Dense Air Response – non confidential

Question 1. How do you think demand for Shared Access is likely to change in future and why; Which use cases do you think are likely to emerge or grow, and which decline? Please provide a view on the bandwidth you would consider the minimum and optimal requirement for growth use cases, and timelines you would expect for their development

Dense Air already has many licenses across three different "Proof of Concept" locations and has a plan to submit more applications in the next 90 days. Scale deployment of our solutions with UK MNOs will ramp later in 2023. Our interest is specifically in the 3.8 - 4.2 GHz band (and a potential release of additional 2.3 GHz shared access spectrum). We believe we can mass deploy shared neutral host networks in this band, both indoors and outdoors providing they are permitted to offer services to Mobile Operators. We are on track to have our first generation of commercial Open RAN products in 2023 and we note that device support for the 3.8 - 4.2 GHz band is improving on a month-on-month basis driven by the use of C-Band / n77 in the US market and the CEPT study item in Europe.

We expect most neutral host deployments to operate using Multi Operator Core Network (MOCN) under Shared Access Licences. Instead of multiple dedicated deployments for MNOs or for individual private network clients, a Shared Access Licence site would provide connectivity infrastructure for several use cases and several clients, capable of connecting to, and hence extending, more than one core network. Multiple core networks could, from a technical point of view, be for commercial MNOs. The technology we have developed permits the deployment of four Public MNOs, a Private Network and a critical communications use case from a single MOCN based RAN. This type of arrangement at specific neutral host sites makes commercial sense for all parties. Finally, as the GSMA, 3GPP and CEPT have earlier established, any feasible 5G service would typically require 100 MHz of spectrum to operate in.

Question 2. Are there elements of the current framework that complicate the use of Shared Access licences for specific use cases? If so, please provide specific examples and indicate the changes that would be required to facilitate this and how this might co-exist with other use cases.

Dense Air's use of the 3.8 - 4.2 GHz spectrum is typically to build shared networks with many use cases in a small targeted geographic area, providing advanced, high reliability and high bandwidth connectivity for multiple network operators, private networks, FWA services and critical communications. Our experience to date, from the deployment of several "scaled proof-of-concepts" using 3.8 - 4.2 GHz Shared Access Licenses has shown that under the current licencing process it only takes one other operator (for example a WISP) with a very low density deployment, operating over very wide areas to severely limit or eliminate the ability of other parties to license the spectrum in their target deployment area. This seems to be largely due to the way frequencies are being assigned, the permissible deployment locations (i.e. on tops of hills / high ground) and the way in which the protection calculations are made. This has led to non-optimal use of the total available spectrum, a desired objective for Dense Air and a fundamental objective for OFCOM.

There is a now an opportunity to improve utilisation of the available spectrum by allowing operators to use all the techniques available to limit the interference footprint of their equipment where a network is being built to cover a relatively compact in-fill area such as business parks, which exist in both Urban and Rural settings.

These improvements can include taking account of directional antennas and azimuths and encouraging single frequency usage enabling operators to contribute to better use of the available spectrum. For operators seeking to cover wider areas greater scrutiny of the surrounding geography and restrictions should be put in place to around the siting of stations on high points, and tighter frequency allocation could reduce the unintended sterilisation of large areas, particularly where those areas have high business occupancy. The current process focusses on individual stations seemingly attempting to allocate the clearest channel available to that site without regard for the wider impact that site may have on overall spectrum availability. Perhaps it would be beneficial for the applicants to set out their intention in terms of intended network coverage in an area and only then to look at the individual stations.

However, the biggest barrier to the utilisation of this spectrum are the constraints that OFCOM attached to the Shared access use cases for the 3.8 - 4.2 GHz band:

Figure 1.1: Overview of Shared Access Use Cases Envisaged in 2019 by Spectrum Band

Uses	1800 MHz shared spectrum	2300 MHz shared spectrum	3.8-4.2 GHz	Lower 26 GHz band
Private network (e.g. industry uses)	✓ (narrowband)	✓	✓	✓ (indoor)
Mobile coverage (rural)	✓	Certain locations	×	×
Mobile coverage (indoor)	✓	✓	×	✓
Fixed wireless broadband	×	×	✓	Prior Authorisations

We agree with OFCOM that Shared Access Licenses should not be permitted to be directly used by Mobile Operators who already have significant spectrum holdings, but should be targeted at Neutral Hosts or Operators building shared networks that can support multiple use cases, multiple customers and deployments that provide RAN-as-a-Service to Mobile operators, where their economics do not permit network build. These scenarios fall into Mobile Coverage (rural), Mobile Coverage (Indoor) and a new category of Mobile Capacity (High Demand Density). This applies especially to allocation of 5G NR SA capable spectrum at 3.8 - 4.2 GHz.

There is a huge opportunity to fix issues associated with High Demand Density (HDD) locations, which occur in various Urban and Rural areas on a seasonal or event driven basis. These are locations where Mobile Operator economics do not permit the construction of sufficient capacity to handle the demand for high traffic demand and large number of users. This creates a very poor mobile service experience, and often creates public safety issues, as even 999 or emergency service access is prevented as networks are overwhelmed.

We propose that OFCOM creates a new category of use case, which is Mobile Capacity (HDD) which permit the deployment of shared networks, which can host multiple network operators and/or multiple use cases, which have dramatically better economics, and permit MNOs to access this additional capacity to service their end users when high traffic demand events occur.

We would suggest that the Shared Access Use Case should be updated as follows.

Uses	1800 MHz shared spectrum	2300 MHz Shared Spectrum (inc. 2.30-2.35 MHz)	3.8-4.2 GHz	Lower 26 GHz band
Private network (e.g., industry uses)	✓ (narrowband)	✓	✓	✓ (indoor)
Mobile Coverage (rural)	✓	With Spectrum automation	✓	x
Mobile coverage (indoor)	✓	With Spectrum automation	✓	✓
Mobile Coverage (HDD)	✓	With Spectrum automation	✓	✓
Fixed wireless broadband	x	With Spectrum automation	✓	Prior Authorisations

In summary, the main issue for the mass deployment and adoption is the restriction that applies to mobile coverage (Rural and Indoor), and the definition of "rural". We believe that neutral host operators should be permitted to deploy services for Mobile Operators using Shared Access Licenses, albeit with some mechanism to prevent MNO's acquiring the spectrum and monopolising the capacity available. We also believe that a new class aimed at Mobile Capacity for High Demand Density deployments will directly drive the mass deployment of networks using Shared Access Licenses (in both 3.8-4.2 GHz and in 2.3 GHz) if the band is extended using a new spectrum licensing automation solution.

Question 3. Do you have any comments on the power restrictions currently in place, particularly in urban/high density areas, under the Shared Access licence? Please explain what benefits could be delivered using a higher operating power (medium power in urban areas), or any concerns you sharing with such operations).

Dense Air has already encountered a situation where a very large, single, development site outside a large conurbation is defined by ONS to be "urban" and so only low power licences are available. The nature of the site is not urban in that it is a development area where one authority is laying down the infrastructure across the whole site. The size is such, together with the need to cover the entire site before individual developments take place, coupled with the nature of some of the proposed uses of individual areas with the development area that medium power is essential to allow initial coverage (perhaps later to be infilled with low power as development progresses). Some locations will always need medium power to achieve coverage due to physical constraints on the minimum spacing between masts required to accommodate the operations to be carried out in the area. While this is an unusual situation, it is unlikely to be the only case, yet an application for a rural exemption was not successful.

We believe the distinction between Rural; Urban and HDD areas should be removed as it is very arbitrary. We believe that medium power licenses are ideal in all areas, subject to the licensing allocation process and the "shared" nature of the band, which permits multiple operators to coordinate their usage.

Deployment in Urban and HDD areas should have an antenna height restriction if medium power is utilised, i.e. the base stations (with medium power) should be lower than the average clutter height in an urban location.

Question 4. Do you have any comments on the exceptions process, and how some of its benefits could be maintained within more standardised and automated assessments?

The exceptions process has, so far, not helped Dense Air. Where a geographic area is only a few km across and medium power stations can be built right up to the edge of that area under the current rules, any supposed potential benefit would appear, in most cases, to be lost.

Dense Air believe that a more considered approach to restrictions in geographies where, for example, Development Areas or Freeports are being established is required. That approach would need to consider the future plans for areas rather than what exists today and needs to look at the area in the context of the wider geography. We believe a 10m height constraint should apply to the 3.8 - 4.2 GHz band when operating at medium power, or below the average clutter height in the target area.

An automated spectrum allocation process should be in place for new allocation like the proposed 2.30 - 2.35 MHz allocation.

Question 5. Do you have any views whether and how the coordination approach should be modified? If yes, please provide comments in light of the issues set out above.

In making the assumption that all stations use omni directional antenna the current approach misses the opportunity for operators trying to cover specific areas such as urban and suburban in-fill, science and business parks etc. to utilise station location, antenna type and azimuth to control and limit interference with other users. As it is quite common to find such areas on the outskirts of towns the potential opportunity to better utilise the available spectrum in a given area is currently being missed.

Dense Air would welcome consideration of antenna type, azimuth etc. in assessing an application, and would accept a requirement to coordinate with other operators if this brought benefit in terms of greater spectrum availability.

The EIRPs are appropriate for the medium power. We believe that for indoor deployment an increase to 4W, or 36dBm EIRP is appropriate, as the 31dBm impacts the economics when utilised in a band like 3.8 - 4.2 GHz.

Question 6. Do you have views on whether newer or emerging technologies can support coexistence between additional users in the band, and if so, how?

Synchronisation should be introduced for the medium power / outdoor licensed 3.8 - 4.2 GHz TDD band, the new proposed 2.3 GHz TDD allocation based on a downlink centric pattern, already in use by UK MNOs for 5G NR. This will prevent poor performance on license boundaries and provide additional protection to UK MNO licensed spectrum below 3800 MHz. We propose the following synchronisation scheme, and minimum operating parameters.

This pattern is based on the ECC Recommendation 20(03), where Frame B ensures compatibility between LTE at 15 kHz subcarrier spacing and 5G NR at 30 kHz subcarrier spacing. Thus, for 5G NR we would recommend the TDD frame structure of:

Frame format 1: DDDSUUDDDD 5ms:

- Numerology 1
- Special Frame Format 6 [10-0-4]
- Control overhead DL 5%, UL 20%
- DL MCS27 256QAM
- UL MCS28 64QAM / MCS27 256QAM

For Indoor deployment, or campus deployments in a bounded geographic areas there should be a choice of synchronisation patterns including uplink centric. As below:

Frame format 2: DDDSUUUUDD 5ms:

- Numerology 1
- Special Frame Format 6 [10-0-4]
- Control overhead DL 5%, UL 20%
- DL MCS27 256QAM
- UL MCS28 64QAM / MCS27 256QAM

Frame format 3: DDDSU 2.5ms:

- Numerology 1
- DDDSU 2.5ms
- Special Frame Format 32 [10-2-2]
- Control overhead DL 5%, UL 20%
- DL MCS27 256QAM
- UL MCS28 64QAM / MCS27 256QAM

We are aware from the feedback provided at the Spectrum Sandbox kick-off meeting earlier this spring that there are also uplink-oriented usages at 3.8 - 4.2 GHz band. Nevertheless, such use will even under the existing shared access rules abide with coexistence with other sites. We see a clear benefit in spectrum use efficiency if medium power sites operating in a downlink centric fashion would adopt the same TDD frame structure and synchronisation. We can for example see that in the US CBRS band there are coexistence groups that would synchronise amongst access points within the coexistence group.

Question 7. Please outline any comments on the current licensing process (e.g. ease of application, time taken, the information we require). If relevant, please note aspects you are currently content with and areas which could be improved.

Over the past two years, Dense Air has made numerous applications for Shared Access Licences and has experienced a variety of issues with the current process. In addition to issues with the mechanics of making applications, early difficulties were mainly around interference issues towards earth stations. These were quickly addressed with changes made to the way interference was being assessed, improving the process.

From a user point of view there are many deficiencies in application process. Some are relatively trivial in terms of impact and are at the level of simple administration. Some are more fundamental relating to aspects of the interference analysis that is performed, and others relate to important communication with the applicant. But the single most significant issue is the time it takes to progress from submitting an application to having sufficient confidence that a suitable licence will be issued to support a business investment cycle in a commercial environment. Currently, based on experience, that time is approximately three months though it is recognised that supporting the spectrum needs of the Coronation and the Eurovision contest have placed considerable additional load on Ofcom's resources.

Particularly when making multiple applications for the same site, the application form is inefficient. In over 1Mbyte of data that the form requires, only a few bytes vary between stations, yet a completed pdf file is required for each. Emailing multiple forms can, and in our case has, exceed the limits of email systems leading to multiple emails for what are applications for one network, and this leads to multiple case numbers. A bulk application route is needed.

The application form has no facility for requesting a specific frequency such as is needed when adding a station to an existing network or stating that one frequency would be acceptable across multiple stations such as when setting up a new network on a large site.

A case number is returned by Ofcom for each email submitted, but these are not sent as a "reply" so where multiple emails have been needed due to size limits it can be unclear which case number applies to which batch of applications. It would be helpful if the acknowledgement with the case number was sent as a reply in all cases allowing an email system to link the relevant communication.

The next interaction is the "application receipt" email sent from Ofcom. This gives the type of licence, low or medium power, the proposed licence number and the site address, but does not give the frequency or, significantly, the station identity as stated on the application form, making it impossible at this stage to link a licence number to a specific station where there are multiple stations in multiple bands within a large site. It would be helpful if the receipt gave the station name and frequency, and the case number of the application if Ofcom are using the case number in preference to the licence number when tracking applications and responding to queries as seems to be the case.

If there are no problems with the application, then the next stage is an invoice is sent. The person submitting the application is not copied or notified of this step. The invoice carries the licence number and site address, but not the station name, or frequency band. With multiple stations on one site this has made it very difficult to track progress. This is the first time the applicant sees anything indicating a licence can be issued, but no details of the intended licence, such as frequency and power are given, and there are no other details from the application to allow cross checking. This is an opportunity before payment and the issuing of a licence to check details such as frequency, power and location, where Dense Air have experienced errors and other changes which were not able to be discovered until after a licence has been paid for and issued.

If the assessment identifies problems with the application such as interference or other spectrum availability issues, there does not seem to be a reliable way that the applicant is notified. While Dense Air has experienced a dialogue being opened between the assessing officer and the applicant in some cases, Dense Air has also experienced simply 'no further communication' at all after the receipt had been sent, only discovering there was an issue with the availability of spectrum when, after patiently waiting many weeks, the application was chased.

Dense Air would like to see a step after the assessment has been completed but before an invoice is generated where the summary details of the application are sent to the applicant including station name, location, frequency, power etc for verification and only then is the invoicing initiated.

Where an application cannot be granted the same step would include details of why there is a refusal, again giving details of location etc. as Dense Air has experience of one application which was being refused where a typo within the Ofcom process has placed the station more than 150Km from its requested location.

The assessment is currently made using P.452 version 10 together with clutter data that is around 15 years old. Dense Air suggest that a later version of P.452 would be more appropriate and that the clutter model needs to be updated in areas where there has been significant building development.

The time taken for the process from application to the point where a licence is issued is not compatible with the commercial timescale for realising a customer's needs. There is no target date set for each application or ability to quickly identify where in the queue an application sits. There is not even a "fast track" route to identify the radio environment around a specific area at an early stage in examining commercial opportunities. This is further complicated by other operator's applications being at various stages within the Ofcom system, including applications that have completed processing but await payment, payment that may never materialise, where the presence of a potential licence then blocks new applications. There is no ability to "reserve" a cleared channel for a limited time pending conclusion of detailed network design and commercial agreements. These are all serious impediments to planning investment in network infrastructure making use of the available spectrum.

It would also help if the application process was more transparent and provided a portal showing application progress, this could be used to pre-assess the availability of a license in a target location.

Question 8. Do you have any comments on the suitability of available spectrum for your use cases? Please consider the relevance of the additional bands we are proposing for the framework, and the impact of any limitations on existing bands.

Typically, Dense Air uses 100 MHz channels for its shared networks in the 3.8 - 4.2 GHz band so the spectrum available is very well suited to 5G networks designed to support multiple operators and use cases.

The actual spectrum available is from 3805 - 4195 MHz (390 MHz). When combined with various features of the current assessment process this has already resulted in serious spectrum availability issues over one very large area of the country where there are currently very few operators.

At this stage Dense Air has not developed a view on the lower 26GHz band, but recognises that, overall, increasing demand for services means more spectrum will be required with the lower 26GHz band as a potential area for growth, once an eco-system of suitable equipment has become established.

The allocation in 2.3 - 2.35 GHz is extremely attractive and would permit many other use cases if Outdoor use was permitted. Dense Air already uses the band under T&D conditions at its test location at the Millbrook Proving Ground. We have 15, indoor only, shared access, low power licences. Each covers stations in a 50m radius around a designated point. The 15 licences cover 13 buildings, with two buildings being of such a size that two licences were needed.

These licences are for 2390 - 2400 MHz, at a max EIRP of 24dBm for a base station, with terminals allowed 25dBm with a 2dBm tolerance.

We also have a "test and development" outdoor licence covering the whole of the Millbrook Providing Ground, for non-operational use, which we have used for proof-of-concept testing and development purposes. These licenses have been repetitively granted and we have demonstrated that deployment in the lower part of 2.3 GHz can be done successfully without impacting VMO2 commercial operations in the adjacent allocation or MOD usage of the band. The "T&D" licences cover 2300 - 2340 MHz at 9.85dBW ERP or 42dBm EIRP.

We believe the 2.3 GHz band is ideally suited for LTE and future 5G NR deployment and would accelerate the adoption of shared access deployments in the UK, where both 5G and 4G shared access capacity is required. We note that the current 10 MHz allocation is too small to be practical for most shared network deployments with multiple operators or multiple use cases.

In summary, the use of an expanded 2.3 GHz Shared Access License would be indoor mobile coverage and capacity augmentation.

Question 9. Do you have any comments on equipment availability limiting deployment options in 3.8-4.2 GHz? Please comment on the impact of any experiences you have had, and where relevant, your expectations for when more equipment will be broadly available across the band.

The deployment of C-Band in the US has driven rapid market adoption of the upper n77 band and Dense Air has readily available small cell equipment in 3.8 - 4.0 GHz which has been deployed at three proof-of-concept locations across the UK.

Terminal equipment is also available that can cover the 3.8 - 4.2GHz band, however, terminal equipment suitable for the intended applications is currently limited to 3.8 - 4.0GHz. The current list of supported devices on Dense Air's deployment are as follows.

Location	Type	Vendor	Device
UK	Phone	Samsung	S23
UK	MiFi	D-Link	DWR-2101
UK	MiFi	Netgear	Netgear 6 Pro
UK	Router	Airspan	9621 Indoor CPE
UK	Router	Airspan	7621 Indoor CPE
UK	Phone	Oppo	Find X5 Pro
UK	Phone	OnePlus	10T
UK	Phone	Xiaomi	12
UK	Industrial Router	Proroute	H685 5G Router
UK	MiFi	Zyxel	NR2101
UK	Outdoor Modem	Zyxel	NR7101
UK	Phone	Samsung	S23 (TEMS Pocket)
UK	Tablet	Samsung	Tab Active4 Pro 5G

Note: Many devices required Carrier Mobility Updates to activate (for example Apple iPhones).

CEPT is working on the EC mandate on "Shared used of the 3.8 - 4.2 GHz frequency band by terrestrial wireless broadband systems providing local area network connectivity", Looking at the timeline of the response due to the Commission in early 2024, we expect immediate deployment in several Europeans countries which will increase the momentum for both RAN and devices.

We are positive that a wider adoption of shared use across CEPT member states will follow once the sharing and compatibility studies are available and the Commission makes a decision. We are particularly encouraged by the fact that the UK Shared Access Licence mechanism is the starting point for CEPT evaluations in WG FM and PT1.

Question 10. Do you have any other general comments on the Shared Access framework? Please consider any areas where future innovations could further support Ofcom's policy objectives for this spectrum, and/or improve the experience for users.

We believe the current approach of granting a licence to an applicant at a given location is the right approach as this gives the applicant confidence that spectrum with the necessary bandwidth will be available when it is needed. Most use cases for business customers require defined, often high, service levels. The current approach, once operating effectively, allows applicants to predict and achieve defined service levels for their networks. Services provided using spectrum used under a DSA regime would, once demand increases, not be able to achieve high service levels with an acceptable level of confidence.

We agree with Ofcom that there is no need to introduce DSA, which may further complicate deployment and certainty of spectrum access. The focus should be on how OFCOM enables the mass deployment of licenses via automation.

CBRS SAS in the US provides a real-time way to deploy products and provides key ways to enable priority for certain users (aka Government / Military).