Your response

Question	Your response
Question 1: Hybrid sharing could mean that the upper 6 GHz band will be used for mobile outdoors and Wi Fi indoors. What are your views on the priorities for each of these two services, assuming that suitable coexistence mechanisms are developed?	*Is this response confidential? – N* We would prefer priority to be placed on indoor Wi-Fi usage, as this is much less likely to interfere with our passive use of the band. Our radio telescopes are in isolated areas, away from most residential zones where Wi-Fi is used, but still exposed to emissions from mobile base stations.
Question 2(a): Hybrid sharing could mean that the upper 6 GHz ban will be used for mobile in some locations, and Wi Fi in others. We would like feedback on the priorities for each of these two services, assuming that suitable coexistence mechanisms are developed. From the point of view of mobile, is the upper 6 GHz band most useful to provide outdoor coverage, or indoor coverage? Is it most useful in urban areas, or in those base stations that are currently carrying more traffic, or some other split?	*Is this response confidential? – N* We would prefer, per question 1, that this band be used for Wi-Fi rather than mobile. While UK radio telescopes are predominantly in rural areas, where mobile use may not be prioritised due to lower demand, compatibility studies (using the methodology of ITU-R RA.769) would be required to assess suitable separation distances between radio telescopes and mobile transmitters. This applies particularly to the band around the 6.67 GHz methanol line used for observations of interstellar gas, which is of great importance for radio astronomy. Separation distances for mobile base stations required for compatibility with radio astronomy (following ITU-R RA.769) are likely >10s of km.
Question 2(b): Similarly, what are the priorities from the point of view of Wi Fi deployments?	*Is this response confidential? – N* We would still prefer minimal usage of this spectrum, but indoor Wi-Fi usage would likely have less impact on us than mobile.
Question 3: What are your views on a modified AFC or SAS type approach to enable hybrid sharing? What additional work do you think would be required?	*Is this response confidential? – N* Since radio astronomy is a purely passive user, there is no spectrum sensing technique that can detect its use. Radio telescopes are in fixed locations and operate 24/7/365. Subject to compatibility studies (following ITU-R RA.769) any co-existence with radio astronomy use would need to be determined on a geographic basis, but the required separation distances are likely to be large.
Question 4: How could existing access protocols and sensing mechanisms be leveraged (i.e., those in Wi Fi or 5G NR U) to enable hybrid sharing?	*Is this response confidential? – N* See above – spectrum sensing would not apply for a passive service.

Question 5: What mechanisms could potentially enable device to device connectivity?	*Is this response confidential? - N* See above – this is not relevant to our use case.
Question 6: If hybrid sharing is eventually adopted, and requires licensed mobile to operate at medium power, in what way would mobile networks use the upper 6 GHz band?	*Is this response confidential? – N* Compatibility studies with existing registered UK radio astronomy sites (Jodrell Bank, Cambridge, Darnhall, Defford, Knockin, Pickmere) would need to be done to enable protection of the 6.67 GHz methanol band, following the methodology of ITU-R RA.769.
Question 7: How would you suggest that the mechanisms presented here can be used, enhanced, or combined to enable hybrid sharing or are there any other mechanisms that would be suitable that we have not addressed?	*Is this response confidential? – N* We have no position on this.
Question 8(a): Assuming the future of the band includes indoor use for Wi Fi and outdoors use for mobile: How could this be achieved without creating or suffering interference?	*Is this response confidential? – N* To minimise interference experienced by our radio telescopes, outdoor mobile use of this band should be contingent on compatibility studies for the 6.67 GHz methanol band.
Question 8(b): Could there be a combination of technical adjustments such as power limits and other mechanisms (including databases or sensing mechanisms)?	*Is this response confidential? – N* Potentially, but compatibility studies following the methodology of ITU-R RA.769 would be required.
Question 9(a): We are interested in input about the importance of the upper 6 GHz band for its incumbent users, and on the potential impact of hybrid sharing of the band. What evidence do you have on whether incumbents are likely to coexist with hybrid sharing of the band with mobile and Wi Fi? Are there unique advantages of the upper 6 GHz band for these uses?	*Is this response confidential? – N* The 6.67 GHz band (6650.0 – 6675.2 MHz) is of great importance for radio astronomy for observations of methanol in interstellar space, and currently recognised by the 5.149 RR footnote and listed in the Ofcom table "Space science and meteorology spectrum allocations in the UK". UK radio telescopes operated at and by Jodrell Bank Observatory (STFC/University of Manchester) observe emission from methanol molecules in interstellar space and around stars at 6.67 GHz. Emission at this frequency is produced by a specific molecular energy transition and is fixed in frequency (except for any Doppler shift due to relative motion of the source and the Earth). **These signals from interstellar gas in the process of forming new high-mass stars simply cannot be observed at any other frequency. The 6.67 GHz emission is a tracer of a brief phase of star-formation that allows the developmental stage of star-forming regions to be characterised.**

Methanol emission is uniquely associated with the formation of stars around ten or more times heavier than our Sun. Such stars become even hotter than the Sun, have short lifetimes, and drive clouds of gas into space, eventually exploding as supernovae. They have created most of the oxygen, gold, iron and many other heavy elements in the Universe. Methanol produces maser emission, the naturally-occurring radio equivalent of lasers, which means that the line 6.67 GHz is so bright it can be detected from most places where massive stars are forming anywhere in the Galaxy, thus providing a birth census of such stars. Furthermore, detailed studies show that this methanol line often traces a disc around a star where planets could be forming, and can also track the speed of material falling into the star or being expelled as jets. Methanol is the most complex molecule, with 6 atoms, which is easy to detect from the ground, and it (along with some simpler molecules) also has masers at other radio wavelengths. Each maser line only appears for particular combinations of gas temperature and density - not to mention the right conditions needed to form each molecule. Emission at the 6.67 GHz line appears during the particular period in massive star formation, for a few tens of thousands of years out of a total of less than half a million years (our Sun, a smaller star, took about ten million years to form). Thus 6.67 GHz observations are the most important contribution to revealing the progress towards forming massive stars in each region and provide a major boost to our understanding of the life cycle of our Galaxy.

In addition to specific observations of methanol, many wide-band observations are made in the upper 6 GHz band. E-MERLIN at this frequency achieves an angular resolution of 50 milli-arcseconds, matching that of the Hubble Space Telescope and James Webb Space Telescope. Combining and comparing images from these optical/IR telescopes and our radio observations at this high resolution provides a unique insight into many astrophysical phenomena from the formation and evolution of stars to the development of stars and the distribution of dark matter revealed by gravitational lensing.

Question 9(b): What are your views on the initial analysis we have conducted around hybrid sharing and coexistence with incumbents?	*Is this response confidential? – N* No views on this point.
Question 9(c): For any incumbent uses that you view as unlikely to be able to coexist, what alternatives are there? What are the barriers that might prevent those alternatives?	*Is this response confidential? – N* There is no alternative to the 6.67 GHz methanol line -it is unique and its frequency is completely fixed by the physics of molecules.
Question 10: Do you have any other thoughts that you would like to share about hybrid sharing in the upper 6 GHz band, or about hybrid sharing more generally and its potential for applications in other bands?	*Is this response confidential? – N* No thoughts beyond those mentioned above.
Question 11: Do you have any other comments to make on these proposals or on the future use of the upper 6 GHz band?	*Is this response confidential? – N* No further comments.

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