 5G deployment will have similar costs of rolling out 4G (£1.3bn/year for 5 years, £6.5bn in total)[66]
    - Medium - £8bn; This is the central scenario, based on Future Telecoms Infrastructure Review (FTIR)[67] analysis which estimates the cost of 5G deployment. This figure represents MNOs upgrading all existing sites with 700MHz to provide a thin layer of 5G nationwide, and upgrading a subset of sites (roughly half in urban and suburban areas) with the 3.5GHz band to provide high capacity 5G (no mmWave costs are included within this analysis).
    - High - £10bn. In absence of better evidence, we have taken a 25% uplift on the central scenario.

101. To the best of our knowledge, there are no reliable figures for operational costs. However, based on information obtained from technical experts, we note that capital costs and operational costs follow a ratio of roughly 50:50 throughout life (although year-on-year share vary). Therefore, the model assumes operational costs to be £6.5bn, £8bn and £10bn under the low, medium and high scenarios, respectively. It also assumes that they are evenly distributed over a 15-year appraisal period, and discounts them at a rate of 3.5% per year[68].

102. For spectrum costs, we have included approximate costs for spectrum bands identified in the FTIR which are likely to be used to deliver 5G services:
    - Low capacity layer providing wide-area 5G coverage:
        i. 700 MHz. Based on Ofcom's reserve price for the 700 MHz consultation[69]. £600-£1,440m.
    - High capacity in areas of high demand such as towns and cities:
        i. 3.4-3.6 GHz. £1.15bn (cost incurred by MNOs at last year's auction[70])
        ii. 3.6-3.8 GHz. Based on Ofcom's reserve price for the 3.6-3.8 GHz consultation[71]. £360-600m.

103. MmWave spectrum cost was not included in the model as there were no plans for Ofcom to auction it when this model was built.

104. The model *by default* assumes each cost profile is evenly spread over four-year period, e.g. £8bn (central scenario) is assumed to be spent as £2bn/year. Evidence gathered in the FTIR

[66] HSBC (2018), Does 5G have a use? Available online at: https://www.gbm.hsbc.com/insights/technology/does-5g-have-a-use
[67] DCMS (2018), Future Telecoms Infrastructure Review. See online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/732496/Future_Telecoms_Infrastructure_Review.pdf
[68] In line with HMT Green Book guidance (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/685903/The_Green_Book.)
[69] Ofcom (2018), Award of the 700 MHz and 3.6-3.8 GHz spectrum bands, p 124. Available online at: https://www.ofcom.org.uk/__data/assets/pdf_file/0019/130726/Award-of-the-700-MHz-and-3.6-3.8-GHz-spectrum-bands.pdf
[70] Kavanagh (2019), 5G UK auction, Available online at: https://5g.co.uk/guides/5g-uk-auction/
[71] Ofcom (2018), Award of the 700 MHz and 3.6-3.8 GHz spectrum bands p 124. Available online at: https://www.ofcom.org.uk/__data/assets/pdf_file/0019/130726/Award-of-the-700-MHz-and-3.6-3.8-GHz-spectrum-bands.pdf

suggests that operator capex has remained broadly flat over the past few years *and* rollout is feasible within existing capital envelopes[72].

105. The benefits of 5G are very difficult to quantify. The literature on impacts of mobile technology is immature (see Deloitte study for DCMS[73]) and there is still uncertainty around 5G use cases/services (and hence overall value proposition). The impact on output growth has been informed by evidence from the Australian paper[74], which studied how incremental advances in mobile technology and more fundamental shifts in technology (including general purpose technologies (GPTs) which are considered to impact the whole economy), impacted output and productivity. While GPTs tend to provide longer periods of productivity growth, the rate of this growth is not necessarily faster than that for more incremental technologies. Therefore, we use a central estimate of 0.3% per annum.

106. The model assumes total output (gross value added) follows an incremental growth pattern, increasing from 0.01% to a maximum 0.3%. The distribution of annual output growth (GVA) is kept constant in the model, however the time period over which this growth occurs is varied across different scenarios as 'Impact of 5G' variable.

107. The variable 'Impact of 5G' is defined as how quickly output growth outlined above is achieved over the appraisal period 2020 - 2030. For simplicity, we have modelled output growth based on three factors:

- The number of people using 5G;
- The extent to which 5G affects productivity;
- The lag between 5G uptake and impact on productivity.

108. 5G users - We have developed three scenarios on the response of users to adopt 5G connection, as shown in the diagram below:

- *3G - "slow and steady"* - this is based on the historical trend of 3G technology whereby it grew slowly towards the beginning of the roll-out and gradually picked up a steady pace.
- *4G - "fast and accelerated"* - this is based on the historical trend of 4G where its uptake grew quickly since its roll out in 2012, growing to 60% of total active mobile subscription in 2016[75].
- *5G - "3G / 4G hybrid"* forecasts suggest that 5G uptake will be somewhere in between 3G and 4G. This is based on 5G mobile subscription estimates are based on UK GSMA forecasts for 2020 to 2025, which account for a number of factors including spectrum allocation, operator launch plans and latest technology development.

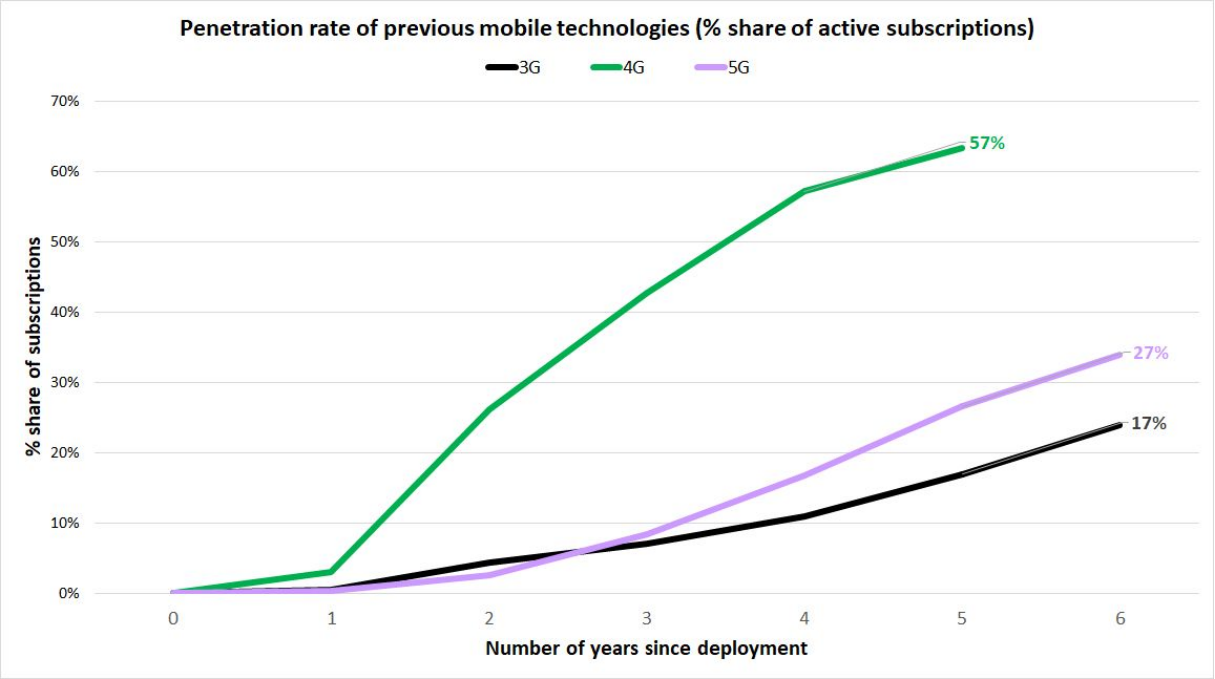
Figure 6: User response to adopt 5G

[72] DCMS (2018), Future Telecoms Infrastructure Review p57. See online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/732496/Future_Telecoms_Infrastructure_Review.pdf

[73] Deloitte (2018). The impact of mobile broadband and 5G. Available online at: https://www.gov.uk/government/publications/the-impacts-of-mobile-broadband-and-5g

[74] Australian Government (2018), Impacts of 5G on productivity and economic growth, Appendix B. Available online at: https://www.communications.gov.au/departmental-news/impacts-5g-productivity-and-economic-growth

[75] DCMS own analysis.



Source: DCMS own analysis

109. 5G impact on productivity - We consider two cases where 5G is:

- **Evolutionary** (5G provides incremental impacts compared to 4G) - productivity impacts last for 10 years.
- **Revolutionary** (5G provides transformative impacts compared to 4G - it acts as a 'general purpose technology). Productivity impacts last for 15 years. A more transformative 5G is likely to include a wider variety of use cases / services, including those that use very high speed and ultra low latency that can be provided through the use of mmWave spectrum (e.g. connectivity in ultra dense areas such as stadiums, virtual reality, telemedicine, superfast fixed wireless access). *Given that mmWave costs are not included in the analysis, this scenario may overstate the potential benefits in relation to the estimated costs and has not been included.*

110. Lag between uptake and productivity, we assume the following scenarios:

- **Delayed impact** - growth does not follow until 2024 since initial investment in 2019.
- **Lagged impact** - growth follows slowly, starting at 0.1% in 2021 and gradually increasing to 0.3% in 2023 and remaining constant till 2026 until the growth phases out to 0% in 2030.
- **Instant impact** - growth follows a year after the initial investment in 2019. This is unlikely but we have included to illustrate an upper bound.

111. Based on these factors, we have chosen three cases of impact of 5G as outlined below. The central scenario reflects the most realistic assumption under each variable. The lower and upper scenarios take the most optimistic / pessimistic variable to provide an upper and lower bound of impacts. Each of these correspond to a different scenario when combined with cost input.

- **Scenario 1 [lower]** - 3G, evolutionary, delayed rollout (benefit occurs over 11 years);
- **Scenario 2 [central]** - 5G, evolutionary, lagged rollout (benefit occurs over 11 years);
- **Scenario 3 [upper] -** 4G, evolutionary, instant (benefit occurs over 15 years).

112. According to the model the estimated cumulative benefits of 5G by 2034 for the UK are in a range of £20-41bn with a central estimate of £31bn, with costs in a range of £13-21bn with a £16bn central estimate, discounted over a 15 year appraisal period. Costs and benefits exclude

mmWave. These benefits are significantly more conservative than what described by GSMA and give an idea of the potential over-estimate of 5G benefits provided by the industry.

113. We will work to integrate mmWave benefits to the DCMS 5G model post consultation when more reliable data will be available.

Annex

Annex A: Article 47

Article 47

Conditions attached to individual rights of use for radio spectrum

1. Competent authorities shall attach conditions to individual rights of use for radio spectrum in accordance with Article 13(1) in such a way as to ensure optimal and the most effective and efficient use of radio spectrum. They shall, before the assignment or renewal of such rights, clearly establish any such conditions, including the level of use required and the possibility to fulfil that requirement through trading or leasing, in order to ensure the implementation of those conditions in accordance with Article 30. Conditions attached to renewals of right of use for radio spectrum shall not provide undue advantages to existing holders of those rights.

   Such conditions shall specify the applicable parameters, including any deadline for exercising the rights of use, the non-fulfilment of which[76] would entitle the competent authority to withdraw the right of use or impose other measures.

   Competent authorities shall, in a timely and transparent manner, consult and inform interested parties regarding conditions attached to individual rights of use before their imposition. They shall determine in advance and inform interested parties, in a transparent manner, of the criteria for the assessment of the fulfilment of those conditions.

2. When attaching conditions to individual rights of use for radio spectrum, competent authorities may, in particular with a view to ensuring effective and efficient use of radio spectrum or promoting coverage, provide for the following possibilities:

   (a) sharing passive or active infrastructure which relies on radio spectrum or radio spectrum,

   (b) commercial roaming access agreements,

   (c) joint roll-out of infrastructures for the provision of networks or services which rely on the use of radio spectrum.

   Competent authorities shall not prevent the sharing of radio spectrum in the conditions attached to the rights of use for radio spectrum. Transposition by undertakings of conditions attached pursuant to this paragraph shall remain subject to competition law.

Annex B: Recital 122

Recital 122

In order to avoid the creation of barriers to market entry, namely through anti-competitive hoarding, enforcement of conditions attached to radio spectrum rights by Member States should be effective and all competent authorities should participate where necessary. Enforcement conditions should include the application of a "use it or lose it" clause. In order to ensure legal certainty in respect of the possible exposure to any penalty for failure to use radio spectrum, thresholds of use, including in terms of time, quantity or identity of radio spectrum, should be established in advance. Trading and leasing of radio spectrum should ensure the effective use by the original holder of the right.

[76] this refers to parameters

Annex C: Article 54

Article 54:

Coordinated timing of assignments for specific 5G bands

1. By 31 December 2020, for terrestrial systems capable of providing wireless broadband services, Member States shall, where necessary in order to facilitate the roll-out of 5G, take all appropriate measures to:

   (a) reorganise and allow the use of sufficiently large blocks of the 3.4-3.8 GHz band;

   (b) allow the use of at least 1 GHz of the 24.25-27.5 GHz band, provided that there is clear evidence of market demand and of the absence of significant constraints for migration of existing users or band clearance.

2. Member States may, however, extend the deadline laid down in paragraph 1 of this Article, where justified, in accordance with Article 45(3) or Article 53(2), (3) or (4).

3. Measures taken pursuant paragraph 1 of this Article shall comply with the harmonised conditions set by technical transposing measures in accordance with Article 4 of Decision No 676/2002/EC.

Annex D: Glossary of terms

Term	Definition
5G	The term used to describe the next generation of wireless networks beyond 4G LTE mobile networks. 5G is expected to deliver faster data rates and better user experience. Technical standards are still under development and are likely to include both an evolution of existing and new radio technologies. Generations of technology are often defined as 2G (the introduction of rudimentary data and SMS services), 3G (upgraded online data services and connectivity quality), 4G (introduction of high-speed data services).
5G Testbeds and Trials programme	A programme that coordinates the development of 5G services and applications through a series of trials, which contribute to the development of the 5G ecosystem across the UK.
Access	The making available of facilities and/or services to another undertaking, under defined conditions, on either an exclusive or non-exclusive basis, for the purpose of providing electronic communications services, including when they are used for the delivery of information society services or broadcast content services.
Bandwidth	The measure of the maximum capacity of a data link in the network.
Body of European Regulators for	The Body of European Regulators for Electronic Communications (BEREC) was created in 2009 to improve consistency of the EU

Electronic Communications (BEREC)	telecoms rules and to contribute to the development of the Single Market. The mission of BEREC is to assist the Commission and the national regulatory authorities (NRAs) in the implementation of the EU telecoms rules, to give advice on request and on its own initiative to the European institutions and to complement at European level the regulatory tasks performed at national level by the regulatory authorities.
Broadband	A service or connection generally defined as being 'always on' and providing a bandwidth greater than narrowband. Broadband has been the norm for Internet connectivity (non-mobile) since the mid-2000s, with ADSL being the first mainstream technology standard adopted.
Bundled offers, services, or 'bundles'	A contract that includes more than one service, such as a landline, broadband, pay TV and/or mobile service. The majority of Internet broadband services in the UK come bundled with a telephone line, and increasingly so with a pay-TV offer.
Competent Authority	A person or organisation that has the capacity and legally delegated authority to perform the functions assigned to it. In many places, for example spectrum management, the EECC updates the current framework to give Member States the flexibility of assigning certain functions to a competent authority other than the National Regulatory Authority.
Devolved Administrations	The governments of the devolved nations of the UK. These are the Scottish Government, the Welsh Government and the Northern Ireland Executive.
European Commission	The European Commission is the EU institution that has the monopoly on legislative initiative and important executive powers in policies such as competition and external trade. It is the principal executive body of the European Union and it is formed by a College of members composed of one Commissioner per Member State.
European Electronic Communications Code (EECC)	The EECC is a European directive setting out current rules for telecoms. The EECC will replace the following four existing telecoms directives: Framework, Access, Authorisation and Universal Service.
EU institutions	There are a number of EU bodies which are defined under the Treaties as EU institutions including the European Parliament, the European Council, the Council of the European Union and the European Commission.

Electronic Communications Network	Transmission systems, whether or not based on a permanent infrastructure or centralised administration capacity, and, where applicable, switching or routing equipment and other resources, including network elements which are not active, which permit the conveyance of signals by wire, radio, optical or other electromagnetic means, including satellite networks, fixed (circuit- and packet-switched, including internet) and mobile networks, electricity cable systems, to the extent that they are used for the purpose of transmitting signals, networks used for radio and television broadcasting, and cable television networks, irrespective of the type of information conveyed.
Fibre to the Premises (FTTP), or Full Fibre	An access network using optical fibre to provide the connection between the local exchange and the end users' houses or business premises. The optical fibre may be point-to-point – a dedicated fibre connection for each home – or may use a shared infrastructure such as GPON (Gigabit passive optical network). This type of connectivity is considered in general more reliable and being capable of providing higher throughput and speeds than legacy copper-based networks (i.e. DSL services provided over telephone lines).
Future Telecoms Infrastructure Review (FTIR)	The FTIR, published in July 2018, set out a national, long-term strategy for digital infrastructure in the UK, with the aim of securing world-class connectivity that is gigabit-capable, reliable, secure and widely available.
General Conditions of Entitlement, or 'General Conditions'	Regulatory conditions that all providers of electronic communications networks and services must comply with in order to provide services in the UK.
GHz	Gigahertz – a unit of frequency of 1 billion cycles per second.
Gigabit-capable networks	A network connection that is capable of achieving 1,000 Megabits per second (Mbps), i.e. 1 Gigabits per second (Gbps), download speeds.
Interconnection	The physical and logical linking of public communications networks used by the same or a different undertaking in order to allow the users of one undertaking to communicate with users of the same or another undertaking, or to access services provided by another undertaking. Services may be provided by the parties involved or other parties who have access to the network. Interconnection is a specific type of access implemented between public network operators.
Latency	The amount of time a message takes to travel across a system.

National Regulatory Authority (NRA)	The body or bodies charged by a Member State with any of the regulatory tasks assigned in the EECC. Ofcom is the UK's National Regulatory Authority and is responsible for regulating the telecoms, broadcasting, and postal sectors.
Number-independent interpersonal communication service (NIICS)	An interpersonal communications service which does not connect through the use of publicly assigned numbering resources, namely, a number or numbers in national or international numbering plans, or which does not enable communication through a number or numbers in national or international numbering plans. This includes several over-the-top (OTT) communication apps that allow users to communicate using Internet Protocol (IP) communications. Some OTT communication apps enable voice-over-ip (VoIP) using assigned numbered resources while being enabled by the Internet.
Ofcom	Ofcom is the regulator and competition authority for the UK communications industries. It regulates the TV and radio sectors, fixed line telecoms, mobiles, postal services, plus the airwaves over which wireless devices operate.
Ofgem (Office of Gas and Electricity Markets)	Ofgem is the independent regulator for the electricity and gas industries. It is a non-ministerial government department and an independent National Regulatory Authority, recognised by EU Directives. Its principal objective when carrying out its functions is to protect the interests of existing and future electricity and gas consumers.
'Outside-in' approach	The Government's approach to ensure connectivity across all areas of the UK is achieved at the same time, and no areas are systematically left behind.
Over the top (OTT) services	An Over-The-Top (OTT) application is any digital product that disrupts or provides an alternative to the traditional billing models of telcos or cable/satellite companies.
Spectrum	The descriptor of the range of electromagnetic frequencies which can be modulated to carry information. Spectrum is a finite resource and a critical national asset that the Government wants to ensure is maximised for its economic and social value.
Significant market power (SMP)	A communications provider is deemed to have significant market power if, either individually or jointly with others, it enjoys a position in the market equivalent to dominance, that is to say a position of economic strength affording it the power to behave to an appreciable extent independently of competitors, customers and ultimately consumers.

Statement of Strategic Priorities (SSP) for Ofcom	As described in Clause 98 of the Digital Economy Act 2017, the SSP will set out the Government's strategic priorities for Ofcom in telecommunications, the management of radio spectrum, and postal services. Under the legislation Ofcom must have regard to the Statement when carrying out its regulatory functions.
Universal service obligation (USO)	A legal right established by the UK Government for everyone to access high speed fixed broadband (10 Mbps download, 1 Mbps upload) if they do not have it, subject to a cost threshold.