Improving consumer access to mobile services at 3.6 GHz to 3.8 GHz: techUK response

About techUK

techUK is the industry voice of the UK tech sector, representing more than 900 companies which collectively employ over 800,000 people, about half of all tech jobs in the UK.

These companies range from innovative start-ups to leading FTSE 100 companies. The majority of our members are small and medium sized businesses. Every tech vertical is represented enabling techUK to propose joined-up thought-leadership for the entire tech sector.

Relevant to the 3.6 GHz to 3.8 GHz spectrum, techUK represents satellite and ground segment operators; MNOs and their equipment and infrastructure suppliers; and fixed link operators. This response has been drafted by members of techUK's Communications Policy Council and Satellite Telecommunications Committee.

Executive summary

Consumer data demand per capita is increasing rapidly, driven by video, and that demand is increasingly generated by mobile devices. It is necessary that mobile operators are able to continue to meet that demand.

While infrastructure investment (particularly in small cells) and re-farming of existing mobile spectrum to the latest mobile technologies, as well as Wi-Fi offload and increasing use of carrier aggregation, must be part of the solution, it will be necessary to make available additional mobile spectrum to meet capacity demands - at least in "hotspots" during peak periods - and to facilitate introduction of new services aligned to global developments.

Additional mobile spectrum also drives opportunities for innovation and new business models to more economically extend and enhance the service delivered to citizen-consumers.

RSPG has identified 3.4-3.8 GHz (part of the existing satellite "C-Band") as the "primary band suitable for the introduction of 5G use in Europe even before 2020", offering an attractive balance between coverage and capacity. The band 3.4-3.6 GHz is more readily usable than 3.6-3.8 GHz, where Ofcom is already consulting on the auction design; but even when this spectrum has been awarded to industry, with the potential for mobile operators to utilise carrier aggregation and supplemental downlinks, and with increasing provision of public Wi-Fi, it is expected that at some point the 3.6 – 3.8 GHz spectrum will also be required to meet growing data demand.

What isn't clear yet is when that point is likely to be, how extensively this spectrum may be deployed outside of urban and inner suburban areas, or how much contiguous spectrum may be required to meet demand.

Given that the band 3.6-3.8 GHz has been used for years to support satellite and fixed link services for a range of public and private customers (and, in the case of satellite, including international customers), the answers to these questions determine:

- how long existing spectrum users could reasonably expect to continue operating as now; and
- how, if at all practical, they might share 3.6-3.8 GHz with mobile use.

techUK believes that it is important that, where required, the option to protect existing satellite earth stations from undue interference continues to be available given the importance of the traffic that is carried and the benefits that satellite connectivity provides to UK businesses, consumers and government.

The satellite operations in this band represent considerable investment to support high value contracts of lengthy duration and it would be unreasonable to remove protection from harmful interference. This said, the value of mobile is also likely to be high and it will be important to work constructively to maximise the availability of the spectrum to existing services that cannot be removed as well as to new mobile services.

The existing fixed links and satellite use appears to be partly in more remote areas, which may improve potential for sharing, with mobile use in urban areas where greatest capacity is expected to be needed.

We therefore propose that mobile operators be required to coordinate their deployments in 3.6-3.8 GHz with incumbents, which we would expect to provide limited constraint on 5G deployment for several years from bringing the spectrum into use for mobile. Where mobile operators believe their planned deployment may be constrained by incumbent use, they would be free to contribute towards the cost of the incumbents' mitigation where necessary to optimise their deployment, with Ofcom providing backstop regulation to ensure that incumbents don't abuse their position in respect of the mitigation demanded of new mobile operators.

Given that the Transfinite analysis was conducted a while ago with reference to IMT-Advanced, and the fact that 5G has yet to be specified, it is impossible to determine whether co-existence has been modelled in a way which predicts the potential for co-existence with a reasonable degree of accuracy. It is quite possible that the analysis over-estimates the potential for harmful interference.

Further, we are aware of more detailed mapping exercises being undertaken by Ordnance Survey which could aid in better understanding propagation characteristics. Database-driven access could be used to provide existing users with greater certainty of protection, and could maximise the opportunity for mobile services without wastefully extended exclusion zones. It could also allow existing users wanting to deploy new sites to benefit from faster, simpler and more certain access spectrum compared with the current coordination procedures. We note that the recently published ECC Report 254 provides guidance on enabling administrations to protect incumbent use of the band with exclusion zones, whilst also facilitating its use by new entrants.

Answers to Questions

Question 1: Do you have any comments on the use of the 3.6 to 3.8 GHz band by existing services?

Like the mobile sector, the satellite industry is innovating and growing. Satellite operators are making ongoing investment in improving efficiency with which this spectrum is utilised, including deployment of High-Capacity Satellites and greater spectrum re-use. Next-generation modulation standards for satellite communications have been tested with speeds ranging from 300-700 Mbit/s for professional video applications on standard C-band transponders. New high-performance satellite platforms will combine C-, Ku- and Ka-bands wide beams, spot beams, and frequency reuse technology to support broadband, media and mobility solutions.

This investment is providing consumers with: high performance and lower cost per-bit; wide beams and spot beams in the same band for broadcast and high-throughput applications; frequencies which can be aligned to regional and application-specific requirements; high throughput, efficiency and reliability; smaller mobility-friendly terminals; and benefits data-centric services such as cellular backhaul.

As not all receive-only Earth stations will have RSA, no-one can be sure where VSAT users are, and UK uplinkers don't always know where data is downlinked, so the economic benefits from use by satellite sector of C-band is almost certainly greater than Ofcom believes.

C-band's propagation characteristics and resilience to rain fade limits the substitutability of alternative spectrum. The band 3.6-3.8 GHz, as part of the wider C-band currently in use, will continue to be used by satellite operators with the deployment of new satellites, and earth station operators have limited scope to transition to the upper part of C-band.

C-band offers region-wide coverage at high availabilities, irrespective of rain zones. In the consultation, Ofcom appears unfairly dismissive of the value to UK satellite operations of resistance to rain fade, given that end customers may be in tropical areas.

Most of the world's coverage via C-band is anchored through Fixed Satellite Service Earth Stations (FSS-ES) which are based in Europe and the UK, used for intercontinental links and links with high reliability requirements (including broadcast distribution, TT&C, and feeder links for MSS systems).

Often teleports are located where there is sufficient, reliable connectivity available, which other sites may not readily have. Additionally, even if alternative locations could be identified, large dishes (up to 32m diameter) require planning permission which may not be forthcoming and in any case requires time. It can take up to 2 years for mobile operators to receive permission to deploy a new mast, there is no reason why a much larger satellite dish would receive permission more quickly, if it received permission at all.

Question 2: Do you agree with our identification of a trend towards the use of mobile in the 3.6 to 3.8 GHz band?

Yes. The RSPG considers the 3.4-3.8 GHz band to be "the primary band suitable for the introduction of 5G use in Europe even before 2020, noting that this band is already harmonised for mobile networks, and consists of up to 400 MHz of continuous spectrum enabling wide channel bandwidth. This band has the possibility to put Europe at the forefront of the 5G deployment."

Given the global identification of 3.4-3.6 GHz for IMT, plus the CEPT rules for mobile broadband in 3.4-3.8 GHz, manufacturers are already developing equipment to operate in 3.4-3.8 GHz. The ability to implement wide tuning ranges in the radio front-end could permit an adaptable form of harmonisation with other countries and regions which are utilizing parts of the same band or adjacent bands for mobile broadband services including 5G.

But such use won't necessarily align with traditional "mobile" use. We expect fixed and mobile applications. Ongoing international deployments encompass Fixed Wireless Access (FWA); mobile backhaul and fronthaul; macro cells and small cells; rooftop, street level and in-building. Additionally Relish[1] has deployed "MiFi"[2]-style devices using their C-Band spectrum (84 MHz, 3605-3689 MHz), and they are expecting much more extensive use of these devices going forwards but which are likely to be predominantly in urban areas away from C-band Earth Stations.

As such the Question's use of "trend towards the use of mobile" seems unnecessarily narrow. As a result, it isn't obvious that the Transfinite modelling captures all of these permutations.

We see no reason to doubt that the majority of the data demanded by mobile devices will continue to be offloaded to Wi-Fi. While satisfying an exponential increase in Wi-Fi offload could challenge the amount of spectrum currently allocated to Wi-Fi, there is substantial untapped capacity in the 5 GHz band. Extensive outdoor deployment of Wi-Fi in some Far Eastern markets tends to increase offload, and we note that public Wi-Fi provision continues to increase in the UK (including requirements for Wi-Fi in trains, and public investment in Wi-Fi provision in public buildings), and scope for additional public investment in Wi-Fi was announced as part of the European Commission's Telecoms Framework Review.

However, regardless of Wi-Fi offload, there will be continued growth in the traffic carried by mobile networks.

[1] Relish is a trading name of UK Broadband Limited, which is a spectrum licence holder.

[2] Mi-Fi is actually a trademark of Three. A generic term is "pocket Wi-Fi device". Relish's pocket Wi-Fi devices hand over from one cell to the next where there is contiguity of coverage, so they are mobile devices.

Question 3: Do you agree with our high level proposal to make 116 MHz within the 3.6 to 3.8 GHz band available for mobile and 5G services, bearing in mind our statutory duties and the high level trends we have identified?

Yes, but additionally techUK believes that to maximise the benefits from the use of this band, efforts should be made to carefully examine all existing usages to try to maximise the spectrum made available for 5G, without unduly compromising the wide – and expanding - range of commercially viable[3] services already operated in this band.

While we take a pragmatic approach towards the use of mobile services in 3.6– 3.8 GHz, we emphasize that European Commission Decision 2008/411/EC, which seeks to harmonise the conditions for the availability and efficient use of the 3.4 to 3.8 GHz frequency band for terrestrial systems in the band 3.6 to 3.8 GHz, states in Article 1 that:

> *"This Decision aims at harmonising, **without prejudice to the protection and continued operation of other existing use in this band**, the conditions for the availability and efficient use of the 3400 - 3800 MHz band for terrestrial systems capable of providing electronic communications services"(emphasis added)*

The EU regulatory framework requires international treaties including the ITU Radio Regulations to be respected. In this context, given the ITU Table of Allocations, where FSS has primary status in this band and mobile is secondary, it seems appropriate to retain the possibility to protect existing Earth station sites from undue interference. However we recognised that in the European Table of Allocations the 3.4-3.6 GHz and 3.6-3.8 GHz bands have a co-primary mobile allocation.

Question 4: Do you agree with our general approach regarding spectrum currently licensed to UK Broadband?

Like the satellite operators, UK Broadband, which trades as Relish, is investing in expanding its service. Where it deploys 3.6 GHz spectrum this is subject to coordination requirements in some areas.

It would be sensible to apply the Mobile Trading Regulations to UK Broadband's licence, but techUK members have differing opinions about when might be the appropriate timing for that. The uncertainty over when that may be, and how much the Annual Licence Fee (ALF*)* may then be, could potentially act as a disincentive to investment.

Ofcom should be clear that it will vary the ALF basis to reflect mobile as the alternative users of the spectrum when there's an eco-system for the band[4], and the

[3] Services in the band at present are commercially viable based upon the current level of annual licence fees calculated on an AIP basis which doesn't reflect mobile as a blocked application.

[4] This may well coincide with the release for mobile, but in the event that e.g. terminals support 3.4-3.8GHz generically before that occurred and the only thing stopping usage of 3.6-3.8GHz is incumbent usage, the ALF should probably reflect the AIP of the "blocked" usage from that time.

approximate magnitude of that (which could be derived from the forthcoming PSSR auction and/or a future auction of the remaining 116 MHz of 3.6 GHz spectrum).

Also we note that Relish's 3.6 GHz licence currently permits leasing, whereas "mobile spectrum" currently cannot normally be leased. As we move towards a 5G world, from a focus on maximum coverage for voice services to one of targeted coverage for various kinds of data services, Ofcom should consider permitting spectrum leasing (and other forms of capacity sharing), perhaps subject to competition law reviews as they would have to do for a trade of mobile spectrum. This would permit commercial deals which encouraged competition, innovation, market entry and maximum usage of a scarce resource.

Question 5: Do you agree with our assumptions, methodology, and conclusions with regards to potential coexistence between mobile and existing fixed links and satellite earth stations? Please refer to annex 5 for further details.

We accept the principle of adopting two different interference thresholds to equate for long term and short term threshold.

We also note with interest that the Transfinite analysis shows that there is potential to deploy small cells reasonably close to satellite earth stations on a co-channel basis, provided that adjustments are possible for the location of the base stations and for the antenna orientation. We consider that the sharing solution needs to look at the full range of possible power levels of future mobile networks with the right level of geographical separation.

Such an approach could be used as a third option method to be adopted by Ofcom, where geographic separation is imposed similar to option A, but with a case by case geographical separation based on the specific parameters of the satellite earth stations and mobile base stations, including elevation angles of the FSS-ES and mobile base station EIRP, and provided the necessary adjustment are made in terms of additional mitigations such as the base station antenna orientation.

However as the Transfinite analysis was conducted a while ago with reference to IMT-Advanced, and the fact that 5G has yet to be specified, it is impossible to determine whether co-existence has been modelled in a way which predicts the potential for co-existence with a reasonable degree of accuracy. There is limited detail generally in annex 5, to enable us to comment on the accuracy of the modelling. In particular the assumptions behind the density of small cells modelled is important, but is not clearly explained.

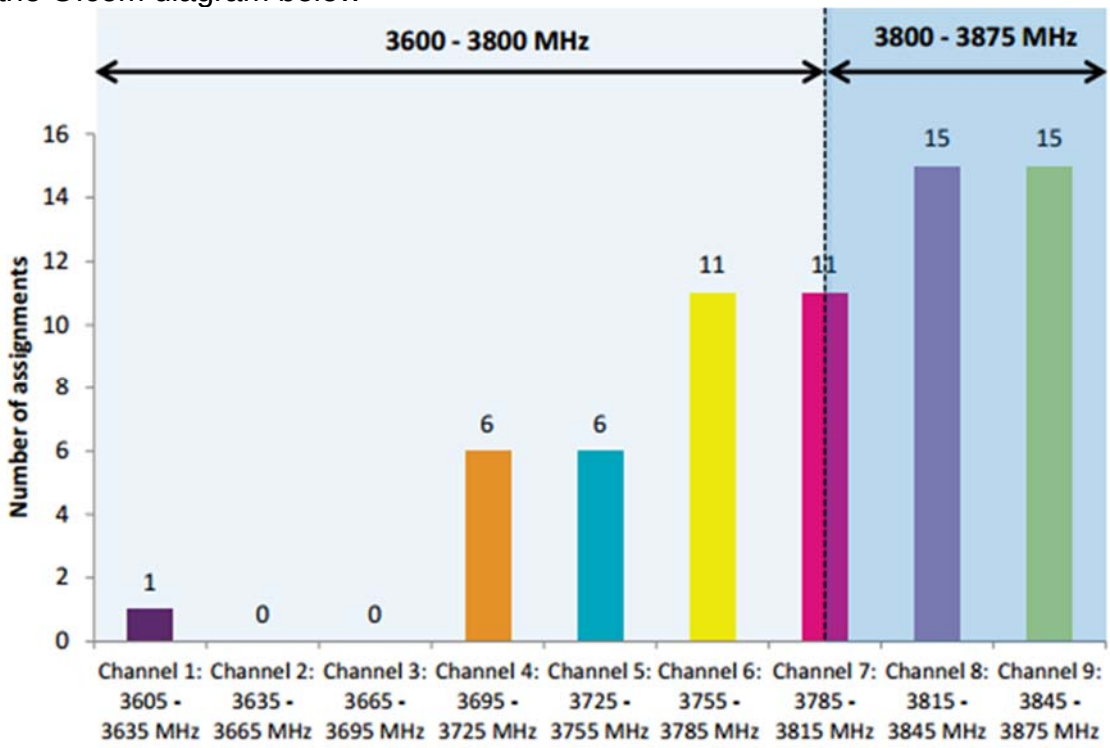
Additionally, as we point out in our answer to Question 2,we expect fixed and mobile 5G applications in this spectrum, FWA, backhaul and fronthaul; macro cells and small cells; rooftop, street level and in-building; beam-steering (which need not be restricted to millimetre wave bands); and software-configured antennas adjustable in real-time.

It will be necessary to define the procedures and assumptions to be used to minimise interference to the incumbent stations from mobile deployment. Draft ECC Report 254 would be a relevant basis for such considerations.

Question 6: Do you have a view on any of the two options we identified?

We recognise that mobile operators would prefer that this spectrum were currently unused, or at least contained no users requiring protection, and that UK-wide spectrum licences were offered to the market. That would create greater certainty to encourage investment in early deployment of 5G systems. They are also unlikely to want those licences to restrict 5G deployment by power output to small cells, which would require far less geographic separation from existing uses.

However in the UK 3.6-3.8 GHz has for many years supported Broadband Fixed Wireless Access, fixed links and a growing number of (often international) satellite services. As our answer to Question 1 shows, although Ofcom believes this spectrum to be relatively lightly used, there are a range of commercial services, whose operators are continually investing in innovation and increasing spectrum efficiency. It is clear however that there are very few Fixed Links in the 3.6-3.8 GHz band as depicted in the Ofcom diagram below –



These existing uses are the result of considerable investment - investment which continues, not least in innovation by satellite and ground segment operators. Those operators had expected to continue to invest in operating these services in this spectrum.

Some techUK members consider that these services shouldn't be unduly degraded by any mobile deployments. Their operators have considerable sunk investments, made in good faith, and an increasing customer base. Clearly those operators would not wish those uses to be required to move either to an alternative location and/or to an alternative spectrum band (where substitute spectrum could be identified), which would involve writing off existing investment, incurring additional investment,

potentially disrupting customers (with the risk that those customers then contract with a provider in another country), and could not be planned and implemented overnight.

So the choice presented by Ofcom is therefore a stark one between:

- Retain - Option A, which potentially reduces the benefit which UK plc might derive from early, widespread deployment of 5G in this spectrum and injects uncertainty around licensing fees for incumbents; or
- Remove - Option B, where the threat of incoming interference would likely halt investment in additional innovation with a risk that uncertainty of tenure (with acceptable quality of service) causes customers to take their business to providers in other countries.

Neither Option is cost-free. techUK also considers that neither extreme solution put forward by Ofcom is the optimal way to manage future shared use of the band and that a different solution - falling somewhere between the two Options - may be appropriate. This would mean providing continued protection for some satellite Earth stations and providing some means to encourage release of more spectrum to mobile where this has higher value.

techUK notes that, where satellite operators have nowhere else to go e.g. where use of C-band is essential for technical reasons such as global reach to areas with high rainfall, the effect of increased AIP may be to cause that element of the satellite industry - the benefits it delivers - to leave the UK.

While we recognise that it isn't for Ofcom to second guess how widespread future licensees of this spectrum may deploy 5G infrastructure, there is nonetheless a risk that Ofcom adopts a strategy for this spectrum which inadvertently leads to the cessation of some of the current, profitable uses of this spectrum in locations which never, in fact, have 5G infrastructure deployed sufficiently close as to have affected those services.

Put simply, for all the potential consumer benefits resulting from 5G deployment, maximising the immediate deployment potential from this latest allocation of spectrum for 5G shouldn't be an objective Ofcom strives to achieve at any price.

Continued protection for existing uses – where appropriate - would be consistent with EC Decision 2014/276/EU, which requires mobile deployment to be "Without prejudice to the protection and continued operation of other existing use in this band" and also requires that Member States (which the UK remains for now) "give appropriate protection to systems in adjacent bands".

It is expected that deployment of 5G infrastructure in this spectrum would, for commercial reasons be predominately in urban and inner suburban deployments, although a 3.6 GHz cell could be deployed on a mast in a rural village. Many – but not all - of the base stations may also be small cells, with reduced geographic separation to protect existing uses required.

techUK considers that sharing would be most feasible in the case of Earth stations and fixed links that are located in the more rural areas away from high population

density as this would reduce the impact the protection of these services has on the benefits that would be lost to mobile.

techUK therefore suggest that a hybrid or 'middle ground' solution that might allow continued incumbent use with appropriate protection from interference whilst maximising the benefit for early 5G deployments would be to retain existing users' current authorisations (including receive frequencies) in this spectrum and to require the new licensees to co-ordinate.

To this end extensive work has been carried out by CEPT in the development of (draft) ECC Report 254 (which we understand is due to be published imminently) which offers guidance on approaches that could be used for effective coordination between incumbents and mobile services in this band.

As the intent behind mandating coordination is to protect existing uses, whose operators have considerable sunk investments made in good faith, and minimise disruption and uncertainty for their users, Ofcom shouldn't authorise any new fixed links, or grants of RSA; new satellite earth station receiver components should be taken account of only in the specific situation of an urban or suburban earth station being relocated to a rural environment.

Depending upon the practicality of deploying macro cells in this band, it may take years from award of spectrum licences to mobile operators before any effect upon consumer benefits from constraints on 5G network topologies resulting from coordination would potentially arise. Those mobile licensees would then have the option of funding genuine costs of mitigation for existing users, which may include securing agreement from them to accept lower benchmark spectrum quality. Ofcom could also accelerate such a process, subject to having the right regulatory powers.

However we recognise that it is quite plausible, were full protection to be granted, that the operator of an urban or suburban earth station could demand payments to allow a new entrant mobile operator usage of spectrum which far exceeded the licence fees paid by the satellite operator, for which there would have to be backstop regulation by Ofcom to address such a circumstance.

This approach would support Ofcom's objective of securing optimal use of spectrum, and avoiding unnecessary disruption and unintended consequences, enabling commercially viable deployments of 5G where retaining existing uses would be unlikely to deny access to this band for mobile users in any commercially attractive locations for many years.

Any mitigations implemented by the incumbents should be underpinned by regulatory certainty such as security of tenure provisions where (for example) satellite operators move earth stations to rural areas, and consideration ought to be given to funding any future mitigations given the high costs incurred by the incumbents (particularly by earth station operators) and that incumbents have had expectations that they would have had longer access to this spectrum, given the requirements of *EC Decision 2014/276/EU.*

Question 7: Do you have any quantitative evidence on the costs and benefits associated with the options? This include costs for existing users and/or consumers of existing services associated with potential changes, and benefits to UK consumers in gaining access to mobile services in this band.

No comment.

Question 8: Do you have any other suggestions that would allow widespread 5G availability using the 3.6 to 3.8 GHz band across the UK while allowing certainty for at least some existing users to continue to provide the benefits currently provided by use of the 3.6 to 3.8 GHz band?

New 5G services and applications will almost certainly require access to additional spectrum with larger bandwidths. Offering a compromise for mobile operators between deploying for coverage and for capacity, along with 3.4-3.6 GHz, the 3.6 to 3.8 GHz band offers larger bandwidths to mobile operators than could be accommodated within existing 2.3/2.6 GHz, sub-1 GHz bands, and/or 5 GHz RLAN bands.

With its earlier availability for mobile operators, 3.4-3.6 GHz is a preferable option for deploying larger bandwidths, but we recognise that this may ultimately be insufficient and the availability of 3.6-3.8 GHz would provide potential for even larger bandwidths, directly for adjacent spectrum licences or indirectly via carrier aggregation, and enable any mobile operators which failed to secure spectrum within 3.4-3.6 GHz the potential to offer 5G services with large bandwidth.

The propagation characteristics of this spectrum lend themselves particularly well to small cells and in-building use. But deploying urban cells can currently take operators a couple of years, dealing with planning issues, landlords, and ensuring fibre availability. While there will be a need for many sites which aren't the traditional rooftop sites, we would ;point out that in London (where mobile data demand almost doubled over the last year) roof space is running out where demand is highest.

Given the importance placed by the Treasury on earliest deployment of 5G (as highlighted in the Autumn Statement), so that consumer benefits from 5G aren't delayed, there is arguably a facilitation role for Ofcom to bring together:

- central and local government (where we note that London has 33 local authorities)
- mobile operators
- infrastructure providers (such as Arqiva, Wireless Infrastructure Group)
- fibre providers
- major landlords and/or the British Property Federation.

The intention is that sites where mobile operators want to deploy 5G early would be available, with fibre, when those operators wanted them, provided with minimal disruption to consumers and tenants of commercial property (a result of coordination could be that roads be dug up only once).

Additionally we suggest that Ofcom examine the proposals in ECC Report 254 to look for opportunities to maximise the spectrum usage and provide a positive framework for early 5G deployment in the band.

We would also suggest that the mobile licensees could be required to consult a database of the locations of existing uses as an integral part of their network planning, and respect necessary exclusion zones.

We suggest that both those points could be addressed via database-driven access, which could be used to provide existing users with greater certainty of protection, and could maximise the opportunity for mobile services without wastefully extended exclusion zones. It could also allow existing users wanting to deploy new sites to benefit from faster, simpler and more certain access spectrum compared with the current coordination procedures.

Such a database-driven sharing scheme would be consistent with Ofcom's Spectrum Sharing Framework and drive opportunities for innovation in technology and business models, tapping into the growing international industry ecosystem for mobile shared spectrum opportunities in this band and serving unmet consumer demand. This would take proper account of likely deployments in this band and of the opportunity for protecting existing systems, assisting operators in reaching customers with 4G and 5G services more economically.

Question 9: Do you have any comments in relation to these proposals?

Unfortunately there is no obvious route for Ofcom to make this spectrum available for 5G which would be an ideal solution for both incumbents and for mobile operators. We expect responses to this consultation to be polarised.

Representing mobile operators (and their suppliers); satellite and ground segment operators; and fixed link operators; techUK has attempted to identify a "middle way" so that 3.6-3.8 GHz could be made available for early 5G deployment without unduly compromising the viability of incumbent users.

In this we recognise the considerable consumer benefits which we expect 5G to generate, and that additional spectrum will be needed to offer the bandwidth to provide some of these benefits. But we also recognise that this spectrum already supports a range of services with a range of customers, both UK and foreign, and their operators have continued to invest in more efficient and innovative uses of their infrastructure and spectrum.

No spectrum user should expect tenure in perpetuity, or even necessarily for as long as a service continues to be commercially viable. Ofcom has an objective to secure optimal use of spectrum and must have regard to new, ostensibly higher value, uses for spectrum currently in use.

But Ofcom must also have regard to the detrimental effect on investment where existing, viable uses with growing customer bases are threatened with degradation to

the point of withdrawal, in respect of both the spectrum in question and the precedent which may be applied by the market to other spectrum.

Satellite and ground segment operators have made considerable investment in C-band infrastructure in the UK which supports a range of customers, both UK and foreign, and have continued to invest in more efficient and innovative uses of that infrastructure and spectrum. But that investment takes many years to recoup and the uncertainty around long-term access without undue interference will tend to discourage additional investment by those operators and may also undermine winning new business. That doesn't set a good precedent.

techUK believes that, in determining how mobile services should be introduced to this spectrum, Ofcom should have regard, not just to the value of existing uses and the expectations which underpinned investment in them, but also to the message given to those who are investing in other spectrum bands which are – or may become – 5G candidate bands.

Additionally the limited regard which Ofcom appears to have for RSA awarded to protect passive users in C-band will undermine support for what, until now, had been seen by industry to be an Ofcom innovation which provided much-needed certainty as a basis for ongoing investment.

Recognising that 3.4-3.6 GHz should already have been deployed for 5G; and in expectation that, like that spectrum, most use of 3.6-3.8 GHz for 5G is likely to be in urban and inner-suburban areas; we propose that it wouldn't be disproportionate to require mobile operators to coordinate with existing uses at least in rural areas, potentially assisted by a database. No new fixed link or satellite uses would be authorised or taken into account for frequency management purposes in this spectrum, other than in the specific situation of an urban or suburban earth station being relocated to a rural environment.

We recognise that this approach would constrain mobile operators from deploying macro cells in this spectrum anywhere, but we would expect most existing uses to provide no constraint on 5G deployment for several years from licence award. Mobile operators would be free to contribute towards the cost of incumbents' genuinely and efficiently incurred mitigation where necessary to optimise their deployment.