Strategic Review of UHF Spectrum at 420-470 MHz

UHF Bands 1 and 2

Call for Inputs

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About this document

This Call for Inputs forms part of our strategic review of the 420-470 MHz band (also known as UHF bands 1 and 2). In this document, we explain how the current uses and configuration of this band brings about challenges for its efficient management, with particular implications for managing congestion, future competing demand, and interference.

We are publishing alongside this Call for Inputs a report from Aegis examining these matters. We have also developed a broad programme of work designed to develop our understanding and support future decisions for managing the 420-470 MHz band.

This document invites comments from stakeholders on Aegis's findings, as well as other input which stakeholders consider relevant to our analysis of the 420-470 MHz band, including our proposed work programme for the next phase of our strategic review.

Contents

Section 1

Executive Summary

1.1 This document concerns the 420-470 MHz frequency range, known as the UHF 1 and UHF 2 bands. Frequencies in this range are attractive to users due to their favourable propagation characteristics; they deliver good coverage along with better in-building penetration.

1.2 The band is used by a wide range of parties to deliver a diverse set of services ranging from the RAF Fylingdales radar and the emergency services (ES), to civil users of business radio (BR) including transport, security and manufacturing industries, utilities, programme making and special events (PMSE), maritime and aeronautical sectors, amateurs and licence exempt (LE) use (including short range devices). BR is the most significant civil user of the 420-470 MHz band (of which professional private mobile radio (PMR) is the most common type of use).

1.3 The pattern of use of the 420-470 MHz band is particularly complex and its current configuration is not fully aligned with the relevant European configuration plan. We have previously considered (on various occasions since 2002) the need to reorganise and rationalise the band to be consistent with Europe, but after weighing up the costs and benefits of intervening and the lack of stakeholder appetite for these changes, we concluded that it was difficult to justify taking regulatory action (though we would keep the situation under review).

1.4 There are indications of increasing demand from some existing users of the 420-470 MHz band, particularly in dense urban areas, and signs that new types of use also want to make use of these frequencies. In addition, the risk of interference is growing from wideband and narrowband technologies deployed by our continental neighbours (which can be exacerbated in some meteorological/ atmospheric conditions).

1.5 Against this background, and having regard to our statutory duties, we commenced a strategic review of the 420-470 MHz band earlier this year. This Call for Inputs (CFI) forms part of our initial phase of work in the strategic review.

1.6 In keeping with our duty to ensure efficient use of the spectrum, our strategic review seeks to understand whether our current approach to managing the band is able to meet the needs of current and future users. We have set out to achieve this in two ways:

a) *Improving our understanding of current and future use of the band, including competing demand for its use:*

- We commissioned Aegis to provide an independent view of the band over the next ten years and how it is likely to evolve. Aegis modelled possible future scenarios and identified a number of complexities, challenges and risks in relation to the management of the 420-470 MHz band, and potential solutions to these.

- This work is now complete and Section 4 of this CFI summarises Aegis's key findings (the report is being published alongside this CFI, a summary of which is set out in Annex 5). We are seeking stakeholder views on Aegis's findings, as well as other input which stakeholders consider relevant to our analysis of the 420-470 MHz band.

b) *Gathering evidence to address the challenges brought about by competing demand and the bands' fragmentation and existing configuration, in order to support future decisions:*

- The Aegis report highlighted a large degree of uncertainty for future use of the band. On the basis of Aegis's findings and our other work in this sector, we have identified a number of areas where further monitoring and analysis may be appropriate.

- Therefore, we have developed a broad programme of work designed to develop our understanding and support future decisions for managing the 420-470 MHz band. This is outlined in Section 5 of this CFI, and we also welcome stakeholder views on this proposed work programme.

1.7 We propose to publish the outcomes of our analysis from the monitoring and data gathering activities set out in our work programme, along with a summary of key themes from responses to this CFI and any proposals following our analysis of intervention options before the end of 2015. At that time, we may also be in a better position to put forward options for future management of the band (if evidence indicates that action is needed).

1.8 Accordingly, we invite views and comments on the questions posed in this CFI from stakeholders representing all incumbent users as well as those with a future interest in the 420-470 MHz band.

Section 2

Purpose of this Call for Inputs

Introduction

2.1 The 420-470 MHz frequency range is in the UHF spectrum band. The range is split into two further sub bands ─ 420-450 MHz and 450-470 MHz ─ which are known as the UHF 1 and UHF 2 bands, respectively.

2.2 Frequencies at 420-470 MHz are attractive to users due to their favourable propagation characteristics. These characteristics result in spectrum which delivers good coverage along with good in-building penetration and lower infrastructure costs.

2.3 Current users of the 420-470 MHz band, many of whom have requirements for business critical applications, include:

- business radio (BR), which includes users of private mobile radio (PMR);
- the public sector, primarily from the emergency services (ES), Ministry of Defence (MoD), and Department of Health (DH);
- programme making and special events (PMSE);
- scanning telemetry for the utilities sector;
- maritime, including the internationally harmonised frequencies at 467-467.5 MHz;
- aeronautical, for airside ground use (also internationally harmonised at 457 MHz and 467 MHz);
- radio amateurs; and
- licence exempt (LE) devices, including short range devices (SRDs).

2.4 Planning in the band is complex for two reasons: fragmentation and configuration[1].

2.5 First, the band is heavily used, with many different types of sectors and technologies operating in it (as listed above), but in a fragmented, non-contiguous way. Second, the UK's configuration is not fully aligned with the relevant European harmonised configuration plan, resulting in the potential for interference from devices operating in continental Europe. The different configuration plan could also inhibit the growth of existing use and new technologies.

2.6 Changes to how the band is used are creating a further degree of complexity. There are indications of increasing demand from some existing users of the 420-470 MHz band, particularly in dense urban areas. With potential new users also wanting to make use of these popular frequencies, competing demand between existing and new users is expected to increase. In addition, the risk of continental interference is growing from wideband and narrowband technologies deployed by our continental neighbours (which can be exacerbated in some meteorological/atmospheric conditions).

[1] We explain the implications of fragmentation and configuration for the band further in Section 3.

2.7 Against this background, and having regard to our statutory duties, we commenced a strategic review of the band earlier this year. This Call for Inputs (CFI) forms part of our initial phase of work in the strategic review.

Our relevant duties

2.8 Ofcom must act in a manner consistent with its statutory duties, including in particular its primary duty, as set out in Section 3(1) in the Communication Act 2003, to further the interests of citizens in relation to communications matters; and to further the interests of consumers in relevant markets, where appropriate by promoting competition. Ofcom is also required to secure the optimal use of spectrum.[2]

2.9 When carrying out functions related to the management of radio spectrum, section 3(1) of the Wireless Telegraphy Act 2006 (the WT Act), imposes a number of further duties. Ofcom is required to have regard to the extent to which spectrum is available for use, or further use, for wireless telegraphy; the demand for use of the spectrum for wireless telegraphy; and the demand that is likely to arise in future for the use of spectrum for wireless telegraphy.

2.10 Section 3(2) of the WT Act provides that Ofcom must also have regard to the desirability of promoting the efficient management of radio spectrum, the economic and other benefits that may arise from the use of wireless telegraphy, the development of innovative services and competition in the provision of electronic communications services.

Approach to our strategic review of 420-470 MHz spectrum

2.11 The purpose of our strategic review of the 420-470 MHz band, and in keeping with our duty to ensure efficient use of the spectrum, is to consider whether our current approach to managing the band is able to meet the needs of current and future users. The focus of the strategic review is twofold:

a) *Improving our understanding of current and future use of the band, including competing demand for its use:* we commissioned Aegis to provide an independent view of the band over the next ten years and how it is likely to evolve. Aegis modelled possible future scenarios and identified a number of complexities, challenges and risks in relation to the management of the 420-470 MHz band, and potential solutions to these. This work is now complete and Section 4 of this CFI summarises Aegis's key findings (the report is being published alongside this document[3], and a summary of the report is set out in Annex 5). We are seeking stakeholder views on the findings of this report, as well as other input which stakeholders consider relevant to our analysis of the 420-470 MHz band.

b) *Gathering evidence to address the challenges brought about by competing demand and the bands' fragmentation and existing configuration, in order to support future decisions:* the Aegis report highlighted a large degree of uncertainty for future use of the band. On the basis of Aegis's findings and our other work in this sector, we have identified a number of areas where further monitoring and analysis may be appropriate. Therefore, we developed a broad programme of work designed to develop our understanding and support future decisions for managing the 420-470 MHz band. This is outlined in Section 5 of this CFI, and we also invite stakeholder views on this proposed work programme.

[2] Section 3(2)(a) of the Communications Act 2003.
[3] http://stakeholders.ofcom.org.uk/binaries/consultations/420-470-mhz/annexes/aegis-report.pdf

2.12 We expect the outcome of our work to improve our understanding in light of evolving developments, including the increasing risk of interference, so that we are able to facilitate any changes to the regulatory regime which may subsequently be needed.

Background

2.13 We, and the previous spectrum regulator, the Radiocommunications Agency (RA), have previously considered the need to reorganise and rationalise the 420-470 MHz band to address the issues related to its historical planning, congestion in major cities and continental interference. We last considered intervening in 2008, to address the band's fragmentation and configuration issues. However, after weighing up the costs and benefits of intervening and considering the lack of stakeholder appetite for these changes, we concluded that it was difficult to justify taking regulatory action, though we would keep the situation under review (the reasons for this are discussed further at paragraphs 3.14-3.31).

2.14 Nonetheless, earlier in 2014 we published our Spectrum Management Strategy, which established the strategic approach and our priorities for spectrum management over the next ten years[4], as well as our Mobile Data Strategy[5]. Our consultations on both of these strategies positioned the 450-470 MHz band (UHF 2)[6] as a strategic priority due to the potential competing demands for access to the band, as well as its potential future release for mobile data use (recognising that the band is already globally harmonised for that specific purpose, but also the significant level of existing use for a variety of purposes).

2.15 In responses to both of these consultations, stakeholders expressed little interest in the 450-470 MHz band for future mobile data use. In light of this, we concluded that the prospects of using the band for public mobile networks in the UK long term were reduced, which reduced the need for us to consider the case for a change of use in the band. This led us to revise our priority of the 450-470 MHz band to low, with no proactive work needed for future mobile data use at this time.

2.16 However, we are still moving ahead with our strategic review of the 420-470 MHz band to address the issues of other types of competing demand and interference, and accordingly, we identified it as a major work area in our Annual Plan 2014/15: Programme of Work[7].

Purpose and structure of this document

2.17 The purpose of this CFI is to take forward our initial work in the strategic review. In this document we are seeking to:

- provide an overview of how the band is currently managed, and highlight the complexities and challenges faced with the band's configuration and use;

[4] http://stakeholders.ofcom.org.uk/consultations/spectrum-management-strategy/
[5] http://stakeholders.ofcom.org.uk/binaries/consultations/mobile-data-strategy/statement/statement.pdf
[6] The UHF 2 band is adjacent to 420-450 MHz (UHF 1) and due to the similar propagation characteristics and challenges faced by users of the band, we took the view that it was appropriate to consider both bands, ranging from 420-470 MHz, within the overall scope of the strategic review.
[7] http://www.ofcom.org.uk/files/2014/03/Programme-of-Work-2014-15.pdf

- offer stakeholders an opportunity to provide feedback on the findings and conclusions from Aegis's report which explores future demand scenarios, and the implications of these scenarios for future management of the band; and

- update stakeholders on the proposed programme of work we are undertaking to inform our thinking and address the key issues identified by Aegis, and seek any further input from stakeholders on it.

2.18 The remainder of this document is structured as follows:

- **Section 3** provides background information on how the band is used and the complexities and dependencies of its use.

- **Section 4** summarises the key findings of the Aegis report and poses a number of questions for stakeholders on whether they agree with these findings (a more detailed summary of the report can be found in Annex 5).

- **Section 5** sets out our programme of work to address the key issues and challenges we and Aegis have identified, providing a plan for managing this work.

Section 3

Background to the 420-470 MHz spectrum band

Terminology used in this CFI

3.1 In this document, references to 'configuration' of the band includes the concepts of:

a) *fragmentation:* the allocation of many different sectors, users and technologies in a band in non-contiguous blocks; and

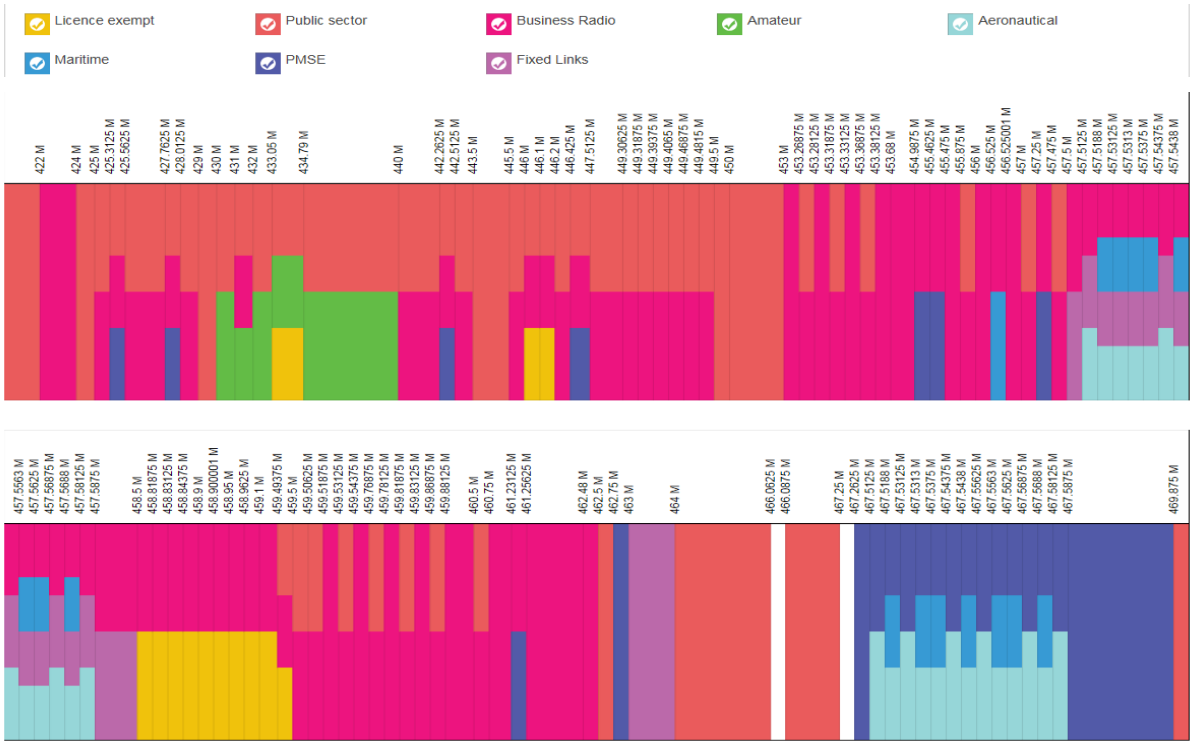
b) *alignment:* the extent to which the band plan is harmonised with the European plan (see paragraphs 3.8-3.13 below for more details) with respect to:

- aligning single, base and mobile transmit/receive frequencies (including duplex spacings); and
- allocating mobile frequencies low and base transmit frequencies high, relative to each other within a duplex channel pair.

Users of the band

3.2 Frequencies at 420-470 MHz strike a good balance between wider coverage, good building penetration and lower infrastructure costs. As a result, it is a heavily populated and complex band, used by a multitude of different uses (see Figure 1 for an overview of sectors using the 420-470 MHz band).

Figure 1: UK configuration of 420-470 MHz (UHF bands 1 and 2) – by user



NB Figure 1 is not to scale from a frequency/bandwidth perspective

3.3 UHF 1 between 420-450 MHz is primarily a military band for the MoD in which the RAF Fylingdales radar operates. Other users in the band include Arqiva and the DH (both using 2 x 2 MHz), BR users, amateurs (secondary use between 430-440 MHz), ES, PMSE and LE devices.

3.4 RAF Fylingdale's operation places a number of constraints on other spectrum users of the 420-450 MHz band. Civil and military users are permitted restricted access to specific areas around major UK conurbations[8] to manage the total power received by the radar. Use beyond such areas is subject to coordination arrangements agreed by the MoD on a case-by-case basis. There is also a 40km exclusion zone in place around the radar site which means that it is not possible to use the band for any service that requires national coverage.

3.5 UHF 2 from 450-470 MHz contains many different types of users including mission and safety critical services. It is used as follows:

- BR which uses around 7 MHz of fragmented spectrum. This is the most popular BR band in the UK and example BR users are shown in Table 1 below;
- ES who are licensed to use 7.3 MHz of fragmented spectrum, and these frequencies are also used to support the TETRA network in adjacent bands. ES and public safety users of the band include the prison, fire, ambulance and police services; and
- The remaining 5.7 MHz is used by:
    - PMSE, which use the band for talkback, and audio and data links (eg. for signalling and remote camera operation), and for hosting air to ground communications which is critical for major events[9];
    - scanning telemetry systems (for utilities - predominantly gas, electricity and water), which operate over fixed multipoint links providing data acquisition, monitoring and control of critical national infrastructure at remote sites;
    - maritime and aeronautical, over internationally coordinated frequencies; and
    - a LE band (UK-specific) including SRDs, which include devices such as key fob car door openers, vehicle paging alarms, safety alarms, medical devices, traffic light controls and SCADA (supervisory control and data acquisition) equipment used extensively by the utilities to provide control of remote equipment.

3.6 BR is the most significant civil user of the 420-470 MHz band (of which PMR is the most common type of use). It has become very successful as a form of private mobile communication because it provides a number of critical features including:

- ultra reliable and fully available communications that provide enhanced security;
- tailored coverage based on user requirements, extending to locations which traditional wireless services rarely reach (e.g. underground and in very remote locations);

[8] This does not apply in Northern Ireland unless there has been specific agreement with the MoD.
[9] PMSE services are also located in many other spectrum bands, but this is the only band which hosts air to ground communications.

- low latency and instant connections between users;
- enhanced support for group working including large numbers of either people and/or machines; and
- customised services to support a wide variety of businesses and activities, and which allow for greater control over use of the PMR communications system.

Table 1: Typical BR users

Commercial industries	Both commercial and public sector	Public sector / Third sector
Banking	Aerospace/airports	Environmental services
Biotechnology / chemical	Healthcare	Emergency services
Entertainment	Ports	Bus operators
Retail centres/warehouses	Transport (including taxi and rail)	Lifeboats
Manufacturing	Utilities (gas, oil, electricity and water)	Prisons
Security		Local Government
		Healthcare

History of the 420-470 MHz band

3.7 The UK's band configuration partly arose because of the constraints associated with military use that have been and still are prevalent in the 420-470 MHz band, and because of historical spectrum management decisions (the UK's current configuration is the result of having no historical harmonisation agreements in place at the time). However, high use of the band for BR purposes in the UK ensured that manufacturers developed equipment that was compliant in both the UK and Europe.

International coordination (CEPT Recommendation T/R 25-08)

3.8 In 1989, the European Communication Office published European recommendation T/R 25-08, which defined the planning criteria and coordination of frequencies for land mobile services in the range 29.7-921 MHz (the CEPT Recommendation)[10]. The CEPT Recommendation highlights the complexities of frequency assignment in an increasingly complex environment where the probability of obtaining successful coordination diminishes rapidly as the number of stations increase and where there is likely to be a higher requirement for coordination with other countries (particularly in border areas).

3.9 To minimise interference it is highly desirable that the channelling arrangements for the land mobile service are harmonised. Accordingly, the CEPT Recommendation recommends that national administrations enter into coordination agreements with neighbouring countries (under the terms of the HCM agreement[11]), and that wherever

[10] CEPT Recommendation T/R 25-08 was made in Lecce in 1989, and was revised in Vienna 1999, Utrecht 2005, Brussels 2008 http://www.erodocdb.dk/docs/doc98/official/pdf/Tr2508.pdf.

[11] The Harmonised Calculation Method (HCM) Agreement was developed for the purpose of formalising coordination of frequencies between 29.7 MHz and 43.5 GHz for fixed and land mobile services against agreed processes, technical criteria and data exchange format. It signatories are the Administrations of: Austria, Belgium, the Czech Republic, Germany, France, Hungary, the Netherlands, Croatia, Italy, Liechtenstein, Lithuania, Luxembourg, Poland, Romania, the Slovak Republic, Slovenia and Switzerland.

possible, the same frequency bands should be assigned in different countries for similar types of use including for BR, PMR, transport, and public safety services for cross border links and cooperation.

3.10 The CEPT Recommendation for the 410-470 MHz frequency range is shown in Figure 4 later in this section. We note that 420-450 MHz is partially aligned with the European harmonised plan (albeit with different duplex spacings), but 450-470 MHz has a reverse (narrowband) configuration.

3.11 The UK has not formally signed up to the HCM agreement but in order to ensure interference is minimised the process is followed 'in spirit' with the HCM coordination levels used as the basis for coordination with relevant neighbouring countries.

3.12 The UK is operating in a 'reverse' configuration to the CEPT plan, and this can potentially result in more assignments failing international coordination and exposing UK base station receivers to continental interference.

3.13 It is worth highlighting that the Republic of Ireland (RoI) has adopted the same band configuration as the UK. This means any future changes that the UK propose would need careful coordination with the RoI.

Previous initiatives to review the band

3.14 There have been several reviews of the band and the associated spectrum management policy. In particular, the issues of band reconfiguration and alignment have been considered in various initiatives over the last 15 years, and back in 2002 there was a strong push to investigate the feasibility of reconfiguring the 450-470 MHz band to harmonise with Europe.

450-470 MHz band alignment consultation

3.15 The RA published an initial consultation on alignment in the 450-470 MHz band[12] in December 2002. Amongst a number of drivers for considering intervening at the time, were:

- making better use of spectrum through rationalising the planning of the band;
- promoting delivery of more equipment to the UK market; and
- lowering the risk of interference from neighbouring European countries.

3.16 A summary of the responses to this consultation was subsequently published[13] which highlighted the many differences of opinion stakeholders expressed, covering technical, commercial and financial issues. Some stakeholders supported the concept of band reconfiguration, noting benefits such as reduced equipment costs by achieving economies of scale in manufacturing (which in turn would aid the introduction of new digital equipment), and the ability to rationalise and improve existing and new assignments. Other responses raised various concerns, including:

[12] http://www.ofcom.org.uk/static/archive/ra/topics/spectrum-strat/450-470-realign/condoc-dec02/450-470condoc.doc
[13] http://www.ofcom.org.uk/static/archive/ra/topics/spectrum-strat/450-470-realign/responses/summary.doc

- the potential scale of the costs and disruption for users, which the current level of continental interference did not justify taking action for;
- the costs were expected to be borne by users who were unlikely to realise any significant benefits from the realignment (as the benefits would only pertain to certain spectrum users eg. coastal users suffering from interference or new users);
- the engineering challenges of realigning the 450-470 MHz band; and
- that sector specific issues on health and safety grounds need to be taken account of in any plan, for example, ensuring continuity of supply for airports and utilities.

3.17 In July 2004, following further discussion with stakeholders and consideration of their responses, Ofcom (which the RA had since become part of) decided to reconsider how our regulatory aims might best be achieved with respect to the 450-470 MHz band. We determined that the complex, centrally planned project as cast at that time was not in line with our policy for encouraging market mechanisms over regulatory intervention, and that taken with the significant costs, disruption and risks it posed for users of the band, we decided not to proceed with the band alignment project initiated by the RA.

3.18 When we gave notice of our decision, we acknowledged the opportunity to release spectrum for other uses, and to reverse use of the band to prevent future interference problems with the rest of Europe, still needed to be addressed. We also highlighted the need to facilitate opportunities where the market recognised value in a realigned approach, so that users were encouraged to initiate changes, rather than change occurring through direct action by the regulator.

PA Consulting Study (2004)

3.19 Following on from the RA consultation, in 2004 PA Consulting undertook an independent assessment of the costs of realigning the 450-470 MHz band, estimating baseline costs of around £277m[14], with total costs for fully managed band alignment (taking account of different parameters) ranging between £260m-£310m.

3.20 These figures assume that the reconfiguration solution would require regulatory intervention and be centrally managed, that each user would be 'aligned' following a single frequency change, and would be implemented over a short period of time. Furthermore, if the plan involved parking frequencies within the 450-470 MHz band, costs were expected to increase by around £180m-£200m for a two-step migration process (two frequency changes). However, if the parking frequencies were outside of the band, alignment costs were expected to double to over £500m.

3.21 It was also noted that this approach gave rise to many risks, including the potential lack of sufficient engineering expertise to manage the band changes, and lack of available equipment (eg. programmable or pre-specified combiners for shared sites).

3.22 No analysis has been carried out on the feasibility of achieving alignment over a longer period of time.

[14] These figures were obtained by summing the costs for the reconfiguring each user category (£67m BR, £9m paging, £13m PMSE, £23m scanning telemetry, and £94m network operators), with the cost of site engineering (£71m).

Mott McDonald Study (2008)[15]

3.23 To understand the effect of digital technology on our regulatory framework for BR, we undertook a further review of the 450-470 MHz band in 2008. We commissioned Mott Macdonald to investigate the band's configuration and factors affecting its optimal management, building on previous studies to develop options for managing the band in the future.

3.24 Objectives for their work, within the context of a market led spectrum management policy and taking into account the needs of industry, included maximising the socioeconomic benefit for the UK, minimising the level of regulatory intervention, and examining the impact of the policy on the user community.

3.25 Mott MacDonald concluded that we should:

- not directly intervene in any alignment of the 450-470 MHz band (given the costs exceeded the potential benefits) but instead should enable the market to align through market mechanisms such as trading and liberalisation, assisting where necessary;
- assist the ES network manager (post 2009) in working closely with stakeholders in any future alignment of the band;
- modify MASTS[16] or put processes in place to assess the impact of aligning a channel within unaligned spectrum, and amendments to the algorithm for a guard band and geographical separation needed between co-channel users, using this tool to aid any future reconfiguration plans;
- develop a Memorandum of Understanding (MoU) with our European neighbours to avoid (mitigate) any future interference;
- reduce uncertainty by communicating our decisions on our future policy for the band to users;
- continue to monitor interference that may be caused by future deployment of wideband networks from the continent and the impact this would have for current licensees; and
- consider the option of partial alignment, for users of the 450-470 MHz band who are least impacted (provided further detailed analysis supports doing so).

3.26 Mott MacDonald also drew a number of conclusions about the technology and market at the time:

- a 10 MHz duplex split is not required to introduce narrowband digital technology;
- digital PMR (dPMR) equipment would outsell analogue over the following two years. This will increase network capacity with users able to benefit from new features;

[15] https://licensing.ofcom.org.uk/binaries/spectrum/business-radio/technical-information/UHF2_realignment_study.pdf
[16] MASTS (Mobile ASsignment Technical System) is an assignment algorithm used for BR.

- there is a market for narrowband dPMR technology in the UK now and in the future;
- CDMA-450 is being used or deployment is planned, elsewhere in Europe; and
- CDMA-450 is seen as a technology to deliver 3G services to rural areas.

3.27 Reconsideration of the costs associated with reconfiguring the band was beyond the scope of the 2008 Study, though the report noted that since the same complexities exist, the costs were expected to be of a similar magnitude to those calculated in the 2004 Study (if based on the same assumptions).

3.28 On this basis, Mott McDonald's cost benefit analysis of the different options for reconfiguring the 450-470 MHz (based on the 2004 PA Study's cost calculations but adjusted for inflation and other factors) ranged from £2.1m (partial alignment, narrowband) to £189m (fully managed alignment)[17].

3.29 Stakeholder feedback at the time also highlighted the following:

- The original drivers for any reconfiguration would need to be revisited at the appropriate time to establish if they were still valid.
- The future spectrum manager of ES spectrum would have a vital role to play in any reconfiguration of the band as they managed the largest amount of spectrum.
- There is still demand for narrowband technology and this would not require reconfiguration.
- Introducing wideband systems would require at least 2 x 4.5 MHz and need to establish whether adjacent channel protection would be required.
- There was little appetite for any reconfiguration within the band from incumbent licensees. They sought clear guidance on the future policy of the 450-470 MHz band, noting that any mission critical services would need a compelling reason, funding and assurances that any risk to service outages were mitigated as part of any reconfiguration exercises.

Outcome of these previous initiatives

3.30 Based on the outcomes of this previous work, our view to date has been that it is difficult to justify directly intervening to reconfigure the band. This has principally been based on the costs and benefits of intervention and the lack of stakeholder appetite for these changes. Accordingly, in 2008, we lifted the notice that was placed on licensees preparing them for changes to the specific frequencies in their licences.[18]

[17] https://licensing.ofcom.org.uk/binaries/spectrum/business-radio/technical-information/UHF2_realignment_study.pdf (see page 5).
[18] http://licensing.ofcom.org.uk/binaries/spectrum/business-radio/technical-information/UHF2_realignment_cover_note.pdf

3.31 Nevertheless, we took forward a number of the recommendations put forward by Mott MacDonald:

- we introduced mechanisms in 2008 as part of the BR reform project[19], which liberalised and simplified the BR licensing structure (reducing the number of licence products from 21 to five), and extended trading options for licensees;
- to help manage interference concerns, we have followed the HCM agreement 'in spirit' since 2008 (as the UK is not currently a signatory), making it an integral part of the licensing process, and ensuring assignments that breach the defined coordination thresholds are sent for international coordination;
- to keep our key stakeholders informed, we engage regularly with several forums including the Business Radio Interest Group (BRIG), Federation of Communication Services (FCS). We are update stakeholders on our latest plans through various public consultations, including through this CFI; and
- Our programme of work for the next phase of the strategic review, described in Section 5, sets out our plans for monitoring interference and further considering the feasibility of reconfiguration (including partially aligning the band).

Considerations affecting the use of the band

3.32 There are a number of factors that lead to the 420-470 MHz band being complex and difficult to manage, and it is important to take account of these in our analysis for how we might manage the band in the future. These go beyond the constraints of use imposed by coordination with RAF Fylingdales as discussed in paragraph 3.4.

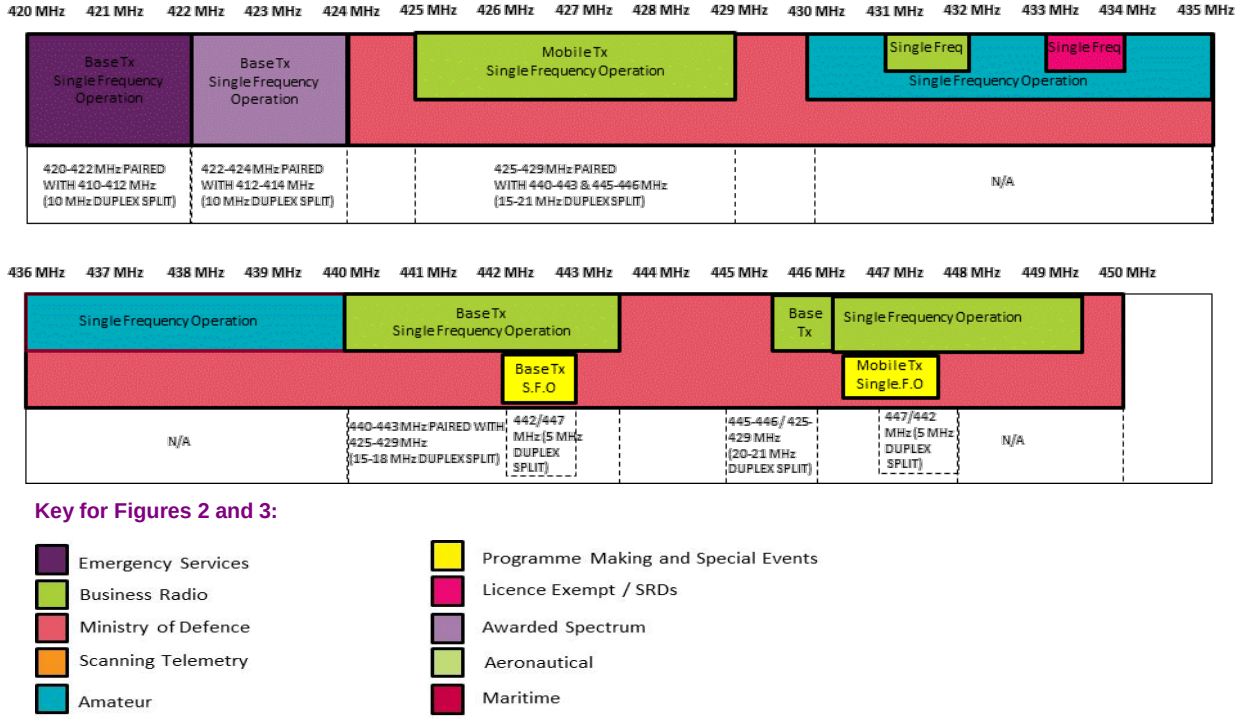
3.33 We referred to the planning challenges associated with the band's configuration and use in Section 2. Below we provide more detail about these issues and associated complexities for managing the band.

Complexity of UK band configuration

3.34 Fragmentation of the 420-470 MHz band has led to a mix of simplex and duplex operation within the band, with a range of different duplex spacings. These different spacings are not compatible with the harmonised band plan detailed in the CEPT Recommendation. Figures 2 and 3 show the complexity of the UK's band configuration for the 420-450 MHz band and 450-470 MHz band respectively, in comparison to the CEPT harmonised band which operates across most of Europe (see Figure 4 which shows the frequency configuration regarding the use of single, base and mobile transmit frequencies along with the duplex spacing (the separation between the base and mobile transmit frequencies).

[19] http://stakeholders.ofcom.org.uk/consultations/busrad/statement/

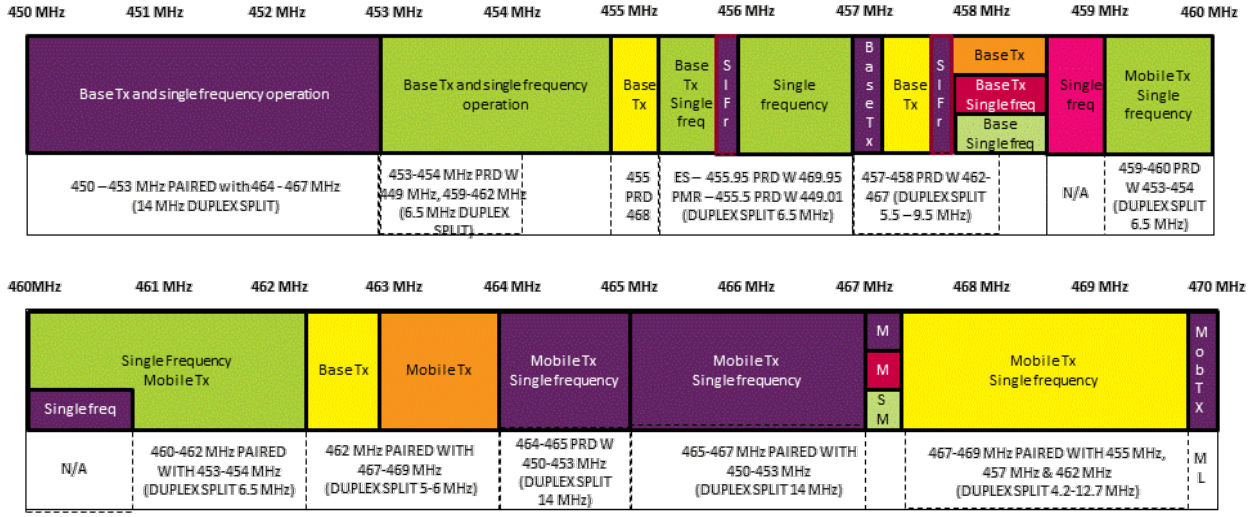
Figure 2: UK configuration of 420-450 MHz (UHF 1) – by frequency configuration



Key for Figures 2 and 3:

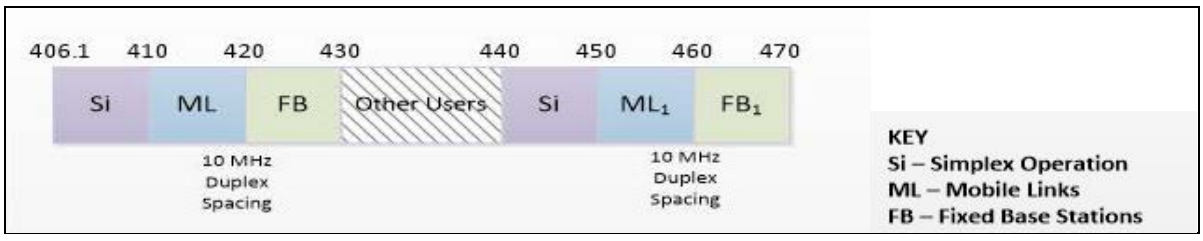
- Emergency Services
- Business Radio
- Ministry of Defence
- Scanning Telemetry
- Amateur
- Programme Making and Special Events
- Licence Exempt / SRDs
- Awarded Spectrum
- Aeronautical
- Maritime

Figure 3: UK configuration of 450-470 MHz (UHF 2) – by frequency configuration



3.35 This configuration complexity arose primarily because the UK was at the forefront of developing the early technologies and introducing PMR into Europe (prior to harmonisation at the European level), which created a buoyant UK market with economies of scale for devices, despite the configuration differences.

Figure 4: CEPT Recommendation for a European band plan at 406.1-470 MHz



3.36 Under the UK configuration, in high demand areas it has been possible to take advantage of the differences in duplex spacings by utilising one frequency of a duplex pair and allocating the same mobile transmit frequency in the same geographical area (effectively enabling sharing of the frequency without raising interference concerns which would otherwise be present if reusing both frequencies of the duplex pair). However, it would not be possible to continue with these kinds of assignments if the band were reconfigured. Therefore, it can be difficult to assess how the UK configuration affects the use of spectrum or its value.

3.37 Furthermore, the UK has the highest level of PMR use in Europe in the band despite (the majority of) it being in a fragmented, non-harmonised format. Due to the size of the UK market, manufacturers have to date, ensured that the majority of their products operate on both the UK and European configuration. However, there have been examples in the 420-470 MHz band where it has not been possible to accommodate certain types of technology due to the constraints imposed by the existing configuration. A good example of this (in the case of civil use) is TETRA which requires 25 kHz channel bandwidth and duplex spacing of 10 MHz, which is not possible to achieve under the current configuration of the band.

Range of technologies adopted

3.38 The 420-470 MHz band has a number of different technologies currently in use across the range of different sectors and users, which further highlights the need to carefully manage it. These include analogue FM which is still the predominant use, although this is slowly making the transition to different types of digital radio (DMR/dPMR using TDMA/FDMA respectively), and is expected to become the dominant technology over the next five years (new equipment coming on to the market tends to be produced featuring dual analogue and digital mode functionality).

Table 2: Technologies in use by market type (business radio)

Market Categories	Vertical Markets	European Standards		Other technology
		Digital	Analogue	
Public Safety / Mission Critical	• Military • Emergency Services	• TETRA Release 2 (TEDS) • TETRA Release 1		• CDMA: PAMR • TIA Project 25 • TETRAPOL
	• Airports / Ports • Public Transport • Local Government • Utilities	• DMR Tier 3: Licensed Trunked	• MPT 1327 & Standard PMR	
Professional / Business Critical	• Mining • Petrochemical • Manufacturing • Taxi / Logistics • Construction • Private Security • Radio Hire	• DMR Tier 2: Licensed Conventional	• Standard PMR (EN 300 086)	
Commercial & Light Industrial	• Retail • Hospitality • Warehousing • Agriculture	• DMR Tier 1: Licence Exempt		

Source Mott MacDonald 2008

3.39 Other technologies currently in use are TETRA, PMR446 and DMR446 (which is LE), along with TETRAPOL and CDMA which are used elsewhere in Europe. Certain

technologies require a fixed spectrum configuration because of the technical constraints on component design[20]. The different technologies are shown in Table 2.

Compatibility of technologies

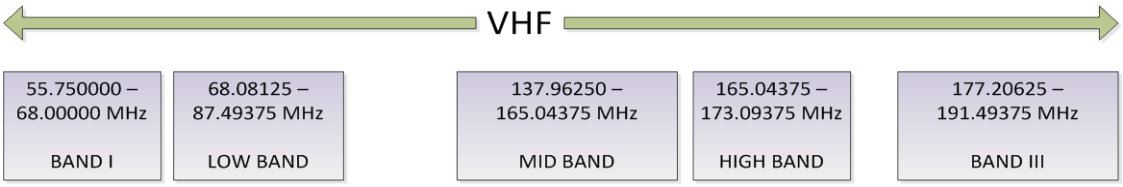
3.40 Successful defragmentation or reconfiguration of the 420-470 MHz band requires an understanding of the diverse range of different technologies that are present in the band. This adds a further level of complexity to band reconfiguration to consider the compatibility and coexistence of different technologies so that licensed users are protected appropriately from harmful interference.

Limited suitable alternative frequencies

3.41 One of the reasons the 420-470 MHz band is so popular is its favourable propagation characteristics (which balance the important attributes of wider coverage, good building penetration and lower infrastructure costs). This makes it difficult to identify bands that could be used as an alternative if required.

3.42 The mid-high VHF band (137-173 MHz) is the closest alternative civil spectrum (the VHF band is shown in Figure 5). However, we note that limited available equipment for existing users of UHF spectrum in VHF Band III (177-191.5 MHz), along with international constraints on its use has led us to exclude consideration of those particular frequencies as suitable alternative spectrum for the majority of applications in the band.

Figure 5: Use of the VHF band



3.43 The physical characteristics of the VHF band, specifically 137-173 MHz, mean that although it is possible to achieve much larger coverage areas for the same number of base stations and radiated power output, building penetration at these frequencies is not as good (as at 420-470 MHz). Therefore, frequencies are much more susceptible to 'noise' from the local environment. A further difficult attribute is that the physical size of antennas operating at VHF frequencies need to be larger than those used in the UHF band.

Other sector-specific issues

3.44 This already complex band is further complicated by a number of emerging issues in other sectors, which we asked Aegis to take account of in preparing their report (the issues are discussed in further detail in Annex 5):

- The ES allocation of spectrum in the band is significant and currently supports some critical communications infrastructure, but it is fragmented and not contiguous. The Public Safety Spectrum Policy Group (PSSPG), which represents all ES users in the band, has agreed to consider permitting civil use of its (currently) underused spectrum in the band on a regional and time limited

[20] Certain components have physical limitations – this often relates to physical size and comes into play when space is at a premium e.g. the size of a hand portable, or battery size.

basis. These frequencies could also be helpful for use as 'parking channels', should band reconfiguration be undertaken in the future. Nearly 6 MHz of spectrum at 143-169 MHz (in the ES allocation of the VHF band) has also already been returned for civil use[21]. Beyond 2020 there are no clear plans yet for the use of this spectrum but it is expected that at least a significant part of the spectrum will be returned for civil use;

- The 450-470 MHz band has been identified as a candidate band for extending rural coverage / providing rural broadband (as well as private mobile networks). Only Brazil and Finland have confirmed an intention to rollout public LTE networks at these frequencies in the near future, though some European countries already operate CDMA networks here[22] and others are trialling LTE (eg. France[23], Russia, Belarus and Latvia). For the UK to follow suit, it would be necessary to reconfigure the band. However, so far, we have received little support for a new public mobile network following our Mobile Data Strategy. We have seen some interest in private wideband services from the fuel and power sector, who are actively working to identify suitable alternative technologies;

- The utilities sector (mainly fuel and power) require low latency, highly resilient end to end communications in order to detect and bypass faults on the network. This sector's demand is growing due to increased data collection requirements which they anticipate will require additional spectrum to accommodate, though the industry is still confirming its specific requirements;

- The PMSE sector has had its access to spectrum in other bands reduced / removed, and therefore their reliance on these bands may increase in order to meet their spectrum needs;

- The UK-specific LE band at 458.5-459.5 MHz was allocated prior to harmonised LE bands being made available at other frequencies. It may not be feasible to retain a UK only LE allocation in this band in the future given increasing congestion and availability of frequencies elsewhere. Likewise ongoing amateur use of this congested band may need to be reviewed.

Projects and activities relevant to this strategic review

3.45 Alongside the strategic review, there are a number of other projects which may either have an impact on this band or are dependent on the evolution of this band. We are tracking their progress and taking account of any implications for this band. This other work includes:

- *BR product improvement*: the BR assignment model has been in place now for nearly six years, and given signs of increasing congestion, we considered it appropriate to review the model. We are looking at making improvements to the accuracy and performance of the model, in light of recent hardware and software developments, and also identifying if improvements can be made to the sharing criteria in order to improve spectrum efficiency. This has the potential help alleviate congestion in major urban areas where lack of available spectrum is becoming an increasing concern.

[21] VHF Release Statement - The release of spectrum within the frequency ranges 143 MHz to 169 MHz, 10 October 2014. http://stakeholders.ofcom.org.uk/binaries/consultations/vhf-143-169mhz/statement/VHF_Release_statement.pdf
[22] In particular, our Scandinavian neighbours.
[23] For example, see http://www.agurre.fr/wp-content/uploads/CCE-2014-Presentation-ANFR.pdf

- *Mobile Data Strategy*: as discussed in Section 2, the 450-470 MHz band is no longer a priority band for future release for mobile data use. However, we intend to keep this under review, taking account the international deployments of LTE-450 and the findings of our strategic review of spectrum at 420-470 MHz.

- *PMSE review*: we are assessing the long term spectrum needs of the PMSE sector and how these might be met as the spectrum supply landscape changes. For example, PMSE use of spectrum will become constrained in the 470-790 MHz bands due to our decision to repurpose the 700 MHz band (from television to mobile use).[24] As a result we are considering the potential for an increase in demand for spectrum in the 420-470 MHz band and the nature of this demand[25].

- *Spectrum sharing*: there are increasing competing demand and limited spectrum available for repurposing, so sharing is increasingly becoming a critical tool with which to address growing demand. We are undertaking a high level review of the spectrum to identify if there are any future opportunities for sharing[26].

- *Internet of Things (IoT):* we published a CFI in July[27] with the aim of developing a better understanding of new and innovative IoT applications, standards and networks, and the role that we should play to ensure that the UK takes a leading role in the emergence of the IoT. We expect to publish the outcome of this consultation in early 2015.

- *Short term access for PMR use*: many assignments that are made in the 420-470 MHz band are for short term use i.e. less than ten months. Examples of this include the construction industry where a short term project is underway and radios are required for cranes and security solely for the duration of the construction. To address this need, we are investigating the potential for additional short term civil use of spectrum between 450-470 MHz which is currently allocated to the ES (as outlined in the previous paragraph). This has the potential to free up spectrum for short term assignments, which is particularly needed in congested urban areas (around 10% of assignments each year (c.800) are for short-term use).

- *ES spectrum release (as part of the wider public sector spectrum release (PSSR) programme*: the ES utilise a significant amount of 450-470 MHz spectrum. They are currently exploring their future requirements, however, these remain unclear while procurement of the new ES network (replacing the existing Airwave service) continues[28]. Further work is ongoing to resolve what the requirements might be (which may not necessarily relate to the 420-470 MHz band), and there may also be scope to migrate existing ES use to the planned ES network and/or other spectrum bands. This may result in released spectrum in the band from 2020.

[24] Our decision to make the 700 MHz band available for mobile data is published here: http://stakeholders.ofcom.org.uk/binaries/consultations/700MHz/statement/700-mhz-statement.pdf
[25] The PMSE Review is set out as a major work area in the 2014-15 Annual Plan http://www.ofcom.org.uk/about/annual-reports-and-plans/annual-plans/annual-plan-2014-15/.
[26] http://stakeholders.ofcom.org.uk/binaries/consultations/spectrum-sharing/statement/spectrum_sharing.pdf
[27] http://stakeholders.ofcom.org.uk/binaries/consultations/iot/summary/iot-cfi.pdf
[28] https://www.gov.uk/government/publications/the-emergency-services-mobile-communications-programme

Section 4

Future demand and use of 420-470 MHz – key findings from the Aegis Report

4.1 As explained in Section 3, the 420-470 MHz band is particularly complex and heavily used by a wide range of parties. Furthermore, because the band is highly fragmented and not aligned with the European configuration, it is both critical and challenging to understand future developments in terms of increasing demand and the implications this might have on the band's future management and configuration.

4.2 To further our understanding of this complicated spectrum band, and as a first step in our strategic review, we commissioned Aegis to produce a report on the future use of 420-470 MHz spectrum over the next ten years. We are publishing that report alongside this CFI[29].

4.3 As a result of the intrinsic uncertainties with forecasting growth and the limited evidence currently available to support taking regulatory action, we are seeking stakeholders' feedback on the analysis and conclusions set out in the Aegis report. We also welcome input more generally on information that would be useful to us in informing our future approach to these bands, as this input will help to shape our proposed programme of work, as set out in Section 5.

Report background and overview

4.4 We asked Aegis to analyse and project the demand for the 420-470 MHz band from existing and potential new users. Their report drew on market information, international developments, stakeholder interviews and responses to the Spectrum Management Strategy Consultation, as well as licensing data from our systems.

4.5 Aegis modelled five[30] hypothetical scenarios for the 420-470 MHz band, which form the central part of the report:

- Incumbent growth under the current band configuration;
- Reduction/expansion of ES use of the band;
- Incumbent growth leading to band reversal (reconfiguration)[31];
- Deployment of managed networks in the band; and
- Introduction of LTE at 450 MHz[32].

[29] http://stakeholders.ofcom.org.uk/binaries/consultations/420-470-mhz/annexes/aegis-report.pdf
[30] Aegis also referred to a further option – Introducing a band manager, to facilitate reconfiguration of the 420-470 MHz band – though did not include this within its list of scenarios. In any case, the use of a band manager was considered and rejected by Aegis as it was considered unlikely to be able to demonstrate a viable business case or have sufficient flexibility to carry out an exercise on this scale.
[31] We refer to band reversal as band reconfiguration throughout the rest of this document.
[32] As context for why an LTE scenario was examined in light of our recent conclusions in the Spectrum Management Strategy and Mobile Data Strategy, we considered it was important for completeness, that the report consider the wider implications of mobile data services in this band.

4.6 For each of their scenarios, Aegis considered the challenges, risks and opportunities which may arise, and also posed a number of potential solutions to these challenges. We welcome input on a number of specific issues identified by Aegis:

- Future growth in incumbent user demand and congestion at 420-470 MHz;
- Deployment of wideband technologies at 450 MHz (e.g. LTE);
- Addressing continental interference; and
- Potential reconfiguration of the band.

4.7 In this section we briefly summarise Aegis's conclusions as they relate to the specific issues raised above, and pose a number of related questions for stakeholders. As Aegis's analysis is necessarily complex, reflecting both the complexity of the band and the number of possible scenarios they have explored, we have produced our own summary of Aegis's analysis to aid respondents, which is included at Annex 5.

Future growth in incumbent user demand and congestion at 420-470 MHz

4.8 Aegis found that growth in the 420-470 MHz band over the next ten years will principally be driven by:

- the BR sector, which Aegis forecast will need approximately 1.5 MHz of additional spectrum to meet voice and narrowband data service requirements, though growth to date has primarily been in the 450-470 MHz band; and
- the utilities industries who require an additional (as yet undefined) amount of spectrum to meet their statutory monitoring commitments and expanding data requirements for smart metering and scanning telemetry (Aegis suggested this might be in the region of two 3 MHz channels to be used by a variety of technologies).

4.9 Aegis also reported signs of unmet demand for wideband BR applications, as public mobile networks do not provide sufficient functionality to meet the needs of BR users (for example, the required levels of coverage or speed of connectivity).

4.10 Considering other incumbent users in the band, Aegis reported emerging demand was limited, as follows:

- *Emergency Services:* demand for ES frequencies may increase to support new applications in the band (up to an additional 1.3 MHz could be required), but as explained earlier (see last bullet at paragraph 3.45), the planned ES network might also result in released frequencies from 2020;
- *Machine-to-machine (M2M)*: no current demand beyond scanning telemetry for the utilities, as M2M applications are generally served by public mobile networks or by LE SRDs in harmonised bands elsewhere;[33]

[33] We note that the future innovative use of IoT and M2M applications was the subject of a separate CFI in July 2014. We expect to publish the outcome of this work in early 2015.

- *Programme Making & Special Events:* no current evidence of growth in PMSE licences for this band (even though assignments are increasing), but PMSE use may rise to accommodate reductions in spectrum availability in other bands;

- *Maritime:* current demand is being met at present due to the sector's switch to digital equipment; and

- *LE and SRDs:* future demand remains unclear as it is difficult to quantify the extent of LE use in the band (due to the nature of its exempt use these users are not captured in our licensing system).

4.11 In Aegis's view, the current situation appears unsustainable longer term, and therefore they recommended that action be taken to accommodate the predicted future growth of incumbent (and potentially new) users.

4.12 We welcome views and comments from stakeholders representing all incumbent users as well as those with an interest in using the 420-470 MHz band in future, on their current and future spectrum requirements.

Question 1: Do you agree with Aegis's conclusions on congestion of current use of 420-470 MHz spectrum? Are there any other signs or areas of congestion that Aegis have not identified from their review?

Question 2: Do you agree with Aegis's conclusions on the future demand and use of 420-470 MHz spectrum over the next ten years? Are there any other future uses or areas for future demand that Aegis have not identified from their review?

In responding to Questions 1 and 2, please provide any supporting evidence for your position with respect to your specific sector(s):

a) business radio (please specify if your response represents a specific subset of the BR sector, such as the utilities or transport industries)
b) public sector users (i.e the ES, DH and MoD)
c) PMSE
d) aeronautical
e) maritime
f) amateur radio
g) licence exempt users, including users of short range devices
h) potential new user of the band

Deployment of wideband technologies at 450 MHz (e.g. LTE)

4.13 Aegis focused their analysis on LTE-450 deployment (although CDMA 450 is also considered in the report) because of the expected limited longevity of CDMA (as countries move to update to LTE), and its use to enhance rural coverage. Therefore, the implications for LTE-450 specifically are discussed.

4.14 Demand for LTE-450 internationally (and CDMA-450 before it) has been driven by the need to extend rural coverage; the favourable propagation characteristics of these frequencies make it well suited for this purpose. However, in line with our recent conclusions in the Mobile Data Strategy, Aegis were uncertain as to whether a sufficiently large UK market exists and were unaware of any expressed demand to deploy LTE-450 in the UK for mobile data use.

4.15 In its report, Aegis highlighted a range of factors which lessen the likelihood of demand and future 'mainstream' mobile LTE use of the 450 MHz band in the UK, including:

- *Consumer handsets*: LTE compatible handsets at these frequencies require antennas of considerable physical size, which will limit consumer appeal. Furthermore, the cost of adding a new frequency band to equipment may need to be recouped through higher priced handsets (and adding the 450 MHz frequency will typically result in a 1dB performance loss to handsets).

- *Availability of alternative mobile frequencies*: in the context of all spectrum bands potentially available for future mobile data use, greater quantities of spectrum are available to mobile network operators elsewhere, resulting in this being a lower priority, lower demand band.

- *Technical issues:* the current UK configuration does not support the 10 MHz duplex channel spacing required for LTE-450. Therefore, it is not possible to deploy LTE-450 MHz band in the UK without changing the configuration of the band (with its associated costs). Further, the limited 20 MHz capacity available between 450-470 MHz may not be sufficient to deploy viable LTE services.

4.16 Aegis suggested that the most likely future demand for LTE-450 will come from the utilities rather than mobile sector, as they require resilient data connectivity on a national basis to support the rollout of smart grid networks. Aegis also notes that with future developments, LTE-450 has the potential to meet BR requirements for wideband PMR services as discussed earlier at paragraph 4.9. However, they remain uncertain as to the levels of interest and appetite for deploying wideband technologies among UK users of this band. Furthermore, the report highlights that there are significant technological challenges to address in order to successfully deploy wideband technologies.

Question 3: Do you agree with Aegis's conclusions that there is not yet any UK demand for wideband services in the 450-470 MHz band (which could for example, be used to improve rural mobile coverage)? Please provide any supporting evidence for your position.

Addressing continental interference

4.17 Increased use of the band in Europe, especially to provide high power wideband services, is expected to increase continental interference into the UK. Aegis pointed to the utilities sector's experience of affected scanning telemetry coverage in East Anglia and the Midlands because of a previous rollout of CDMA-450 in Norway.

4.18 To test this, Aegis conducted a simple analysis to look at the interference from a single transmitter in France (Calais) or the Netherlands (Vlissingen). Results indicated a reduction in continental interference of 40-50% under reconfiguration, and Aegis therefore concluded that alignment with Europe would help to mitigate the increased risk of interference from continental use of LTE and other wideband technologies (such as CDMA).

4.19 Aegis concluded that continental interference, should it prove unmanageable or increase, is a sufficiently important issue to justify considering reconfiguration of the 420-470 MHz band. Though they also considered it to be a secondary concern as it does not affect all users and has a limited geographic impact.

Question 4: Have you experienced degradation in your systems' performance which you consider to be caused by continental interference in the last 12 months? If yes, what approach did you take towards managing and minimising interference?

Please provide any supporting evidence which explains the frequency (of occurrence), impact, duration, time, location and cause (whether suspected or investigated) of the interference with respect to your specific sector(s).

Potential reconfiguration of the band

4.20 In its report (and notwithstanding the constraints of protecting the RAF Fylingdales radar), Aegis highlighted the potential benefits of aligning the configuration of the band with Europe. This would, for example, improve spectrum efficiency through coordinating/defragmenting users, and 'future proofing' our future management of the band by enabling the deployment of wideband technologies for mobile, BR networks and/or utility services, if sufficient demand emerges. It would also help to mitigate incoming continental interference as discussed above.

4.21 However, and further to our previous initiatives considering this issue (as set out in Section 3), there remain a number of challenges to reconfiguration including the likely high costs and disruption for users, a lack of stakeholder support, and the band's fragmented use and multitude of deployed technologies which further complicates any reconfiguration solution.

4.22 Furthermore, the disparate nature of users in the band mean coordination failures may also arise in implementing an efficient and effective solution. Aegis suggested that Government-led intervention would be necessary to garner the necessary support for a suitably efficient spectrum solution.

Question 5: Is there additional information relevant to the configuration of the 420-470 MHz band that we should consider in developing our approach to its future management? Please provide any evidence to support your views.

Aegis's key findings

4.23 The report recognises the complexity of the current structure and how the fragmentation of the band and its misalignment with Europe poses challenges to future growth both for incumbent and new users. Furthermore, the current level of uncertainty about existing and future use makes it difficult to draw definitive conclusions.

4.24 However, Aegis's study of the band has made us aware that there are significant issues associated with future use of the spectrum that require our attention and further investigation. In summary, Aegis concluded that:

- We (Ofcom) should investigate options for more efficient management of the spectrum and of incumbent users to address emerging signs of congestion in some areas (in particular, growth in PMR services). Aegis suggest examining options including reviewing licensing and assignment arrangements, spectrum fees, prioritising spectrum access for business critical applications, and utilising released ES spectrum. However, they note that it is unclear how effective this solution will be if used alone, particularly in resolving the need for contiguous, defragmented frequencies;

- The need to accommodate new services in the longer term (for example, wideband PMR, and M2M services for the utilities sector) and to enable the potential deployment of wideband technologies (as well as the increasing risks of continental interference, see below), presents a strong argument for band reconfiguration. This is due to the high fragmentation of the band at present, a lack of contiguous frequencies to deliver these services and the likelihood that existing users would suffer from continental interference. It is unlikely that the market could drive these changes without regulatory intervention due to the significant challenges of coordinating an effective and efficient reconfiguration of the spectrum;

- There are early indications of interference from the continent, and the potential for interference is increasing (for example, from use of CDMA and LTE technologies), though it is noted that interference only impacts some band users in a limited geographical area (mainly along the UK's east coast);

- Although LTE-450 has been deployed internationally to deliver rural broadband and address coverage concerns, there is no expressed market demand for this type of LTE network in the UK at present. Any future deployment is therefore likely to be within closed user groups (eg. utilities) or M2M rather than by a mobile operator. Furthermore, there are a number of significant technical implications of deploying LTE-450 in the UK which may reduce its appeal to users; and

- While there is some interest in a managed network solution (for example, to support the requirements of the utilities or BR sectors), it has not yet been proven to be a viable model in the UK. The biggest challenge will be in identifying suitable and sufficient spectrum to attract users (ie. a network which has appropriate capacity, speed, outage resilience, service support and is operating the right technologies).

Question 6: Do you agree with the potential solutions Aegis have proposed for managing the 420-470 MHz band to both meet the continued growth in congestion and demand from incumbent spectrum users, and to facilitate the deployment of wideband technologies? Are there any other solutions which you consider we should examine that Aegis have not identified from their review?

Please provide any evidence to support your position and reference each solution in your response as appropriate.

4.25 These issues and how they will evolve, are critical to inform future policy on managing this band. This includes whether to potentially intervene to reconfigure the band, which Aegis consider is necessary to meet demand for wideband services or a more significant change of use (and sustained future increased demand).

4.26 We have drawn on these conclusions in developing a programme of work for the next phase of our strategic review, which is outlined in the following section.

Question 7: Do you have any further comments relevant to how we might manage spectrum between 420-470 MHz?

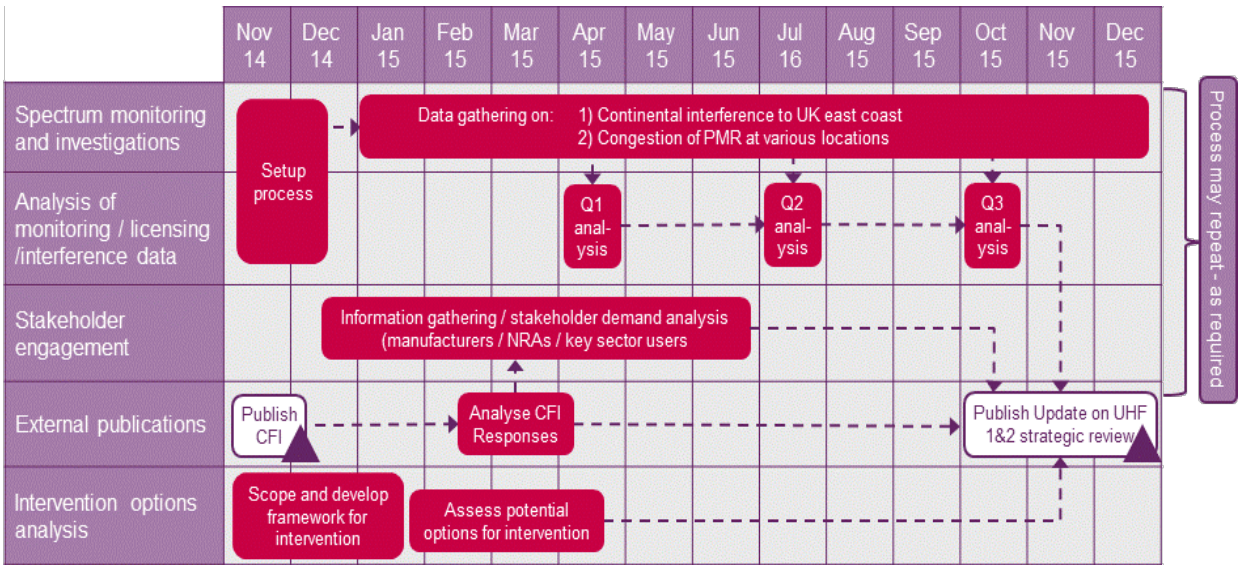
Section 5

Next steps

5.1 Following our review of Aegis's report and its findings, we have identified six areas where further work will help to inform our thinking on the future management of the 420-470 MHz band.

5.2 Our programme of work will help to ensure a robust and structured approach to evidence gathering, and further improve our understanding and ability to respond to the band's future requirements. A high level plan and timeline are set out in Figure 6.

Figure 6: Overview of the work programme for the strategic review of 420-470 MHz band



Summary of our programme of work

Publish a CFI on the 420-470 MHz band

5.3 In publishing this document now, we are seeking to widen our understanding by gathering information from stakeholders on their current and future use of the band. This will help to ensure that the information we consider in our strategic review is current and robust, and that our programme of work captures all relevant and necessary activities to inform future policy making in the 420-470 MHz band.

5.4 We welcome input from stakeholders on the questions posed in this CFI, which are summarised in Annex 4.

5.5 The outcome of this consultation exercise will be included within our subsequent update to stakeholders (see paragraph 5.15 for further details).

Understanding the extent of interference from the continent

5.6 We have received feedback from utility companies on interference outages, but have limited systematic data on interference cases or levels of interference experienced. So that we are better placed to respond to interference concerns in the future, we are

seeking to improve the information we hold on interference cases by measuring interference at various UK locations and tracking the meteorological conditions that prevail at the time. This will help us to understand the cause and impact of problems, and their likely trajectory.

5.7 We will also proactively engage with our European neighbours to understand the patterns of use and future deployment in the band.

Monitoring growth in demand and congestion

5.8 Our licensing system is already reporting high levels of congestion in London and certain other large conurbations are close to being congested, however our understanding of real utilisation is fairly limited. To help us better understand the effect of increasing demand we are implementing new analysis tools to more closely monitor licensing trends (including refusals) and utilisation of the band in congested areas, across relevant sectors.

Understanding the potential for new use

5.9 The Aegis report confirmed that there is limited evidence of demand for public mobile services in the band (such as LTE-450) as a means to improve rural coverage. This is consistent with the outcome from our Mobile Data Strategy. However, we recognise the need to ensure that our current inability to deploy wideband services in this band in the UK does not lead us to lose out on the opportunity to benefit from them in the future.

5.10 Given the uncertainty surrounding potential new uses, and in order to better understand potential growth in wideband services, we will continue to engage with key stakeholders, national regulatory administrations (NRAs) and manufacturers on their plans, through this CFI and elsewhere.

Investigate the opportunity for band reconfiguration (as well as alternative solutions for resolving growth in demand) – intervention options analysis

5.11 As explained briefly in Section 4 (and in more detail in Annex 5), one possible intervention option is reconfiguring the 420-470 MHz band, to align the UK band plan with the European configuration.

5.12 We propose to explore options and feasibility for a managed reconfiguration so that potential implications are understood for all incumbents (updating our earlier work in this area, as outlined in Section 3). In doing so, we intend to consider the practicalities of implementing both piecemeal and ‘all in one go’ reconfiguration options, and we acknowledge previous responses from stakeholders regarding their concerns about the potential cost and disruption of reconfiguring this band.

5.13 We will also consider other options for addressing the challenges set by demand growth, for example reviewing the licensing regime, our approach to spectrum pricing in the band, user migration, and further spectrum sharing opportunities. This work will look to identify opportunities for future proofing the band as part of these considerations, so as not to create new congestion or interference concerns.

5.14 We will publish an update on our analysis in due course (see below). Accordingly, we wish to inform stakeholders that we would consult further at a later date on any specific proposals to address congestion, interference or future growth in the band.

We would do so prior to taking any decisions, not least because if we proceeded it would likely involve amendments to existing licensing arrangements.

Publishing the outcomes of our analysis

5.15 We propose to publish the outcomes of our analysis from the above monitoring and data gathering activities, along with a summary of key themes from responses to this CFI and any proposals following our analysis of intervention options before the end of 2015. At that time, we may also be in a better position to put forward options for future management of the band (if evidence indicates that action is needed).

Other activities

5.16 As mentioned in Section 3, we have also initiated other activities to address short term congestion issues, though these lie outside the scope of our strategic review.

5.17 Activities already underway include:

- investigating the potential for additional short term civil use of spectrum between 450-470 MHz which is currently allocated to the ES (this work is being led through our PSSR programme); and
- taking forward work on increasing shared BR assignments through the BR product development project.

Question 8: Do you have any comments on our proposed programme of work, the outcomes from which we will use to inform future decisions on how we manage the 420-470 MHz band? Are there any additional areas you consider we should explore?

Annex 1

Responding to this call for inputs

How to respond

A1.1 We invite written views and comments on the issues raised in this document, to be made **by 5pm on 19 February 2015**.

A1.2 We strongly prefer to receive responses using the online web form at http://stakeholders.ofcom.org.uk/consultations/420-470-mhz/howtorespond/form, as this helps us to process the responses quickly and efficiently. We would also be grateful if you could assist us by completing a response cover sheet (see Annex 3), to indicate whether or not there are confidentiality issues. This response coversheet is incorporated into the online web form questionnaire.

A1.3 For larger responses – particularly those with supporting charts, tables or other data – please email UHFstrategicreview@ofcom.org.uk attaching your response in Microsoft Word format, together with a consultation response coversheet.

A1.4 Responses may alternatively be posted to the address below, marked with the title of the CFI.

CFI: UHF Strategic Review (420-470 MHz)
Business Radio Team
Spectrum Policy Group
Ofcom
Riverside House
2A Southwark Bridge Road
London SE1 9HA

A1.5 Note that we do not need a hard copy in addition to an electronic version. We will acknowledge receipt of responses if they are submitted using the online web form but not otherwise.

A1.6 It would be helpful if your response could include direct answers to the questions asked in this document, which are listed together at Annex 4. It would also help if you can explain why you hold your views and how our proposals would impact on you.

Further information

A1.7 If you want to discuss the issues and questions raised in this CFI, or need advice on the appropriate form of response, please contact Kevin Delaney on 020 7981 3143.

Confidentiality

A1.8 We believe it is important for everyone interested in an issue to see the views expressed by respondents. We will therefore usually publish all responses on our website, www.ofcom.org.uk, ideally on receipt. If you think your response should be kept confidential, can you please specify what part or whether all of your response should be kept confidential, and specify why. Please also place such parts in a separate annex.

A1.9 If someone asks us to keep part or all of a response confidential, we will treat this request seriously and will try to respect this. But sometimes we will need to publish all responses, including those that are marked as confidential, in order to meet legal obligations.

A1.10 Please also note that copyright and all other intellectual property in responses will be assumed to be licensed to Ofcom to use. Our approach on intellectual property rights is explained further on its website at http://www.ofcom.org.uk/about/accoun/disclaimer/

Next steps

A1.11 Following the end of the consultation period, we intend to publish an update for stakeholders, by the end of 2015.

A1.12 Please note that you can register to receive free mail Updates alerting you to the publications of our relevant documents. For more details please see: http://www.ofcom.org.uk/static/subscribe/select_list.htm

Our consultation processes

A1.13 We seek to ensure that responding to a consultation is easy as possible. For more information please see our consultation principles in Annex 2.

A1.14 If you have any comments or suggestions on how we conduct our consultations, please call our consultation helpdesk on 020 7981 3003 or e-mail us at consult@ofcom.org.uk . We would particularly welcome thoughts on how we could more effectively seek the views of those groups or individuals, such as small businesses or particular types of residential consumers, who are less likely to give their opinions through a formal consultation.

A1.15 If you would like to discuss these issues or our consultation processes more generally you can alternatively contact Graham Howell, Secretary to the Corporation, who is our consultation champion:

Graham Howell
Ofcom
Riverside House
2a Southwark Bridge Road
London SE1 9HA

Tel: 020 7981 3601

Email: Graham.Howell@ofcom.org.uk

Annex 2

Ofcom's consultation principles

A2.1 We have published the following seven principles that it will follow for each public written consultation:

Before the consultation

A2.2 Where possible, we will hold informal talks with people and organisations before announcing a big consultation to find out whether we are thinking in the right direction. If we do not have enough time to do this, we will hold an open meeting to explain our proposals shortly after announcing the consultation.

During the consultation

A2.3 We will be clear about who we are consulting, why, on what questions and for how long.

A2.4 We will make the consultation document as short and simple as possible with a summary of no more than two pages. We will try to make it as easy as possible to give us a written response. If the consultation is complicated, we may provide a shortened Plain English Guide for smaller organisations or individuals who would otherwise not be able to spare the time to share their views.

A2.5 We will consult for up to 10 weeks depending on the potential impact of our proposals.

A2.6 We will appoint someone to ensure we follow our own guidelines and reach out to the largest number of people and organisations interested in the outcome of our decisions. Our 'Consultation Champion' will also be the main person to contact with views on the way we run our consultations.

A2.7 If we are not able to follow one of these principles, we will explain why.

After the consultation

A2.8 We think it is important for everyone interested in an issue to see the views of others during a consultation. We would usually publish all the responses we have received on our website. In our statement, we will give reasons for our decisions and will give an account of how the views of those concerned helped shape those decisions.

Annex 3

Consultation response cover sheet

A3.1 In the interests of transparency and good regulatory practice, we will publish all responses in full on our website, www.ofcom.org.uk.

A3.2 We have produced a coversheet for responses (see below) and would be very grateful if you could send one with your response (this is incorporated into the online web form if you respond in this way). This will speed up our processing of responses, and help to maintain confidentiality where appropriate.

A3.3 The quality of consultation can be enhanced by publishing responses before the consultation period closes. In particular, this can help those individuals and organisations with limited resources or familiarity with the issues to respond in a more informed way. Therefore we would encourage respondents to complete their coversheet in a way that allows us to publish responses upon receipt, rather than waiting until the consultation period has ended.

A3.4 We strongly prefer to receive responses via the online web form which incorporates the coversheet. If you are responding via email, post or fax you can download an electronic copy of this coversheet in Word or RTF format from the 'Consultations' section of our website at www.ofcom.org.uk/consult/.

A3.5 Please put any parts of your response you consider should be kept confidential in a separate annex to your response and include your reasons why this part of your response should not be published. This can include information such as your personal background and experience. If you want your name, address, other contact details, or job title to remain confidential, please provide them in your cover sheet only, so that we don't have to edit your response.

Cover sheet for response to an Ofcom consultation or call for inputs

BASIC DETAILS

Consultation title:

To (Ofcom contact):

Name of respondent:

Representing (self or organisation/s):

Address (if not received by email):

CONFIDENTIALITY

Please tick below what part of your response you consider is confidential, giving your reasons why

Nothing ☐

Whole response ☐

Part of the response ☐

Name/contact details/job title ☐

Organisation ☐

If there is no separate annex, which parts?

If you want part of your response, your name or your organisation not to be published, can Ofcom still publish a reference to the contents of your response (including, for any confidential parts, a general summary that does not disclose the specific information or enable you to be identified)?

DECLARATION

I confirm that the correspondence supplied with this cover sheet is a formal consultation response that Ofcom can publish. However, in supplying this response, I understand that Ofcom may need to publish all responses, including those which are marked as confidential, in order to meet legal obligations. If I have sent my response by email, Ofcom can disregard any standard e-mail text about not disclosing email contents and attachments.

Ofcom seeks to publish responses on receipt. If your response is non-confidential (in whole or in part), and you would prefer us to publish your response only once the consultation has ended, please tick here. ☐

Name

Signed (if hard copy)

Annex 4

Consultation questions

Question 1: Do you agree with Aegis's conclusions on congestion of current use of 420-470 MHz spectrum? Are there any other signs or areas of congestion that Aegis have not identified from their review?

Question 2: Do you agree with Aegis's conclusions on the future demand and use of 420-470 MHz spectrum over the next ten years? Are there any other future uses or areas for future demand that Aegis have not identified from their review?

In responding to Questions 1 and 2, please provide any supporting evidence for your position with respect to your specific sector(s):

a) business radio (please specify if your response represents a specific subset of the BR sector, such as the utilities or transport industries)
b) public sector users (i.e the ES, DH and MoD)
c) PMSE
d) aeronautical
e) maritime
f) amateur radio
g) licence exempt users, including users of short range devices
h) potential new user of the band

Question 3: Do you agree with Aegis's conclusions that there is not yet any UK demand for wideband services in the 450-470 MHz band (which could for example, be used to improve rural mobile coverage)? Please provide any supporting evidence for your position.

Question 4: Have you experienced degradation in your systems' performance which you consider to be caused by continental interference in the last 12 months? If yes, what approach did you take towards managing and minimising interference?

Please provide any supporting evidence which explains the frequency (of occurrence), impact, duration, time, location and cause (whether suspected or investigated) of the interference with respect to your specific sector(s).

Question 5: Is there additional information relevant to the configuration of the 420-470 MHz band that we should consider in developing our approach to its future management? Please provide any evidence to support your views.

Question 6: Do you agree with the potential solutions Aegis have proposed for managing the 420-470 MHz band to both meet the continued growth in congestion and demand from incumbent spectrum users, and to facilitate the deployment of wideband technologies? Are there any other solutions which you consider we should examine that Aegis have not identified from their review?

Please provide any evidence to support your position and reference each solution in your response as appropriate.

Question 7: Do you have any further comments relevant to how we might manage spectrum between 420-470 MHz?

Question 8: Do you have any comments on our proposed programme of work, the outcomes from which we will use to inform future decisions on how we manage the 420-470 MHz band? Are there any additional areas you consider we should explore?

Annex 5

Summary of the Aegis Report

Report background and overview

A5.1 We asked Aegis to analyse and project the demand for the 420-470 MHz band from existing and potential new users. Their report drew on market information, international developments, stakeholder interviews and responses to the Spectrum Management Strategy Consultation, as well as licensing data from our systems.

A5.2 Aegis modelled five[34] hypothetical scenarios for the 420-470 MHz band, which form the central part of the report:

- Incumbent growth under the current band configuration;
- Reduction/expansion of ES use of the band;
- Incumbent growth leading to band reversal (reconfiguration);
- Deployment of managed networks in the band; and
- Introduction of LTE at 450 MHz.

A5.3 For each of their scenarios, Aegis considered the challenges, risks and opportunities which may arise, and also posed a number of potential solutions to these challenges.

A5.4 Having reviewed Aegis's report, we identified two core scenarios of future demand for the band. We have used these core scenarios to help summarise Aegis's analysis, and to frame the solutions Aegis identify to help meet the challenges presented by the scenarios.

A5.5 The two core scenarios[35] summarised in this annex are:

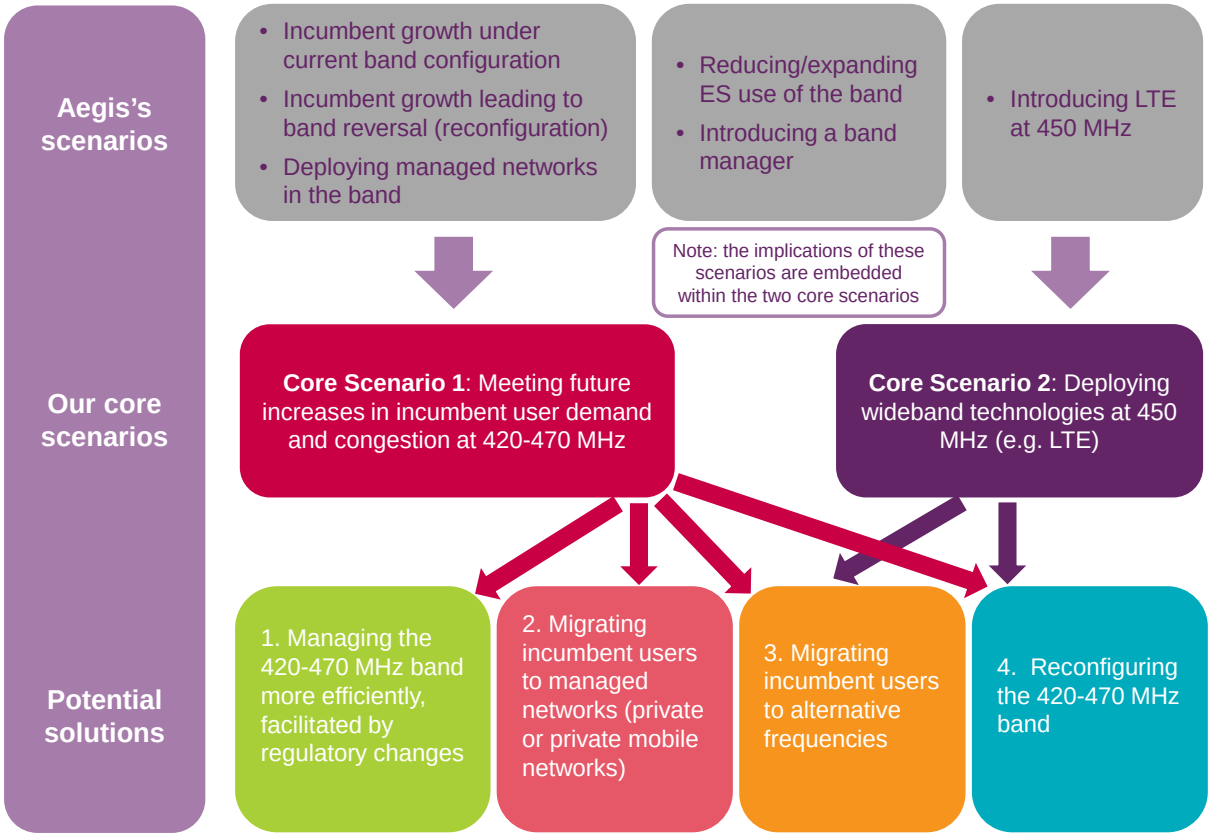
- Future growth in incumbent user demand and congestion at 420-470 MHz; and
- Deployment of wideband technologies at 450 MHz (e.g. LTE).

A5.6 The rest of this annex explores the two core scenarios and accompanying potential solutions in more detail, summarising the findings from Aegis's report. Figure 7 below shows how Aegis's scenarios and solutions relate to the two core scenarios we have highlighted.

[34] See footnote 30.

[35] Note that we have not included the ES spectrum release as a separate scenario in its own right, but instead treated it as an enabling mechanism to aid our ability to deliver potential solutions. For example, alleviating band congestion or reconfiguring the 420-470 MHz band through the release or sharing of frequencies. Its implications have therefore been embedded within the two core scenarios.

Figure 7: Revised scenarios and solutions for the 420-470 MHz band



Future growth in incumbent user demand and congestion at 420-470 MHz

A5.7 In this scenario, Aegis considered the implications of a projected increase in demand (as extrapolated from licensing data), particularly from incumbent users, and their spectrum requirements now and over the next ten years.

Current use and future demand by sector

Business Radio

A5.8 Aegis recognised that there is emerging demand for spectrum across all classes of BR licence, though this has primarily been in the 450-470 MHz band. Aegis projected limited growth, with a further 1.5 MHz likely to be needed over the next ten years:

- *Technically assigned and area defined licences*: around 0.9 MHz of additional spectrum will be needed to meet future growth in voice and narrowband data services, particularly for onsite campus networks (this amount of spectrum would also be sufficient to accommodate future demand for area defined licences).

- *Light licences*[36]: although the current spectrum allocation (around 0.6 MHz) has met growth in both types of licence, Aegis predicts that the requirement may need to double to support future growth, with additional channels to minimise the

[36] Light licences refer to licences which are not technically coordinated and assigned by Ofcom.

potential for interference. They also indicate growth is being fuelled by increased demand for campus on-site handheld devices (rather than wide area applications).

A5.9 Although a slight upward trend in technically assigned and light licences is observed from 2010-2014 licensing data, Aegis considered this to be largely due to demand growth from existing congestion in the band, and there are no indications (from stakeholder interviews) that current levels of demand will subside. Aegis reported heavy congestion to be already present in major conurbations (such as London, Manchester and Birmingham), which may be deterring users from applying for licences in those areas[37]. Furthermore, there are signs that users are deciding to use to light licences due to the (assumed) shortage of frequencies for technically assigned licences in some congested conurbations which has contributed to the growth in light licences.

A5.10 Aegis also reported signs of unmet demand for professional wideband BR networks, among users who are reverting to BR because their communications requirements are not able to be met by existing public mobile networks[38] (for example, the required levels of coverage or speed of connectivity). According to Aegis, demand for wideband applications could help the BR market to evolve, as users may migrate to other managed networks by their own volition (though they remind us that it would be necessary to reconfigure the 420-470 MHz band in order to deploy such networks). Aegis suggested that this type of market structure could support the future demands of incumbent BR users, as well as attracting new entrants and applications (this is discussed further in paragraphs A5.43-A5.50).

Utilities and machine-to-machine industries

A5.11 Aegis found that emerging demand for machine-to-machine (M2M) communications will most likely be driven by the utilities sector. Smart metering and scanning telemetry are noted to be the primary markets for M2M applications and sources of significant spectrum demand, due to the sector's commitments to Government to achieve nationwide rollout of smart grid networks by 2020.

A5.12 They suggest demand for spectrum for scanning telemetry and smart metering will come chiefly from the following utilities industries:

- *Energy*: the Joint Radio Company (JRC) seek a further 2 x 3 MHz of spectrum on behalf of the fuel and power industries between 2015 and 2020 to meet UK Government/EU monitoring requirements[39] and to safeguard supplies/aid the fast restoration of supply if interrupted. The JRC consider that public mobile networks are unsuitable for supporting the utilities' specific requirements, since mobile network latency cannot guarantee a connection which is necessary on health and safety grounds (and in any case is not able to provide the required connection times), and given that geographic coverage outside of conurbations and the necessary level of resilience/security to maintain operations in the event of a power outage is not assured.

[37] Aegis found that users were not applying for licences in certain areas due to an expectation that the licence request would be refused because of existing congestion.
[38] This view was supported in stakeholder interviews, and by the Federation of Communications Services' (FCS) in their response to our Spectrum Management Strategy Consultation, though it is difficult to quantify the precise level of demand given the service is not yet deployed.
[39] The industry needs more extensive network monitoring capabilities to meet specific targets by 2020, for reducing CO^2 emissions and levels of energy consumption, as well as a number of renewable energy objectives.

- *Water*: the industry is fully using their spectrum allocation (24 national fixed link channels of 12.5 kHz) to ensure compliance with statutory requirements for treatment and distribution, and monitoring of water quality and flood defence. These scanning telemetry applications work well at these frequencies because they can obtain high levels of coverage while operating with low maintenance and operating costs, and carrying a low risk of interference. Aegis reasonably assume the sector will require additional spectrum to support increasing sensor numbers and a growing trend to more granular monitoring data, though specific spectrum requirements are yet to be quantified by the industry.

A5.13 Aegis did not identify any further M2M demand in this band beyond scanning telemetry for the utilities, as M2M applications are generally served by public mobile networks or by LE SRDs in harmonised bands elsewhere[40].

Emergency Services

A5.14 According to Aegis's report, demand for ES frequencies may increase to support the introduction of new applications in the band (potentially up to an additional 1.3 MHz will be required), including new nationwide breathing apparatus applications for the UK Fire Service, new Home Office systems, and air-to-ground communications systems.

A5.15 However, the extent of the ES' future requirements is unclear while procurement of the new ES network (replacing the existing Airwave service) continues[41]. Further work is ongoing to resolve what the requirements might be (which may not necessarily relate to the 420-470 MHz band), and there may also be scope to migrate existing ES use to the planned ES network and/or other spectrum bands.

Programme Making & Special Events

A5.16 Aegis reported that while licensing data between 2000 and 2013 shows growth in the number of PMSE assignments made in the 420-470 MHz band, there is no evidence of corresponding upwards growth in PMSE licences for this band[42]. However, Aegis noted that PMSE use may rise to accommodate reductions in spectrum availability in other bands and/or displaced PMSE users elsewhere. For example, Aegis recognised that potential reductions in the availability of white spaces above 470 MHz to support wideband talkback communications could impact upon the future spectrum requirements, and cite past stakeholder experiences of congestion at major events in the 450-470 MHz band over the last ten years.

Maritime

A5.17 Aegis found that although demand for maritime frequencies exists, it is being met at present due to the sector's switch to digital equipment. Aegis also noted that there is a WRC-15 agenda item looking at on-board communications stations for maritime mobiles services which has implications for internationally harmonised spectrum in

[40] We note that the future innovative use of IoT and M2M applications, was the subject of another recent CFI. We expect to publish the outcome of this work in early 2015.
[41] https://www.gov.uk/government/publications/the-emergency-services-mobile-communications-programme
[42] The number of assignments made at 420-470 MHz does not necessarily reflect an increase in PMSE licences nationwide, as assignments may only relate to particular geographic locations and last for short periods of time.

the 420-470 MHz band, though any new allocations are likely to take longer than ten years to implement.

LE and SRDs

A5.18 Aegis noted the difficulty in quantifying the extent of LE use in the band as due to the nature of its exempt use these users are not captured in our licensing system. Stakeholder interviews did not indicate further demand for frequencies for SRDs. Therefore they note that future demand for this use remains unclear.

A5.19 Aegis did however refer to stakeholder concerns about the impact of LTE in the 800 MHz band on SRDs in adjacent frequencies as LTE services rollout, and the implications this might have on the available frequencies if increased interference requires SRDs to be moved to the 420-470 MHz band.

Challenges and considerations

A5.20 Aegis noted the main impediment to addressing users' growing spectrum demand is the shortage of available spectrum in the band to meet user needs in the future. This lack of available spectrum is exacerbated by high fragmentation in the band making it difficult to coordinate a suitable solution, and constraints imposed on part of the band's use by RAF Fylingdales. The future impact of constrained spectrum in the band could be particularly significant on critical infrastructure users.

A5.21 In addition, Aegis highlighted that spectrum use may also be affected by the increasing risk of continental interference arising from the UK's non-harmonised use of the band, which could reduce its availability for use in the easternmost parts of the UK. Incoming signals are more likely to be wideband, which could be more challenging to avoid than the narrow band interference previously experienced (as it affects the base station receiver, it is more severe and impacts the entire network).

A5.22 Aegis also indicated that implementing solutions for growing demand may be hampered because of the diverse, often very specific requirements needed to address the wide range of uses (a one size fits all approach will not work for all users). For example, public mobile networks are unable to meet the coverage and functionality needs of some users.

Aegis's view on future demand

A5.23 Aegis concluded that the current situation appears unsustainable longer term, and advised that action is required to accommodate the predicted future growth of incumbent (and potentially new) users. Growth will principally be driven by:

- the BR sector which Aegis forecast will need approximately 1.5 MHz of additional spectrum to meet voice and narrowband data service requirements. There are also signs of unmet demand for wideband BR applications (presently, mobile networks do not provide sufficient functionality to meet the needs of BR users).

- the utilities industries who require additional spectrum to meet their statutory monitoring commitments and expanding data requirements. Aegis suggested this might be in the region of two 3 MHz channels to be used by a variety of technologies (though their specific requirements have not yet been fully defined).

Deployment of wideband technologies at 450 MHz (e.g. LTE)

A5.24 In this scenario, Aegis explored the potential uses of wideband technologies in the 450-470 MHz band in the UK. Although the use of CDMA-450 is considered by the report[43], Aegis focused on LTE-450 deployment under this scenario because of the expected limited longevity of CDMA (as countries move to update to LTE), and its use to enhance rural coverage. Therefore, the implications for LTE-450 specifically are discussed below.

A5.25 Demand for LTE-450 internationally (and CDMA-450 before it) has been driven by the need to extend rural coverage; the favourable propagation characteristics of these frequencies make it well suited for this purpose. However, in line with our recent conclusions in the Mobile Data Strategy, Aegis are uncertain as to whether a sufficiently large UK market exists and were unaware of any expressed demand to deploy LTE-450 in the UK for mobile data use.

A5.26 In its report, Aegis highlighted a number of key issues which lessen the likelihood of demand and future 'mainstream' mobile LTE use of the 450 MHz band in the UK. These include:

- *Consumer handsets*: LTE compatible handsets at these frequencies require antennas of considerable physical size, which will limit consumer appeal. Furthermore, the cost of adding a new frequency band to equipment may need to be recouped through higher priced handsets (and adding the 450 MHz frequency will typically result in a 1dB performance loss to handsets).

- *Availability of alternative mobile frequencies*: in the context of all spectrum bands potentially available for future mobile data use, greater quantities of spectrum are available to mobile network operators elsewhere, resulting in this being a lower priority, lower demand band.

- *Spectrum configuration*: 10 MHz duplex channel spacing is required to support LTE-450. This is present in the European, but not the current UK configuration. Therefore, it is not possible to deploy LTE-450 MHz band in the UK without reconfiguration of the band (with its associated costs).

- *Propagation characteristics*: while 450 MHz has good propagation characteristics to achieve widespread rural coverage, use of LTE-450 will increase the risk of interference into neighbouring cells (and spectrum uses) including SRDs operating at 800 MHz. These characteristics also limit the traffic carrying capacity of LTE networks, as a result of single channel reuse.

- *Quantity of spectrum*: the limited 20 MHz capacity available between 450-470 MHz may not be sufficient to deploy LTE services as well as fulfil requirements to install the guard bands required to protect adjacent users from interference risks.

A5.27 Accordingly, Aegis concluded that the most likely future demand for LTE-450 is expected to come from the utilities rather than mobile sector, as they require resilient data connectivity on a national basis to support the rollout of smart grid networks. They also noted that with future developments, LTE-450 has the potential to meet BR requirements for wideband PMR services as discussed earlier at paragraph A5.10.

[43] While not directly mentioned in the report, we note other wideband technologies could also be suitable, for example MiMo.

Addressing continental interference

A5.28 Increased use of the band in Europe, especially to provide high power wideband services, is expected to increase continental interference into the UK. Aegis noted the utilities sector's experience of affected scanning telemetry coverage in East Anglia and the Midlands because of a previous rollout of CDMA-450 in Norway.

A5.29 To test this, Aegis conducted a simple analysis to look at the interference from a single transmitter in France (Calais) or the Netherlands (Vlissingen). As noted earlier, this interference is more challenging for existing services (due to higher antenna heights and transmitter powers), so the analysis also investigated the implications of reconfiguring the band on the likely level of interference.

A5.30 The results of the analysis indicated a reduction in continental interference of 40-50% under reconfiguration, and Aegis therefore concluded that alignment with Europe would help to mitigate the increased risk of interference from continental use of LTE and other wideband technologies (such as CDMA). Alignment would also enable greater deployment flexibility for UK masts/sites should wideband technologies be rolled out in the UK, because there would be more locations available where sites did not exceed cross-border coordination thresholds.

A5.31 Aegis also noted LTE interference into SRDs operating within the UK in the 800 MHz band, and drew attention to the potential for similar interference concerns to arise with SRDs operating at the proposed LTE uplink in the 450 MHz band.

A5.32 Aegis concluded that continental interference, should it prove unmanageable or increase, is a sufficiently important issue to justify considering reconfiguration of the 420-470 MHz band. Though they also considered it to be a secondary concern as it does not affect all users and has a limited geographic impact.

Challenges and considerations

A5.33 In addition to the potential interference mitigation benefits discussed above (and notwithstanding the constraints of protecting the RAF Fylingdales radar), Aegis note the potential benefits of reconfiguring the band to align with the CEPT band plan in Europe. This would, for example, improve spectrum efficiency through coordinating/defragmenting users, and 'future proofing' our future management of the band by enabling for the deployment of wideband technologies for mobile, BR networks and/or utility services, if sufficient demand emerges.

A5.34 However, Aegis point out that it would not be possible to deploy wideband technologies without first reconfiguring the band (see Solution 4 below). The band's fragmented use and multitude of deployed technologies, and lack of stakeholder support for the changes, further complicates any reconfiguration solution.

A5.35 Furthermore, the disparate nature of users in the band mean coordination failures may also arise in implementing an efficient and effective solution. Aegis suggested that Government-led intervention would be necessary to garner the necessary support for a suitably efficient spectrum solution.

Aegis's view on future use of wideband technology

A5.36 While Aegis indicated that LTE-450 (and other wideband/broadband technologies) in the UK could support the future requirements of BR and the utilities (and

potentially other) sectors, they remain uncertain as to the levels of interest and appetite for deploying wideband technologies among UK users of this band.

A5.37 Furthermore, the report highlighted the significant technological challenges to address in order to successfully deploy wideband technologies, as well as the likely need to reconfigure the band to reduce increasing risks of interference.

Aegis's proposed solutions

A5.38 Having considered the future demand scenarios of the 420-470 MHz band, including the potential to deploy wideband technologies, the rest of this annex explores the solutions proposed by Aegis to address the challenges, considerations and risks posed by their scenarios.

A5.39 The potential solutions Aegis identified can be summarised as:

- Solution 1: Managing the 420-470 MHz band more efficiently, facilitated by regulatory changes;
- Solution 2: Migrating incumbent users to managed networks (public or private mobile networks);
- Solution 3: Migrating incumbent users to alternative frequencies; and
- Solution 4: Reconfiguring the 420-470 MHz band.

Solution 1: Managing the 420-470 MHz band more efficiently, facilitated by regulatory changes

A5.40 Aegis considered that more efficient management of the 420-470 MHz band could help meet the future demands of incumbents, in particular for BR. Although this would be relatively less interventionist compared with alternative solutions (such as reconfiguring the band), it is still expected to require action at a regulatory level.

A5.41 Suggestions put forward by Aegis or stakeholders for more efficient management of the band included:

- *Transmitter restrictions:* restricting transmitter power levels to the minimum necessary, and base stations heights to provide only the requested levels of coverage, would reduce the size of the sterilised area and allow for greater geographic co-location of users. This could help to alleviate urban congestion.

- *Justify spectrum need when requesting frequencies:* monitoring the use/ assignment of frequencies which could otherwise be reassigned may also help to reduce congestion. For example, requiring licensees to a) substantiate additional frequency requests at a site, b) confirm the proposed scale of spectrum traffic required at assignment for dPMR use (i.e. whether both channels are required), or c) be held to a "use it or lose it" approach where frequencies are monitored to identify any 'dormant' (i.e. licensed but unused) frequencies in the band (though we note that licences do not currently permit revocation for this reason).

- *Spectrum pricing:* reviewing (and potentially increasing) spectrum fees for congested frequencies to reflect the value of their use (which could lead band users to change their behaviour and their use of spectrum in the band).

- *Spectrum sharing:* encouraging more sharing among users would make more channels available to meet future demand and could help to alleviate congestion. For example, we (Ofcom) are already reviewing our licensing and assignment framework through the BR product development project and one of the areas being investigated is looking at the feasibility of increasing the level of sharing of assignments. In addition, Aegis suggest that sharing MoD/ES spectrum with commercial services could also potentially manage congestion and future demand (for example, by reviewing area restrictions, power levels and coordination arrangements for assignments sharing Fylingdales frequencies[44]). However, doing so would depend on the MoD/ES permitting commercial access to its spectrum. It would also require the alignment of timing (of any release) in order to maximise sharing benefits. Aegis suggest that public sector sharing could be encouraged through the existing PSSR programme (see paragraph 3.45 for more details on our current work).

- *Prioritise access:* giving priority to business critical applications in the 420-470 MHz band could help to alleviate congestion and manage future demand. However it potentially means that less critical applications have less spectrum available, and therefore they may need to find alternative frequencies to accommodate their spectrum requirements.

A5.42 These suggestions create more immediate opportunities to resolve emerging challenges in the band, as there are already the means to implement them under the existing regulatory framework. While on the whole, they are likely to be less disruptive to existing users in the band, Aegis are mindful that changes to address congestion, which effectively increase the number of users in the band, could make future reconfiguration (under solution 4) more complex longer term.

Solution 2: Migrating incumbent users to managed networks (public or private mobile networks)

A5.43 Migrating existing services onto a new, shared network presents an opportunity to release the subsequently freed up spectrum for alternative uses (for example, to meet future increases in incumbent user demand or to deploy new wideband services).

A5.44 Aegis identify two potential options to this solution, where:

- the market structure evolves driving users to create their own network or to migrate to managed (public or private) networks themselves, or led by dealers for BR users; or

- a government-led process coordinates spectrum users in the band to create, or migrate to, managed (public or private) networks (for example, this might be appropriate where sector(s) are so disparate that intervention is needed to avoid a coordination failure).

A5.45 Managed networks are an attractive solution for meeting BR demand, as it minimises the costs of investing in and maintaining separate networks. They present a suitable alternative for users who have been refused access to spectrum in congested conurbations. Aegis highlight that managed networks could also

[44] As mentioned in paragraph 3.4, shared use of MoD spectrum is restricted to designated areas around radar locations. Use outside of these areas must be coordinated and agreed by the MoD.

support the requirements of the utilities (as seen internationally[45]). However, they note that this may depend on the Government to encourage and create the impetus for users to collaborate and develop their own shared network.

A5.46 As outlined in the final bullet of paragraph 3.45, Aegis note the ES' plans to migrate certain services onto an ES managed network. The services identified include the existing HM Prisons systems as well as potential future applications of breathing telemetry for the Fire services and air-to-ground communications. However, the precise ES network solution is unknown, and it is not yet confirmed whether the solution will be able to support all users and applications. If successful, there may be an option for the ES to release UHF spectrum in the future, which could be used to facilitate these types of commercial networks.

A5.47 Aegis also suggested that the spectrum made available from migrating to managed networks could potentially be used to deploy LTE in the UK, which could help to meet the future requirements of the utilities and BR sectors.

A5.48 However, Aegis acknowledge that this solution raises a number of implications for users:

- *Interest and demand*: users may see an advantage in moving to a managed network by saving themselves investment and maintenance costs. However, there will need to be an existing market of sufficient size in place in order to drive demand for networks and to justify the cost of installing network infrastructure. Aegis did note that there is interest in managed networks among some BR users who wish to expand their coverage across major urban areas, but were unable to qualify the level of interest in its report. The likelihood of future demand for use of managed networks is also unclear.

- *Incentives for migration*: users who have either recently invested or already have pre-existing long term investments in their own networks, or have met their operational requirements by alternative means (such as moving from analogue to digital equipment) would see only marginal benefits and therefore little incentive to further invest in this solution, according to Aegis[46]. This places further uncertainty on the potential levels of demand for these networks.

- *Limitations in network functionality*: public mobile networks do not support group calling and push-to-talk applications which are required by many BR users and services. Aegis noted that this reduces the number of users who would be able to benefit from this solution. Aegis also suggested that any managed network solution should ideally be capable of supporting both narrowband and wideband applications.

- *Network resilience and robustness*: this is a significant issue for business critical applications which would heavily rely on the infrastructure to meet and support their needs from the point of migration, including sufficient speed and capacity to meet user requirements. Any power outages or failures in network performance which result in a loss of functionality for a given amount of time may have significant economic (and potentially health and safety) implications.

[45] Managed TETRA networks deployed by Entropia are supporting scanning telemetry and PMR systems for the utilities sector in Belgium and Holland.
[46] For example, HM Prisons have recently invested in migrating from on-site analogue equipment to their own TETRA networks and so they may be unwilling to migrate once more onto the planned ES network.

Furthermore, mobile networks provide limited service underground and are unlikely to provide the widespread coverage required for some services. Aegis noted that public mobile networks may therefore not be suitable for business critical services.

A5.49 Aegis recognised that managed networks as a viable solution are unproven in the UK, and that those currently operational provide limited coverage[47] and therefore may be unsuitable for some services. This constitutes the main risk for this solution, though Aegis noted that the successful rollout of TETRA networks in Europe could encourage international providers to enter the UK market.

A5.50 Aegis was also uncertain whether this outcome would create sufficient contiguous spectrum to address future growth of incumbent users or facilitate the deployment of wideband technologies in the UK, so its potential benefits may not be fully realisable.

Solution 3: Migrating incumbent users to alternative frequencies

A5.51 This solution follows the same principles as Solution 2 above, but instead involves migrating users to alternative frequencies in other spectrum bands. Aegis proposed this potential solution as a way to accommodate future incumbent growth, as well as supporting LTE-450 rollout in the UK.

A5.52 For example, Aegis considered the VHF spectrum band (in the UK, this is between 55-191 MHz – see Figure 5). VHF spectrum provides alternative frequencies suitable for supporting some existing applications, such as those which do not require small handheld terminals (e.g. vehicle dispatch services), although this assumes these applications use modern digital equipment in order to reduce the past problems associated with these lower frequencies. Aegis noted that narrowband dPMR and DMR equipment are both capable of operating in the 68-88 MHz (with some equipment manufactured), and 138-174 MHz bands, though the need to create a market for mainstream products remains.

A5.53 Aegis also considered that VHF frequencies above 174 MHz could support the future requirements of PMSE, if required, though antenna sizes make these frequencies less ideal for body worn devices (and the lack of available equipment at present may present challenges for doing so).

A5.54 However, migration to other frequencies may not be a suitable alternative for all applications and sectors, and this point is highlighted by Aegis. For example, while VHF spectrum supports the less critical applications of the water industry[48], its use may not be suitable for services of a higher criticality due to the large antennas that are required for their operation.

Solution 4: Reconfiguring the 420-470 MHz band

A5.55 The possibility of reconfiguring the 420-470 MHz band is prevalent throughout Aegis's report as a solution which could both accommodate continued incumbent user growth and facilitate the deployment of LTE-450 in the UK. They note that reconfiguration is a necessary step to support wideband technologies.

[47] Aegis cite Fleetcomm and Mercantile Radio as examples.
[48] VHF spectrum is already used for less critical applications as it provides the required resilience and levels of coverage not provided by UHF spectrum.

A5.56 This solution involves restructuring the current configuration of the 420-470 MHz band, which could be achieved either partially or in a full reconfiguration. Aegis consider that efficiencies can be achieved by grouping user allocations together into block frequencies, thereby reducing fragmentation and potentially releasing frequencies to benefit both core scenarios. They also note that this solution would minimise the risk of continental interference by aligning the UK's configuration with the European band plan (though it may still not fully address it), and places the UK in a stronger position (under the HCM agreement) to resolve cases of incoming interference.

A5.57 Aegis highlighted the importance of a clear plan with sufficient resources and engineering expertise in order to deliver successful reconfiguration of the band.

A5.58 However, Aegis also emphasised a number of significant implications of reconfiguration that need to be carefully considered:

- *Method of reconfiguration*: Aegis suggested that reconfiguration could be simultaneous (reconfiguring user frequencies at the same time) or piecemeal (reconfiguring individual users at different times[49]). However, Aegis did not qualify a definitive method in the report. In either case, the report addresses that regulatory action would be needed to implement any reconfiguration. Furthermore, Aegis noted that it is not feasible for only one sector to reconfigure to align with Europe, as it would essentially introduce additional interference into the band.

- *Complexity and impact*: linked to the fragmented use of the band at present, Aegis noted that reconfiguration of the band is likely to be a very time consuming and disruptive procedure for band users. Stakeholder responses to Aegis, and past consultations, have all highlighted these concerns.

- *Cost*: band reconfiguration is likely to be a highly expensive venture. In 2004, reconfiguration of the 450-470 MHz band was assumed to cost between £260m-£310m. Though this estimate needs updating to more accurately reflect current costs, Aegis expected that some costs were likely to reduce as a result of lower retuning impacts with new equipment, while engineering costs were likely to increase, for example, where antenna changes were required).

- *Sources of funding*: identifying and securing sources of suitable (and cost effective) funding is likely to be a significant consideration for any future reconfiguration exercise. Aegis suggested that collaboration between other relevant regulators including Ofwat and Ofgem may be necessary, and noted that this may have implications for the respective business cycles of each body if funding was not able to be secured directly from Government.

- *Availability of parking bands*: Aegis considered the benefits of using spectrum from the potential ES release as parking channels to temporarily house displaced users and services while the reconfiguration takes place. However, this option ultimately depends on the ES releasing spectrum in the future. In addition, the opportunity to use this spectrum relies on the timing for spectrum release aligning

[49] Aegis concluded that a piecemeal approach could be feasible with the reconfiguration of users prioritised by order of criticality of use. For example, the report suggests that spectrum in which business critical applications operate in is reconfigured first ahead of less critical ones.

with any planned reconfiguration[50]. Further, any released ES spectrum must suit the requirements of displaced users and be in sufficient supply to accommodate the number of displaced users. In the absence of released ES spectrum, Aegis considered that it could still be feasible to reconfigure the band by considering smaller geographic areas in a phased solution.

- *Implementing other solutions prior to reconfiguration:* Aegis suggested that implementing some of the other potential solutions would subsequently aid reconfiguration of the 420-470 MHz band. For example, migrating users to other frequencies or networks could reduce the number of users who need to be reconfigured in the band, which in turn would likely decrease the overall amount of risk, disruption and effort required for reconfiguration. Although they also point out spectrum efficiencies that introduce greater numbers of users may also make it more difficult to reconfigure the band long term.

Aegis's conclusions

A5.59 Aegis's key findings are summarised in paragraph 4.24 in the main body of this CFI.

[50] The timing of spectrum release itself is also contingent upon both the readiness of the planned ES network and the success and time taken to migrate ES services to it.

Annex 6

Glossary

BR	Business radio
BRIG	Business Radio Interest Group
CDMA	Code division multiple access
CEPT	European Conference of Postal and Telecommunications Administrations
CFI	Call for Inputs
Communications Act	The Communications Act 2003, which came into force July 2003
DH	Department of Health
DMR	Digital mobile radio
DMR446	A licence exempt version of PMR that specifies the use of digital radios
dPMR	Digital private mobile radio
ES	Emergency services
FCS	Federation of Communications Services
FDMA	Frequency division multiple access
HCM agreement	Harmonised Calculation Method agreement
IoT	'Internet of Things'. Refers to the interconnection (wirelessly) of uniquely identifiable embedded computing-like devices within the existing internet infrastructure. There is no universally agreed definition but in general it is used (like M2M) for communications involving at least one machine.
LE	Licence exempt
LTE	Long term evolution. A standard for communication of high-speed data for mobile phones and data terminals.
M2M	Machine-to-machine. Refers to technologies that allow both wireless and wired systems to communicate with other devices of the same type. M2M is a broad term as it does not pinpoint specific wireless or wired networking.
MHz	Megahertz. A unit of frequency of one million cycles per second.
MoD	Ministry of Defence
PMR	Private mobile radio
PMR446	A licence exempt version of PMR that specifies the use of analogue radios
PMSE	Programme making and special events. A class of radio application that supports a wide range of activities in entertainment, broadcasting, news gathering and community events.

PSRCP	Public Safety RadioCommunications Project
PSSPG	Public Safety Spectrum Policy Group
PSSR	Public sector spectrum release
RA	Radiocommunications Agency (now part of Ofcom)
RoI	Republic of Ireland
SCADA	Supervisory control and data acquisition
SRD	Short range device. A general term, applied to various radio devices designed to operate usually on a license exempt basis, over short range and at low power levels.
TDMA	Time division multiple access
TETRA/TETRAPOL	Terrestrial Trunked Radio
UHF	Ultra high frequency. The part of the spectrum between 300 MHz and 3 GHz.
UHF 1	Frequencies between 420-450 MHz
UHF 2	Frequencies between 450-470 MHz
VHF	Very high frequency. The part of the spectrum between 30-300 MHz.
WT Act	Wireless Telegraphy Act 2006