Issue 1

BT's response to Ofcom's consultation on:

Public Sector Spectrum Release (PSSR)

Technical coexistence issues for the 2.3 and 3.4 GHz award

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Executive Summary

1. BT agrees that a market led award through an auction is an acceptable approach if Ofcom is releasing the spectrum in relatively small packages. However, in BT's preferred scenario of a large block allocation to a neutral host operator, with appropriate rights and obligations attached, other options could be more appropriate (e.g. beauty contest). We can only give a final view on the award mechanism when details of the proposed spectrum packaging are available.

2. BT has no objection to Ofcom's plan to not enable aggregation of bids for low power licences, which may allow a simpler auction, but we consider that other means of facilitating shared use of the spectrum (e.g. a large block allocation for a neutral host with wholesale access obligation) should be examined. A shared small cells network could represent a very efficient use of these spectrum bands.

3. BT appreciates the considerable work done by Ofcom to understand potential interference to WiFi and other existing systems that might arise as a result of releasing the 2.3GHz spectrum for LTE. However we are concerned that insufficient work has been done to enable the interference situation to be properly understood. We consider that the risks of interference to WiFi have been under estimated by Ofcom and we are of the opinion that the proposed mitigation measures have been over played and are costly and unrealistic or unsuitable. Thus we are unable to endorse Ofcom's technical assessment and the view that no intervention in the market is necessary for this issue.

4. Further measurement work is needed before decisions are taken, particularly to understand the risks of interference to in home WiFi networks from 2.3GHz LTE devices. It is not sufficient to base decisions on "median" performing devices and a range of devices needs to be considered, particularly popular devices that are in everyday use in large volumes. Measurements of WiFi access point throughputs that are more realistic and current and future broadband backhaul speeds should also be taken into account.

5. Pending completion of further measurements work, which BT is willing to contribute to, we cannot endorse Ofcom's technical conclusions and consider that additional mitigation options need to be looked at, such as introducing a larger guard band between WiFi and 2.3GHz LTE or other technical measures.

6. The costs of the mitigation measures to resolve any interference problems that might arise have not been identified by Ofcom and we consider this to be an important item to be assessed. This will enable comparison of these costs with the benefits of releasing spectrum (or less spectrum if a guard band is introduced) and might be relevant to consideration of possible compensation to affected parties.

1. Introduction

BT welcomes Ofcom's consultation on the technical issues that must be considered in relation to the proposed award of the 2.3GHz and 3.4GHz bands for mobile systems. We have an interest in the technical licence conditions associated with this spectrum, both as a potential future user of the bands and because of our extensive interests in existing systems deployed in adjacent spectrum bands that could be affected, especially WiFi systems used by BT and its customers[1]. More generally we are mindful that UK citizens and consumers, who may often use numerous WiFi devices on a daily basis, have reasonable expectations that these will not experience undue interference as a result of regulatory actions. We are therefore pleased to contribute our views on this important topic and are keen to work further with Ofcom and all other stakeholders to ensure that the award of additional LTE spectrum does not have any negative impacts on other existing and ongoing spectrum use.

A summary of our position is provided in Section 2 and answers to the individual consultation questions are provided in Section 3.

2. Summary of BT's position

BT appreciates the considerable amount of work that Ofcom has instigated or has undertaken to understand the risks of future 2.3GHz LTE TDD networks interfering with other systems, in particular the adjacent 2.4GHz WiFi networks. We consider the technical assessments to be reasonably comprehensive, apart from the scenario of LTE UE equipment interfering with WiFi access points and client devices. For this scenario we have undertaken some practical measurements of our own and have further measurements planned. We will endeavour to share these with Ofcom in due course.

Overall we do not share Ofcom's interpretation of the findings of the existing technical assessments. We are concerned that the risk of interference occurring has been underplayed, and too readily dismissed with over reliance on mitigation techniques that may not be feasible.

We consider that the level of risk of interference and the impracticality of the mitigation techniques warrants further assessment of whether the 2.3GHz release band could be changed to allow a larger spacing between 2.3GHz LTE and 2.4GHz WiFi. Our measurements indicate that an additional guard band in conjunction with improved WiFi receiver filtering would substantially reduce the risks of interference scenarios arising. The Government use of the 2.3 - 2.4GHz band is not described and so we cannot ourselves assess whether or not this is feasible and the costs that this would entail. The option to limit power levels in the top part of the 2.3GHz band in order to reduce the risk of blocking to WiFi should also be considered.

Finally, the likely costs of the necessary mitigation measures to resolve interference problems, that Ofcom suggests will be paid for by operators and end users, should be identified. This can then be compared with the expected economic benefits of making available all new spectrum for LTE, rather than leaving some unallocated to provide a larger guard band to reduce interference risks or implementing other measures such as reduced power. The question of whether it is appropriate to provide financial compensation to those affected by interference from 2.3GHz LTE deployments needs to also be addressed when the costs are properly understood.

[1] BT Broadband customers have access to over 5m BT Wi-fi access points in the UK. Most are located in UK homes and some are in businesses or public locations. Customers typically connect numerous WiFi devices to these access points including smartphones, games consoles, internet radios, PCs, laptops, tablets.

3. Our responses to the consultation questions

Question 4.1: Do you agree with our proposal to conduct a market led award through an auction process for licensed use of the 2.3 and 3.4 GHz bands? If not, please provide evidence to counter this proposal.

BT would be content for the spectrum in question to be subject to individual rights of use (licensed) and awarded by a competitive or comparative process depending on how the spectrum is packaged and the rights and obligations that may be specified. Licensed use seems appropriate in view of the need to manage interference.

If Ofcom were to follow BT's preferred scenario and award part of the available spectrum in a large block suitable for a neutral host network operator and include wholesale access obligations, then a beauty contest might be more appropriate than an auction because this would reduce the cost of spectrum and enable the most attractive shared network to be provided at lower cost. Otherwise we agree that an auction process would be suitable whatever the packaging, although the details of that (including competition measures) will be important to get right and we will be pleased to engage further with Ofcom on such details.

Question 4.2: Do you agree that we should not offer arrangements for aggregate bidding for low power use for these release bands? If you believe we should make such arrangements, please provide supporting evidence.

We consider that the lack of demand for low power shared licences in the previous auction was inevitable because the detailed auction rules made these unattractive to bidders (e.g. if one or more bidders paid the price of having these licences included in the outcome other bidders could free ride). Therefore previous lack of demand does not in itself justify not offering concurrent low power licenses in the next auction. That said, we don't oppose Ofcom's plan to not include these in the next auction for reasons such as simplicity.

We further note that low power shared use of spectrum could be in effect be alternatively achieved by other means, such as a shared neutral host small cells network with regulated wholesale access obligation. We would therefore encourage Ofcom to consider sharing options in the broadest sense and examine all such possibilities.

Question 6.1: Do you have evidence to challenge our methodology and assumptions, which show the number of Wi-Fi routers likely to be affected by LTE interference is low?

Interpretation of standards

Ofcom has made reference to both the IEEE standard and the ETSI standard in relation to blocking performance of WiFi devices and has used these to calculate separation distances (e.g. Table 7.20: minimum separation distances based on standards).

In relation to the IEEE standard we assume that the reference in footnote 2 of the Annex 7 of the consultation paper should refer to Table 18-14 of the IEEE standard rather than Table 18-15. We can then follow the logic of how the IEEE standard implies a blocking level of -47dBm based on the "alternate" channel performance. However we note that, with the 10MHz effective guard band between the proposed 2.3GHz UK LTE allocation and WiFi band, the frequency separation is 32MHz (for a 20MHz wide LTE system), which falls between the adjacent and the "alternate" WiFi channel. Taking this into account a lower value than -47dBm might be implied by the standard.

Regarding the ETSI standard where Ofcom has identified a blocking value of -30dBm for a cw signal, we would point out that the test in the standard is intended to check that the frequency agility in the presence of co-channel interference, if implemented, works correctly in the presence of a blocking signal beyond the opposite end of the Wifi band to the bottom or top WiFi channel. We believe that this is not intended as a measure of receiver adjacent channel rejection performance.

None of the referenced standards are directly applicable to the interference scenario that is under consideration and hence we consider that Ofcom should not rely on these to inform its position. Instead the measured performance of actual devices should be the primary focus.

Probability of interference calculated for "Median" router in Ofcom's sample

We have no evidence at present to dispute Ofcom's assessment of the likely incidence of interference to existing 2.4GHz WiFi routers from 2.3GHz LTE *base stations* assumed to be deployed on existing mobile base station sites, but we take issue with the consideration of "median" devices for the analysis and derivation of conclusions. There will be a wide spread in performance of different WiFi routers and the impact on devices that may be more vulnerable than the median must also be considered, particularly where these could be deployed in large volumes. Furthermore we consider it more likely that 2.3GHz would be used for new capacity sites (including small cells) rather than just additional frequencies on the existing 3G base station sites run by the national MNOs. This might lead to an under assessment of the risk of interference to WiFi if only existing 3G sites have been considered.

We understand that the very small proportion of WiFi routers that are predicted to be affected in Table A7.3 of the consultation relates to interference from 2.3GHz LTE base stations if deployed on existing outdoor 3G base station sites. This therefore does not reflect the more likely case of interference to WiFi routers from 2.3GHz LTE *user equipment* devices (terminals). Whilst when considering potential interference from LTE base stations the number of affected networks may be a very small percentage, we nevertheless consider this to be a significant concern.

The report by MASS published by Ofcom alongside the consultation does not give the impression that the number of interference cases will be low. In Table 7 of the MASS report it indicates that 1m-6m separation between LTE devices and indoor WiFi devices is needed to avoid interference and we consider such separation distances, and closer, will occur with a high probability. The same table shows 20m-50m separation from an LTE base station is needed to avoid interference to indoor WiFi devices. The report indicates that 150m to 500m separation from an LTE base station is needed to avoid interference to outdoor WiFi, which again seems quite likely to occur. We acknowledge that for reasons stated in the report these figures might be pessimistic, but we cannot ignore them and assume that consumers and operators will have to replace the WiFi equipment just to maintain the experience they currently enjoy.

The MASS measurement exercise tested only a relatively small sample of devices and the analysis of necessary separation distances only considered protecting the best performing 75%. The report did also not take into account the typical ratio of LTE base stations to mobile devices when concluding that the LTE uplink interference (LTE UE Tx) is less of a concern than the LTE downlink interference (LTE BS Tx). In residential areas where millions of WiFi networks operate it seems more likely that WiFi – LTE UE separations of a few metres will occur more frequently than 10s of metres separations from an LTE base station. We therefore do not agree that the interference from LTE UEs is of less concern.

We note that the detailed results of the MASS measurements that were made available towards the end of the consultation period indicate that the baseline WiFi throughputs, against which various percentage degradations were measured, correspond to surprisingly low speeds (e.g. 10-15Mbit/s or <6Mbit/s for tests on home hubs). We do not understand why the MASS results show these low

throughput levels, since the WiFi signal levels they are operating with should give at least 40Mbit/s, and we have demonstrated this in our tests. If some part of the MASS test set-up is limiting the throughput to a falsely low level, then a certain percentage reduction, e.g 50%, in this low level (say 12Mbit/s to 6Mbits/) is likely to require a greater level of interference than a more realistic situation of 40Mbit/s reducing to 20Mbit/s. MASS also have changed the WiFi client device between testing different Access Point tests, and mention in Table 1 of the measurements annex different amplifier and attenuator settings 'to reduce the noise floor', and we do not understand the rationale for this. It would be much appreciated if the detailed test procedure used by MASS could be made available to us. This is particularly worrying for us, because many of the Ofcom conclusions about impact of interference are based on the MASS report.

We question whether these tests are representative of the future scenarios that will be of concern to consumers, and we would expect that if degradation of more typical user speeds had been investigated then the interference effects would be apparent at much lower levels and hence would imply greater required minimum separation of networks. Furthermore the measurements mainly looked at good WiFi signal levels and we are concerned that the reduction in coverage caused by interference has not been considered – that is there will be a much greater impact on users located at the fringe of coverage in a house, for a given interference level. In many households there are likely to be users at the extremes of WiFi coverage and hence interference will not just reduce throughput but may have more significant impact.

We have undertaken our own practical measurements to further examine the potential for LTE UE emissions to cause interference to WiFi routers. Our own measurements of this scenario call in to question Ofcom's conclusions that are based on consideration only of the "median" performing WiFi equipment and that have not considered the probability of interference from LTE UE devices. We also have further measurements planned and will endeavour to share these with Ofcom in due course.

Finally we would like to draw Ofcom's attention to a White paper on TDD LTE Spectrum Issues issued last year by the Global TDD LTE Initiative in which tests by China Mobile showed that there is a severe risk of interference to WiFi from base stations and mobiles even when LTE is only operated below 2370MHz (i.e. a 30MHz guard band compared to the 10MHz that is presently proposed in the UK)[2].

Question 6.2: Do you have evidence to challenge our methodology and assumptions, which show the number of Wi-Fi client devices affected by LTE interference is low?

Our comments in response to Q6.1 above (interference to WiFi routers) concerning interpretation of IEEE and ETSI standards are also applicable to Q6.2 (interference to WiFi client devices).

Probability of interference calculated for "Median" WiFi client in Ofcom's sample
We understand that the very small proportion of WiFi clients that are predicted to be affected in Table A7.3 relates to interference from 2.3GHz LTE base stations if deployed on existing outdoor 3G base station sites. This therefore does not reflect the more likely case of interference to WiFi clients from 2.3GHz LTE *user equipment* devices (terminals), as explained in our response to Q6.1 above.

Interference from LTE user devices into WiFi has only been assessed in terms of the separation distance needed between these two devices under various assumptions about LTE UE power and WiFi blocking performance, and no assessment is provided as to the number of cases where such a problematic scenario may arise. Even if the distance is small e.g. 1m to 3m this can be problematic (e.g. a 2.3GHz LTE

[2] See Annex 4 of http://www.lte-tdd.org/d/file/Resources/pub/2013-11-22/180e4fbd9e544d019d42bc6d67913bf2.pdf

device could make 2.4GHz WiFi to adjacent users seated nearby in an office/train/conference centre or home environment).

As mentioned in our response to Q6.1 above, the MASS report indicates to us a high rather than low probability of interference occurring and our concerns are not allayed by Ofcom's analysis of the mitigation options, in particular the implication that WiFi equipment will need to be replaced with Operators and consumers bearing the costs.

We also have further measurements planned to assess interference to WiFi client devices using actual 2.3GHz TDD LTE equipment and will endeavour to share these with Ofcom in due course. We also suggest that Ofcom could usefully do more measurements with a larger number of devices to gain increased confidence in its results.

Question 6.3: Do you agree with our assessment of the available options for mitigation of interference to home networks?

BT agrees that the mitigations techniques have been correctly identified but we do not share Ofcom's opinion of their suitability in some cases.

- We disagree with the idea expressed in para A7.289 that 5GHz WiFi can be expected to match coverage of 2.4GHz. This is not our experience in practical deployments.
- We agree that in some cases it is feasible to use 5GHz instead of 2.4GHz, but must point out that in very many cases this is just not reasonable due to the costs, the coverage limitations of 5GHz, and life expectancy of the equipment (e.g. games consoles).
- We do not consider it acceptable that affected users should be required to upgrade their WiFi devices, especially where these are in expensive items such as PCs, games consoles and tablets that would expect to have a life span of many years. It is also unlikely that the consumer will be able to identify (in advance) whether the receiver adjacent channel rejection performance of a newer device will be any better than the performance of their existing device.
- Moving devices is likely to be impractical and unacceptable in many situations (e.g. in a crowded place). The theoretical separation distances needed are significant and impractical.
    - Ofcom predicts (Table A7.2) that typical WiFi APs may require 1m to 13m spacing from an LTE device depending on its power level, and 1m to 8m spacing between typical WiFi clients and an LTE device depending on its power level.
    - Ofcom has not presented similar calculations using the blocking levels of worst case WiFi AP and client devices within Ofcom's sample of 21 equipment types (as reported in table A7.1). However the calculation would lead to a predicted separation distance requirements from an LTE device (depending on its power level) of 2m to 23m in the case of WiFi APs and 3m to 33m in the case of WiFi client devices.
- Reducing the LTE BS power near the WiFi band might reduce the likelihood of UE devices operating at the highest power levels and so this might reduce interference risks and should be further studied. A further mitigation technique that is not mentioned would be to introduce a larger guard band, combined with a degree of filtering.

Question 6.4: Do you agree with our assessment of the available options for mitigation of interference to public networks (both indoor and outdoor)?

The main suggested mitigation in the case of public WiFi networks seems to be to replace WiFi access points or install filters where feasible. We agree but are concerned that this will introduce new costs to

WiFi operators and in this case financial compensation should be provided. Furthermore, as previously discussed, this would only mitigate interference into the Access Point but would not improve the level of interference experienced by the user terminals.

Question 6.5: Do you agree with our assessment of the available options for mitigation of interference to Enterprise Networks?

The additional mitigation identified by Ofcom is possibly valid, but again the question of compensation if significant interference to existing networks arises needs to be considered.

Question 6.6: Do you agree with our conclusion that the impact to Wi-Fi is not of a significant nature and therefore no regulatory intervention is necessary? If not, can you provide evidence?

We are not at present sufficiently confident that WiFi interference problems will be low enough probability and readily mitigated to agree that regulatory intervention is not needed. We suggest that further practical assessments are undertaken and that due consideration is given to how financial compensation could be provided where problems arise. The cost of fixing such problems should anyway be estimated and compared with the opportunity cost of implementing a larger guard band (i.e. awarding less than 40MHz of spectrum or a slightly different 40MHz of spectrum).

We propose that Ofcom undertakes further investigations of whether with, say, a 10MHz shift in the 2.3GHz LTE assignment, or imposition of reduced LTE power levels in the top channel, the risk of interference to WiFi networks would significantly reduce.

Question 7.1: Do you agree that we do not need to perform technical analysis on the applications in the middle of the band as set out in paragraph 7.7?

We do not have a view on this matter.

Question 7.2: Do you agree with our technical analysis in relation to Bluetooth devices operating in the 2.4 GHz band, and that no additional restrictions are required in order to protect these applications?

We do not have a view on this matter.

Question 7.3: Do you agree with our technical analysis in relation to ZigBee devices operating in the 2.4 GHz band and that no additional restrictions are required in order to protect these applications?

We do not have comments on this matter.

Question 7.4: Do you agree with our technical analysis in relation to video sender devices operating in the 2.4 GHz band and that no additional restrictions are required in order to protect these applications?

We agree with Ofcom's position.

Question 7.5: Do you agree with our technical analysis in relation to radio microphones devices operating in the 2.4 GHz band and that no additional restrictions are required in order to protect these applications?

We agree with Ofcom's position.

Question 7.6: Do you agree with our technical analysis in relation to short range devices operating in the 2.4 GHz band and that no additional restrictions are required in order to protect these applications?

We do not have comments on this matter.

Question 7.7: Do you agree with our technical analysis in relation to medical devices operating in the 2.4 GHz band and that no additional restrictions are required in order to protect these applications?

We do not have comments on this matter.

Question 7.8: Do you agree with our technical analysis in relation to emergency services use in the 2.4 GHz band and that no additional restrictions are required in order to protect these applications?

We do not have comments on this matter.

Question 7.9: Do you agree with our technical analysis in relation to hearing aids and assisted listening devices operating in the 2.4 GHz band and that no additional restrictions are required in order to protect these applications?

We do not have comments on this matter.

Question 8.1: Do you agree that the available mitigations address the potential shortfall of spectrum for PMSE at major events and that no additional regulatory intervention is necessary to protect PMSE in frequencies adjacent to the award bands?
We do not have comments on this matter.

Question 8.2: Do you agree that PMSE should have some continuing access to spectrum in the 3.4 GHz band until new services are rolled out in an area?

We do not have comments on this matter.

Question 8.3: Which option for the provision of information about the roll-out of new services is most the appropriate? Should the requirement to supply information apply only in designated locations?
The appropriate method for notifying where newly licensed spectrum will be used, and where PMSE use can continue on an interim basis, should be agreed between Ofcom and the licensee after the completion of the award. Only the principle of whether unused spectrum should be made available temporarily for PMSE needs to be decided in advance of the award. This is because different operators may wish to use the spectrum in different ways. It is presumably also open to the new licensee to trade or lease the spectrum for use by PMSE on commercial terms beyond any period where Ofcom undertakes to make unused spectrum available for PMSE.

Question 8.4: Do you agree that any continuing access should be limited to five years from the award of new 2.3 and 3.4 GHz licences?

This seems reasonable and any use beyond this period by PMSE could presumably be commercially negotiated with the licensee.

Question 8.5: Do you agree with our assessment that there is little incremental benefit in on-going PMSE access to the 2.3 GHz award band?

BT has no comments on this matter.

Question 10.1: Do you agree with our proposal that no coordination procedure is necessary in respect to maritime radar?

We do not have comments on this matter.

Question 11.1: Do you agree with our proposal to require coordination procedures for the 3.4 GHz band - in order to protect of air traffic control radar - in line with those applied to the 2.6 GHz band?

We do not have comments on this matter.

Question 12.1: Do you agree that for mobile satellite services operating in the band between 2170 and 2200 MHz, coexistence with LTE operating in the award bands above 2.35 GHz is unlikely to be an interference problem?

We do not have comments on this matter.

Question 12.2: Do you agree that satellite services operating in the band 2483.5 MHz to 2500 MHz can co-exist with LTE operating in the award bands (i.e. 2350 to 2390 MHz and 3410 to 3590 MHz) and there is unlikely to be an interference problem?

We do not have comments on this matter.

Question 12.3: Do you agree with that for satellite services operating between 2200 and 2290 MHz, coexistence with LTE operating in the release bands is unlikely to be an interference problem?

We do not have comments on this matter.

Question 12.4: Do you agree that for amateur satellite services operating between 2400 and 2450 MHz, coexistence with unwanted/out of band emissions of LTE operating in the release bands (the nearest release band is 2350 to 2390 MHz) is unlikely to be a greater problem than the current in-band interference from licence exempt and ISM uses?

We do not have comments on this matter.

Question 12.5: Do you agree with our preferred option to adopt our proposed mask with informal co-operation on a case-by-case basis if required?

Yes.

Question 13.1: Do you agree with our preference not to have a transitional region between blocks for licences in the 2.3 GHz band?

Yes.

Question 13.2: Do you agree with our preference not to have a transitional region between blocks for licences in the 3.4 GHz band?

Yes.

Question 13.3: Do you agree with our preference to not require synchronisation between different networks in the frequency band?

Yes.

Question 13.4: Do you agree with our preference to include both the permissive (unsynchronised) and restrictive (synchronised) masks within the TLCs in the 2.3 GHz band?

Yes.

Question 13.5: Do you agree with our preference to include both the permissive (unsynchronised) and restrictive (synchronised) masks within the TLCs in the 3.4 GHz band?

Yes.

Question 13.6: Do you agree with our preference to not require synchronisation between different networks in the frequency band?

Yes.

Question 13.7: Do you agree with our proposed maximum in band power limit for base stations in the 2.3 GHz band?

Yes.

Question 13.8: Do you agree with our proposed maximum in band power limit for user terminals in the 2.3 GHz band?

Yes.

Question 13.9: Do you agree with our proposed maximum in band power limit for base stations in the 3.4 GHz band?
Yes.

Question 13.10: Do you agree with our proposed maximum in band power limit for user terminals in the 3.4 GHz band?

Yes.

Question 14.1: Do you agree with our approach that it is not necessary to impose any guard bands or restricted blocks in order to manage the adjacencies between the incumbent UK Broadband and new users of spectrum to be awarded in the 3.4 GHz band?

Yes we agree. Furthermore we consider that the spectrum currently used by UK Broadband should be included within the planned award, with availability to the new owner from the date of expiry of UK

Broadband's licence in 2018. In this case the UK Broadband adjacency issue will disappear soon after the completion of the award (assuming it takes place before 2018).

Question 14.2: Do you agree with our approach to require UK Broadband to have the same coordination requirements as other users of the band?

Yes, but we also propose that the spectrum currently used by UK Broadband should in any case be included in the auction, with availability to the new owner from the date of the UK Broadband licence expiry in 2018.