Review of Public Sector Spectrum Release (PSSR)

Recommendations to Government on the setting of a revised PSSR target

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About this document

A Central Management Unit (CMU) has recently been established to manage public sector spectrum use. It is responsible for delivering the Public Sector Spectrum Release (PSSR) programme to release or share spectrum with civil users. The CMU has asked Ofcom to review the PSSR programme, including the current target to make 500 MHz of spectrum below 5 GHz available for civil users by 2020. This document provides Ofcom's assessment of civil demand, priority bands for release/sharing, recommendations for a revised target and views on how to deliver that target. The CMU will make a final recommendation on the release target before going to the Secretary of State of the Department for Culture, Media and Sport (DCMS) for approval.

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Section 1

Background and introduction

1.1 Spectrum is used by the public sector for a wide variety of purposes including use by defence, security and emergency services. Applications include military radio, aeronautical and maritime radar, meteorology and radio astronomy.

1.2 Spectrum is critical to the provision of these services, but it is a valuable resource in its own right and must be managed efficiently in order to deliver the services and to accommodate operational changes. Efficient management means not only making sure the spectrum is used efficiently by existing users, but also making public sector spectrum available to civil (non-public sector) users where it is feasible and economic to do so.

1.3 The Public Sector Spectrum Release (PSSR) programme was announced in the 2010 Spending Review[1] and outlined in more detail in a subsequent DCMS report in 2011[2]. The Government established a target of releasing 500 MHz of public sector spectrum below 5 GHz by 2020.

1.4 The PSSR programme has already secured the release of a total of 230 MHz of spectrum in the 2.3 and 3.4 GHz bands as well as the release/sharing of a further 62 MHz of spectrum in other frequency bands. However, progress on releasing/sharing other potentially valuable public sector spectrum has been slow, and there is still some work to do in order to reach the current target.

1.5 The establishment in 2015 of a Central Management Unit (CMU) within the Shareholder Executive (ShEx) to manage public sector spectrum offers Government an opportunity to reinvigorate the PSSR programme. Better incentives to encourage release/sharing – including the ability to offset the cost of technical feasibility studies against AIP charges[3] – will further help delivery of the programme.

1.6 Under its terms of reference[4], the first task of the CMU has been to commission a review by Ofcom of the current PSSR release target and delivery programme. This document is the result of that commissioning. Once it has taken account of Ofcom's assessment, the CMU will make a final recommendation on the release target, together with a strategic plan to deliver that target, and for the coordination of public sector spectrum use. This will be discussed with Departments before going to the Secretary of State of the Department for Culture, Media and Sport for approval.

1.7 This document represents Ofcom's own conclusions and recommendations and not those of other stakeholders - although we have taken account of input from the following:

- Treasury (HMT)
- ShEx /Central Management Unit (CMU)
- Department for Culture, Media and Sport (DCMS)
- Ministry of Defence (MOD)
- Home Office (HO)

[1] HM Treasury Spending Review 2010 (http://cdn.hm-treasury.gov.uk/sr2010_completereport.pdf).
[2] Enabling UK growth – Releasing public spectrum. DCMS, March 2011.
[3] Administered Incentive Pricing – a charge for spectrum based on the opportunity cost of its use
[4] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/453242/Public_sector_spectrum_TOR_-_for_web_PDF_.pdf

- Department for Transport (DfT) representing also:
  - Civil Aviation Authority (CAA)
  - Maritime and Coastguard Authority (MCA)
  - DfT for road and rail services (including HS1 and HS2)
- Business Innovation and Skills (BIS) representing also:
  - UK Space Agency (UKSA)
  - Science and Technology Facilities Council (STFC)
  - Met. Office
- Nations (for national emergency and public services)

1.8 Our conclusions on a revised target are set out in full in Section 4. In summary, we believe the existing target remains relevant. However, we believe that limiting the PSSR target to spectrum below 5 GHz – as is currently the case – is too restrictive, given that technological developments have made higher spectrum frequencies more valuable than previously.

1.9 We believe the PSSR programme should concentrate on key spectrum bands that are both a) of real value to civil users and b) offer a realistic prospect of being released or shared. Our recommendation is for a revised target for the release/sharing of 500 MHz of high value public sector spectrum by 2020, with explicit priority on three high value bands – namely, the lower 2.3 GHz and 1427-1452 MHz bands (for mobile) and 380-385 MHz alongside 390-395 MHz (possibly for Internet of Things applications).

1.10 We also recommend an additional target for the release/sharing of a further 250 MHz of spectrum below 10 GHz by 2022 - making a revised target of 750 MHz of spectrum in total.

1.11 The remainder of this document is structured as follows:

Section 2 identifies where there is particular demand for spectrum by civil users.

Section 3 goes on to note the progress that has been made towards the current PSSR target, including which bands have been targeted so far for release/sharing.

Section 4 sets out our recommendations for establishing a revised target.

Section 5 discusses the practicalities of delivering the target.

Section 6 provides a summary of our conclusions and proposed next steps.

Section 2

Demand for spectrum

2.1 Demand for spectrum within different civil sectors (such as broadcasting, mobile, PMSE[5] etc.) changes over time as technology advances and the needs of business and consumers change. Sometimes, new technology means less spectrum is needed to deliver the same service, such as with developments in digital broadcasting. More often though, increased technical capability fuels greater demand for services, which in turn drives greater demand for spectrum.

2.2 The physical properties of spectrum at particular frequencies make them especially well-suited to certain applications. This is recognised through internationally agreed identification of particular bands[6] for particular purposes, leading to huge benefits in lower equipment costs through economies of scale and easy access to services across frontiers.

2.3 Technological change and harmonisation of spectrum means it can be beneficial for use of particular frequencies to change over time. For civil users, Ofcom manages spectrum use by transferring bands from one sector to another when it makes sense to do so. We are in a position to do this because we are able to assess and optimise the benefits overall, across many different uses. We think the Government should extend this approach across both civil and public sector spectrum.

2.4 Understanding current usage and future demand is a vital first step in managing both civil and public sector users. Ofcom has made significant changes to the way it releases and analyses information on spectrum use and demand to support both internal and external stakeholders, including through the publication of our spectrum interactive map. We continue to undertake scenario analysis to ensure we can provide sufficient spectrum to meet market demand.

2.5 In order to understand civil use and demand, Ofcom also carries out sector reviews, such as the Mobile Data Strategy review, the PMSE review and the Satellite and Space Science strategic review. We think it is equally important that the CMU/Government understands the public sector's current and future demand. We therefore recommend the CMU commissions external audits of current public sector use and future spectrum needs, starting with an audit of the future spectrum needs of the MOD.

2.6 We acknowledge that the development of new applications may lead to an increase in public sector demand for spectrum in some cases - e.g. advances in unmanned aircraft technology which may require access to bands not already in use - but there will also be reductions in demand in other areas. It is important to understand what is necessary to support services in the UK and overseas. Ofcom and the CMU will therefore need to develop a framework in which Departments are confident of being able to meet their long-term spectrum needs.

2.7 The immediate focus of the CMU should be to look at the detail and practicalities for those bands where we have highlighted high priority for release - including taking into account the different risk appetites of particular Departments and their need to maintain their own capabilities.

[5] PMSE – communications for Programme Making and Special Events

[6] A number of international bodies work to ensure spectrum bands are used for the same purposes in different countries where possible, including the International Telecommunications Union (ITU) and European Conference of Postal and Telecommunications Administrations (CEPT).

Initial overview of potential areas for future civil demand

2.8 The table below describes our current understanding of civil demand for spectrum. Some of this demand could be met by access to public sector frequencies. The information that informs the table is taken from a mix of formal and informal requests from stakeholders, including information collected as part of the sectoral strategic reviews. We acknowledge that in some cases more evidence will be needed to support final decisions.

Civil Demand: Short term (~5 years)	
Programme Making and Special Events (PMSE)	PMSE users already operate on a geographically shared basis with other spectrum users. However, changes being driven by mobile demand for spectrum – the award of 2.3 and 3.4 GHz spectrum and planned award of the 700 MHz band – will reduce the volume of spectrum available for PMSE to share. We are conducting a strategic review of PMSE spectrum[7] that considers how we might mitigate the impact of these awards. For audio PMSE applications (e.g. wireless microphones), in addition to access to remaining TV band spectrum we have identified potential opportunities for sharing in new bands which are suitable for the current technology, and which will provide long-term stability. We have carried out detailed coexistence studies with aeronautical navigation use in 960-1164* MHz and mobile satellite services in 1525-1710 MHz. We are working closely with other regulators who face similar issues. For video PMSE applications (e.g. wireless cameras) we have developed a strategy for future spectrum availability consisting of greater use of the 7 GHz bands as the preferred resource, and spectrum at 2 GHz for PMSE applications that cannot be supported at 7 GHz.
Satellite	We are currently undergoing a strategic review of the satellite and space science sectors. There is interest from the EESS/Met Sat/SRS community in 7/8 GHz** (X-band) for data link/tele command and access to 26.5-27 GHz may be beneficial in future. The frequency ranges 150.05-174 MHz and 400.15-420 MHz are of interest for the space operation service for non-geostationary satellites with short duration missions. The spectrum would be used for tracking, telemetry and command (TTC) for small satellites (CubeSats). Of immediate interest is a slot at 450 MHz which has an allocation to Space Ops in the Radio Regulations.
Fixed links	There is growing demand for additional capacity and bandwidth in existing bands (to support mobile backhaul and re-planning of existing links displaced by mobile) as well as along key routes for the financial sector where low latency is critical. There is particular interest in the 4 GHz**, lower and upper 6 GHz and 70/80 GHz** bands.
Business radio	Demand for business radio is growing due to the development of M2M and IoT applications. The Federation of Communications Services has suggested that wideband spectrum may be required (e.g. 2 x 5 MHz).
Mobile (LTE or Wi-Fi)	Ofcom's Mobile Data Strategy[8] outlined our approach to ensuring that sufficient spectrum is available to meet growing demand for mobile data from consumers and businesses. It identified bands for potential wireless broadband use as *2016:* *1452-1492 MHz, 2.3 GHz[9], 3.4 GHz* *2020:* *700 MHz, 1427-1452 MHz* and 3.6-3.8 GHz* *Potential beyond 2022:* *3.8-4.2 GHz, 1492-1518 MHz* There is rising interest worldwide in the 3.6-3.8 bands (already harmonised by

[7] http://stakeholders.ofcom.org.uk/consultations/new-spectrum-audio-PMSE/
[8] See: http://stakeholders.ofcom.org.uk/binaries/consultations/mobile-data-strategy/statement/statement.pdf
[9] Includes upper and lower 2.3 GHz

Civil Demand: Short term (~5 years)	
	the EU on a non-exclusive basis) being released relatively quickly for LTE or for 5G. Currently, the expectation is that a significant contiguous block of spectrum will be needed for 5G by 2020 (according to the 5G IC board at Surrey). 5350-5470 MHz*; 5725-5850 MHz* (or 5725-5925 MHz) are being considered as potential extensions of the licence exempt band.

* *Band assigned to public sector under UKFAT*
** *Part of the band is assigned to the public sector under UKFAT*

Civil Demand: Longer term (~10 years)	
Broadcast TV & Radio	Ofcom is currently trialling innovative DAB technologies. Demand is not yet clear, but it could lead to additional Band III DAB spectrum (174-240 MHz) being sought.
Mobile (5G)	Likely to see increasing demand for spectrum above 6 GHz, although it is not clear when the technologies will be ready to commercialise the use of such high frequencies in consumer mobile devices. The 2.7-2.9 GHz* band was not identified at WRC-15 for mobile and we have identified it as a potential location for new and displaced public sector uses. There is some interest in the 1492-1518 MHz band.

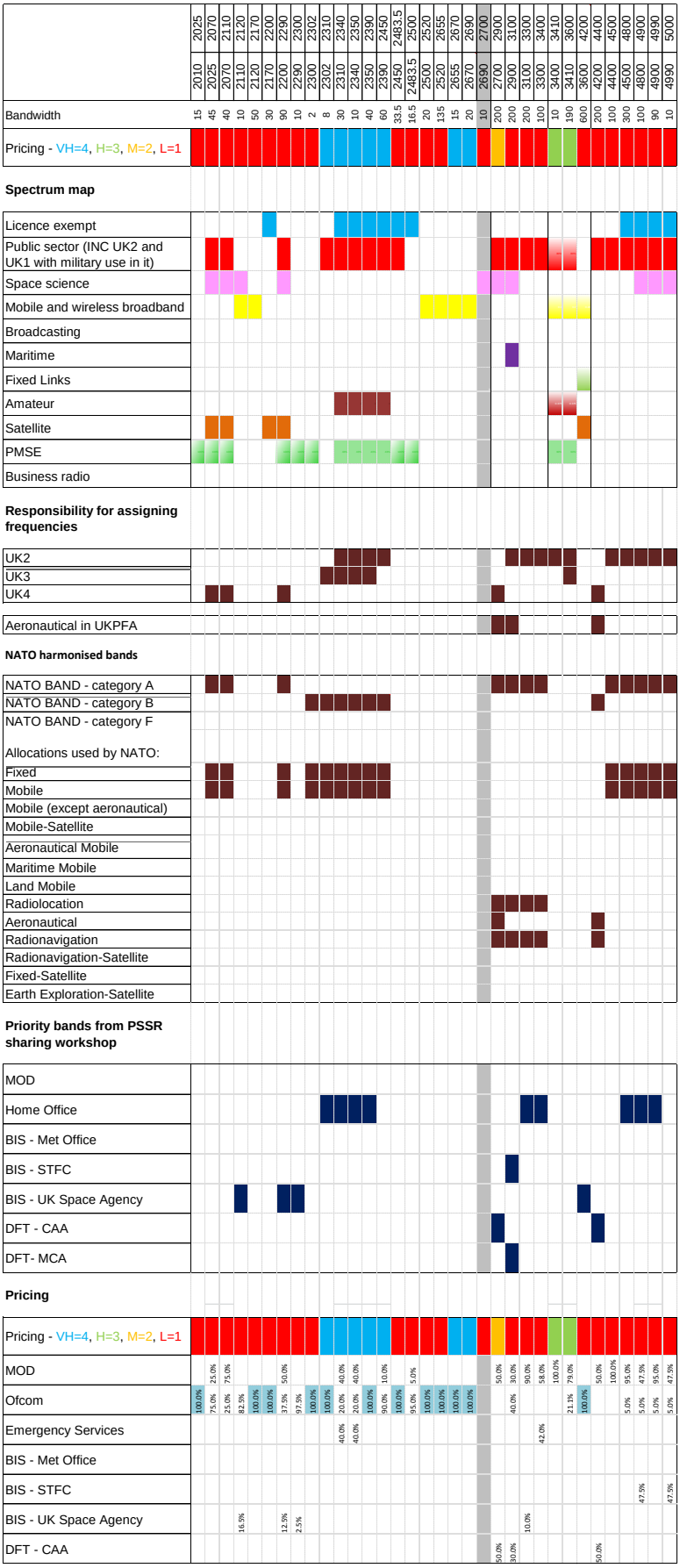
* *Band assigned to the public sector under UKFAT*

2.9 We have used this demand information along with our knowledge of existing spectrum allocations, NATO bands, settlements for Administered Incentive Pricing (AIP) and international developments to create a spectrum map. An extract is shown below, and this information has been shared with all Departments. We are happy to make amendments as new information is brought to our attention[10].

2.10 The map has been used to create our best view of what the next decade may look like, and so provide input into the selection and prioritisation of bands for the revised target discussed in Section 4. Better knowledge of the demand for various bands - and what the desirable rollout timescales would be from potential new users - should enable more open consideration of release/sharing by existing public sector users.

[10] For example, additional information will be added on science uses as we go through the responses we received to our recent call for inputs on satellite and space science uses.

Extract of Ofcom's spectrum map.



Section 3

Current PSSR programme

3.1 As noted in Section 1, the PSSR programme has already secured the release to Ofcom of 40 MHz of 2.3 GHz spectrum and 190 MHz in the 3.4 GHz band for award (including 40 MHz of 3.4 GHz spectrum acquired by UK Broadband). It has also secured the release/sharing of a further 62 MHz of other spectrum.

3.2 However, attempts to release or share spectrum in other bands has proved difficult and slow - in spite of the efforts of many people directly involved in the project in relevant organisations.

3.3 A combination of factors has hindered progress. There has been a lack of clarity over which Departments are responsible for how much of the target. Collective responsibility has led to an inability to move forward in a meaningful way, except for the notable exception of the release of then 2.3 and 3.4 GHz spectrum. Additionally, the financial incentives for Departments to carry out feasibility studies and to share/release spectrum have been weak or non-existent.

3.4 These factors have compounded an already risk averse culture in which Departments have been reluctant to give up assets they consider might be useful in the future. In addition, delivery teams within public sector organisations do not appear to have attached a sufficiently high priority to remediating systems out of release bands, even when encouraged by departmental spectrum management teams.

3.5 This document therefore considers how to re-energise the programme in order to deliver more effectively moving forwards. We believe the creation of the CMU will enable Government to manage public sector spectrum more efficiently and provide a clear focus on release.

Current target bands

3.6 We have reviewed both the existing target of releasing 500 MHz of sub-5 GHz public sector spectrum for civil use by 2020 and the bands that have been targeted as a priority. We have agreed with UKSSC that we should focus on high value bands where there is already demand from civil users.

3.7 We arrived at this conclusion after discussion in a series of demand workshops we carried out with Departments in late 2014[11], together with our analysis for the Mobile Data Strategy, and our on-going work for the PMSE, Satellite and Fixed Link reviews. All this work is informed by international and technology developments.

3.8 In addition to the upper 2.3 GHz and 3.4 GHz bands, now released to Ofcom for award, the main bands within the target range below 5 GHz are:

- The lower 2.3 GHz, 4.8-4.9 GHz, 1427-1452 MHz; and
- 960-1165 MHz for sharing with PMSE (discussions are already underway).

[11] Future Demand Workshop: Summary and next steps, Ofcom internal document

3.9 Although slightly outside the current target range, work is also in progress around the development and extension of the 5 GHz band for Wi-Fi[12] and around parts of the 7.9–8.4 GHz band.

[12] There are discussions around Intelligent Transport Systems underway at a national and European level in the 5 GHz range.

Section 4

Setting a revised target

4.1 A target is important in order to incentivise all parties to deliver the PSSR programme - but we need to be careful to ensure the target is an appropriate one. A good target should drive the right behaviour by helping us to clarify our objectives and deliver them effectively.

4.2 In the 2015 Productivity Plan, the Chancellor of the Exchequer stated:

"Electromagnetic spectrum is a valuable and scarce resource. By securing more efficient use of public sector spectrum (while safeguarding Departments' ability to deliver critical operational public services), the Government will be able to share or release more of its spectrum, realising wider economic benefits both in terms of generating capital receipts and by supporting digital communications innovation and the development of new technologies. To deliver this, the Government has implemented a new model for the centralised management of public sector spectrum."

4.3 The Chancellor, with the Secretary of State for Culture Media and Sport, announced at the same time that the Government's aim would be to better prioritise spectrum management and maximise the economic and social value of spectrum (while maintaining operational effectiveness) by:

- Taking better account of spectrum usage across the whole public sector;
- Improving the coordination of spectrum usage across the public sector; and
- Managing public sector spectrum holdings as a national asset, incorporating greater shared use of spectrum and release for commercial use wherever practicable.

4.4 The establishment of the new Central Management Unit (CMU) is therefore a good point at which to review the existing target. The newly established ability to carry out technical studies, funded through AIP abatement, will also support an evidence-based review.

4.5 This section of the document discusses in turn:

- How a revised target should be defined;
- Priority bands for release/sharing;
- How shared spectrum should be counted in a revised target;
- Our recommendation for a revised target;
- Future public sector access to spectrum;
- Other considerations.

How a revised target should be defined

4.6 Before establishing the details of a revised PSSR programme, we first need to consider the best way to structure and communicate the new target. We believe it is important to aim for a simple target that is easily understood and articulated. The explanation of the target and the surrounding work needs to be clearly set out. The target should also be set in a way which is flexible enough to allow the current users to protect their existing capability.

4.7 The aim of the Central Management Unit, as set out in its terms of reference, is:

'…to better prioritise spectrum management and maximise the economic and social value of spectrum (while maintaining operational effectiveness)'

4.8 We should always be focussed on what creates value rather than just an overall number. Value is complex though. For example, cleared spectrum is usually more valuable to civil users than shared, and release for civil use is more valuable if the spectrum is identified internationally.

4.9 When considering the most appropriate way to define a target to achieve the CMU's aim, the criteria should include the following:

- Clarity and ease of communication;
- Effectiveness of the target to drive delivery of those bands of most economic and social value, both up to and beyond 2020. This includes defining who takes responsibility for delivery;
- Stretch: the target should be aspirational without being unrealistic;
- Risk of unintended incentives e.g. a target based solely on volume might encourage release of less valuable bands simply to achieve the target.

Options considered

4.10 At a workshop held on 8 September 2015, we considered various ways of defining a new and meaningful target using the criteria identified above, and focused on the options identified in the table below. Each of the four definitions of value is useful in considering a revised target, and all need to play a part.

	What	How	Example
1	**Quantity**	Single number	*'500 MHz of sub-5GHz spectrum by 2020'*
2	**Granularity**	Target for above/below a set range (above/below 5 or 6 GHz), % of spectrum used, specific targets by Department	*'MOD will release bands X, Y and Z by 2025, DfT will release ….'* *or* *'Each Department will use 20% less spectrum by 2025'*

3	**Spectrum value**	Weight the target by: Frequency, AIP cost, sharing/full release etc.	*'500 MHz of high value spectrum will be released by 2020*' (>6 GHz counts as 0.5x, shared spectrum counts as 0.25x etc.)
4	**Overall net value**	Value generated by savings in public sector (e.g. cheaper equipment using commercial bands), sum of CBA's of individual projects	*'Spectrum release will generate a total value of £1bn to UK economy of by 2020'*

4.11 Our conclusion is that a simple target expressed in terms of quantity is easiest to understand and communicate. However, within that overall target there should be an explicit focus on spectrum which is of real value to potential civil users. As a result, the revised PSSR target should clearly identify those bands that are to be our main priority at this stage, even if the actual quantity of spectrum targeted in this way is relatively small.

Priority bands for release/sharing

4.12 Next, we consider which particular bands should be prioritised for release/sharing under the PSSR programme.

4.13 In doing so, we recommend that there should be no new public sector systems deployed in identified 'high priority' bands while we carry out appropriate technical/demand studies. This will help to avoid sterilising these bands for future civil use. Once confirmed as priority bands for public sector release, they should be released (or shared) no later than the end of equipment lifetime, or earlier if possible. Earlier release, with remediation if appropriate, will be based on an assessment of the costs and benefits of doing so.

4.14 We have assessed the prospects for a large number of bands currently managed by the public sector (principally by the MOD). Some of these bands have been internationally harmonised (on a non-exclusive basis) for identified civil uses, and could therefore be of particular value in future. A summary of our assessment for the full range of individual bands is set out at Annex 2 of this document.

4.15 Our conclusion that we should focus on the highest value bands (i.e. those bands that are both of value to civil users and have a realistic prospect of release/sharing) has led us to identify three particular bands where there should now be an immediate focus. Studies in these bands should be initiated by the CMU to consider the scope and cost of remediation and to assess 'value for money'. Those bands are:

- **Lower 2.3 GHz:** This band already has an international (ITU) mobile allocation and is included in current mobile phones. Studies should be conducted as quickly as possible to understand the UK potential for release/sharing. There is a good understanding of many of the uses in these frequencies, gained through the release of the upper part of the band.

- **1400 MHz (1427 to 1452 MHz):** The 1400 MHz band (1427-1518 MHz) was identified globally for mobile broadband at WRC-15, which will increase demand for the 1427-1452 MHz band. This band should be a high priority - not least because the neighbouring 1452-1492 band was recently acquired by mobile operators, and will be used to provide additional downlink capacity.

- **380 to 385 MHz (up) and 390 to 395 MHz (down):**[13,14] This spectrum is currently being used by Airwave, and we need to consider what happens when the emergency services contracts and licence end in 2020. However, it could be of potential value for industrial Internet of Things (IoT) type applications, as well as other uses.

4.16 Even taken together, this would be a comparatively small amount of spectrum in the context of the overall programme (total 70 MHz), but the nature of this spectrum in terms of its propagation characteristics mean it would be of real value for mobile and industrial IoT.

Sharing between public sector and civil users is possible in other bands

4.17 Ofcom is already working with the Civil Aviation Authority (CAA) and CMU on the sharing of around 100 MHz of the 960–1165 MHz band with PMSE. Additionally, in response to growing demand for fixed links, up to 168 MHz of the 7.9 GHz band is being considered for possible sharing.

4.18 Preliminary work has also been carried out on the 4.8 GHz band for broadband backhaul (e.g. railway use and CCTV). Finally, MOD already has Recognised Spectrum Access (RSA) for the 406 MHz band. Protections for adjacent uses have now been finalised internationally (at WRC-15) thereby removing a potential hindrance to progress. MOD work on this band should now be completed.

Relation of revised target to earlier priority bands

4.19 Overall, we see no reason for any radical change in the bands being considered for release/sharing under the PSSR programme - because we believe they have been correctly identified in the past and they continue to offer the greatest potential for release.

	Band	MHz	Current PSSR Target	Proposal (Target date)	Notes
Below 5 GHz	VHF and L-band	13			
	870-872 MHz and 915-917 MHz	4			
	2025 to 2070 MHz (shared)	45			
	Upper 2.3 GHz	40			
	3.4 GHz	190			
	380-385 and 390-395 MHz	10		2020	Currently used by Airwave, contract ends 2020
	406 to 430 MHz	5			406.2 to 430 already has RSA in place
	960 to 1165 MHz	100		2016	Potential for sharing with PMSE - work underway
	1375 to 1400 MHz				
	1427 to 1452 MHz	20			
	Lower 2.3 GHz	40		2020	Assessment of options underway
	2.7 to 2.9 GHz				
	3.1 to 3.3 GHz				
	4.4 to 4.8 GHz				
	4.8 to 4.9 GHz	55		2016	CFI ready, potential backhaul for trains
Above 5 GHz	5350 to 5470 MHz (licence exempt)	120			
	5725 to 5925 MHz (licence exempt)	125			
	7.9 to 8.4 GHz	168		2016	Fixed links. Assessment of options underway
	8.5 to 9 GHz				Current military satellite use, potential for civil satellite use
	Total (excl. 'safe havens')		507	935	

Key:

- Complete / implementation
- Further studies / high priority
- Future demand identified / not a priority now
- Not a candidate band

[13] Currently used by Airwave for TETRA, UK 2 spectrum

[14] We note that the band immediately above this spectrum 385-390 MHz/395-399.9 MHz is reserved exclusively for NATO-wide Air-Ground-Air operations. Assignments are centrally managed by NATO.

4.20 As a result, there is a significant degree of overlap between the bands identified at the end of Section 3 as being part of the current PSSR programme (and marked in red in the table above), and those we have identified in this section as being of high priority. As such, we see the setting of a revised target as being an evolution of the old, rather than a completely different approach. The table also lists additional bands considered in Annex 2.

How shared spectrum should be counted in the target

4.21 It is important to clarify what we mean by release and sharing – as this will have an important impact on the certainty and flexibility that the public sector can have over its future use of spectrum. It is essential to have a clear view about what is counted towards the release target and what is not.

4.22 Sharing spectrum between different users – either geographically, or between different services that can coexist, or in time – is already happening in many bands and can offer huge benefits. A useful starting point for a definition of sharing can be based on the ITU interpretation: "...*utilization of the radio spectrum is dependent upon frequency, time, geography (spatial location), and technology (modulation/coding and orthogonal signal separation). Any sharing of the spectrum has to take into account one or more of these four dimensions".*[15]

4.23 Ofcom has recently consulted on a framework for looking at sharing opportunities[16] which focuses on how it can be facilitated without adversely impacting on the rights of existing users. In that context we recognise here, for example, the importance of protecting MOD capability.

4.24 In addressing how shared use should be considered within a revised PSSR target, we have identified three scenarios:

Scenario A: Full release of spectrum to Ofcom

If spectrum within a defined frequency range is released fully to Ofcom for civil use (normally identified as a transfer from UK2 to UK1 allocation[17]) it should be counted 100% towards the target. This is our preferred method of bringing public sector spectrum into civil use, subject to assessment of the costs and benefits of clearance.

Under this scenario there may still be some on-going protections for existing systems (even for many years). The necessary protections will be developed and agreed with the public sector user (usually MOD) based on evidence, and will form part of the civil licence (WT Act) conditions. However, the protections will be limited in nature and will not significantly affect the value of the spectrum for other users. There will be an agreed plan to remediate remaining systems out of the released band in a timely manner. Under this scenario, AIP for the on-going public sector use will be zero.

Illustration: the release of the 2.3 GHz spectrum between 2350 and 2390 MHz is one example of this scenario.

[15] See Rec. ITU-R SM.1132-2 "General principles and methods for sharing between radiocommunication services or between radio stations".
[16] http://stakeholders.ofcom.org.uk/binaries/consultations/spectrum-sharing-framework/summary/spectrum-sharing-framework.pdf
[17] UK1 spectrum is primarily allocated for civil purposes; UK2 is primarily allocated for military use.

Scenario B: Release to Ofcom but with significant on-going public sector use

If spectrum is released to Ofcom for civil use but the public sector user retains significant on-going use (protected by technical, time or geographic conditions) it may still be appropriate to count the release towards a revised PSSR target.

Use of the spectrum within the band could be shared between the new civil licensee and the on-going public sector user in a number of ways e.g. geographically; by time; or by restrictions on power levels etc. Necessary protections would be agreed with the public sector user, but management of the spectrum in the released areas would be by Ofcom.

Civil use should be on similar terms to existing civil licences for that application. This will encourage investment and ensure efficient management of frequencies in the future. In order to count towards the PSSR target the majority of the potential *civil* use of the band must be realised.

No new public sector systems within the released area will be permitted in the band without approval from Ofcom.[18] The public sector user must commit to exercising care with deployments that are close to the boundary of its managed area to avoid causing interference to new civil users.

Illustration: An example might be where spectrum within a defined frequency range is released in particular locations, such as for mobile use in major urban conurbations, but the public sector user (e.g. MOD) retains its management in other particular locations. Another example would be shared use with PMSE.

Scenario C: Sharing without releasing spectrum to Ofcom

If spectrum in a particular frequency range is not released to Ofcom for civil use it should not count towards the target – even if Ofcom issues authorisation for shared civil use of the band – because the public sector user would retain management of the spectrum, and so it could not be regarded as having been 'released'.

This scenario would arise if the public sector user wanted to retain the rights to future use of what is currently white space (unused spectrum), for example. Civil users would only be authorised through agreement with the public sector user on a case by case basis.

We anticipate this scenario arising in only a limited number of cases (e.g. for very localised systems). Ofcom would need to agree the conditions under which systems were protected (in both directions) and would manage the civil users to ensure this happens e.g. through use of licence conditions or databases. The public sector user must still commit to ensuring that any changes in its uses do not cause interference to the new civil users. Civil use should be indefinite (subject to standard revocation conditions) except where there is clear evidence of planned future public sector use.

AIP could be discounted by a level at least equivalent to any opportunity-cost licence fees received for use of the band, thus providing an incentive for sharing.

[18] Ofcom will manage the white space within this area, however in the case where Ofcom has made a "block assigned" authorisation in a particular area (such as is used with MNOs) then the whitespace will not be available to permit new public sector systems in that area

Illustration: An example of this scenario would be a single civil radar used by a commercial airport.

This scenario would also allow for ad-hoc shared use of spectrum for specialised purposes where there was no opportunity cost (i.e. no alternative viable use). Examples might include use of spectrum by an oil rig or a wind farm. As licensee fees in these circumstances may be cost-based (Ofcom's costs) then the incentive for making the spectrum available would be a one-off reduction in the AIP payable by the public sector user to compensate for the necessary studies that would need to be carried out.

Our recommendations for a revised target

4.25 As noted above, we believe it is important to aim for a simple PSSR target that is easily understood and articulated. Retaining a link to the existing target for release/sharing allows us to relate our future ambitions to what has already been achieved through the established programme. It allows the programme to evolve without the necessity of articulating a fresh approach.

4.26 Having regard to this and the other criteria already identified in this section, we are not proposing any change to the existing target of releasing 500 MHz of public sector spectrum by 2020. We believe this volume remains a relevant and achievable objective, alongside the focus on our identified high priority bands.

4.27 However, we believe that limiting the PSSR target to spectrum below 5 GHz – as now – is too restrictive in light of technological changes which make higher spectrum bands more attractive for civil use. We note the expectation that higher frequencies are likely to prove even more valuable in future, including for example for 5G mobile, fixed links, backhaul for small cells or macro base stations, and satellite.

4.28 **Our full recommendation is that the CMU should set a revised target for the release/sharing of 500 MHz of high value public sector spectrum by 2020, with explicit priority on our key priority bands (including the lower 2.3 GHz and 1427-1452 MHz frequencies). We also recommend an additional target for the release/sharing of a further 250 MHz of spectrum below 10 GHz by 2022 - making a revised target for the release/sharing of 750 MHz of spectrum in total.**

4.29 We consider this revised target to be challenging, but achievable. It is especially important that the target is underpinned by clear responsibility for, and funding of, any work that is directed at specific bands.

Future public sector access to alternative bands

4.30 We recognise there is growing demand for spectrum from the public sector for new applications. However, it is important that Departments do not feel an urge to 'hoard' spectrum in order to address unknown and unpredictable future requirements.

4.31 Under all of the release/sharing scenarios we have identified, we acknowledge there will be cases where a public sector user will seek access to additional spectrum, including in some cases spectrum that has previously been released/shared for civil use e.g. for defence or security purposes. We understand the importance of maintaining public sector capability in these and other important areas, as agreed by Ministers.

4.32 In rare circumstances it may be necessary to consider termination of the civil user's rights in specific locations, in particular frequencies, or even overall. This is usually possible under standard WT Act licences subject to five years notice. The public sector user may also consider seeking earlier access, with appropriate consent of the licensee.

4.33 Reassignment of frequencies for spectrum management purposes should be supported by evidence, including a business case (cost/benefit analysis). Ofcom would provide the necessary technical and economic advice to support consideration of any proposals. Where there are wider considerations than those that are captured by Ofcom's duties as the independent regulator, it may be necessary for the assessment to be made by the CMU on behalf of HMG, and a direction made to Ofcom to execute the decision.

Other considerations

4.34 We believe it would be helpful to define more clearly the wider benefits of the PSSR programme, for public sector as well as civil users.

4.35 For example, there may be benefits to the MOD arising from using equipment in civil bands rather than military ones. We note there is little geographic overlap between civil and MOD users in many cases, such as fixed links. Using civil bands may lead to savings in equipment costs for the MOD and would free up spectrum usage in other bands.

4.36 The MOD has suggested there could be temporary use of spectrum in some cases, while longer term solutions are considered. For example, it may be possible to free up spectrum by relocating public sector use from one frequency to another, without adversely affecting capability.

4.37 Access to accurate and up-to-date information will always be important - both for defining target bands and for better management of spectrum. All parties need to be as open and transparent as is possible to ensure the best decisions on spectrum use can be reached.

4.38 It is important that public sector users understand the potential value of the spectrum it uses for alternative use by others. In that regard, it is a matter for Ofcom to ensure users are aware of spectrum identification/harmonisation and other developments in particular bands, so that frequencies can be made available for use in the UK as they are elsewhere. The up-to-date value of spectrum should be reflected in AIP payments for on-going public sector use.

4.39 There is likely to be benefit in developing common approaches and processes across all spectrum e.g. where public sector use leaves white space which is potentially of commercial/civil value. Shared use can develop more effectively if there are clear coexistence rules and authorisation mechanisms understood by all. We consider the management and authorisation of spectrum more fully in the next section.

Section 5

Delivering the target

5.1 This section of the document is focussed on how a revised PSSR target can actually be delivered. It identifies the different management and authorisation regimes applicable to spectrum, and then goes on to consider the incentives for Departments to deliver the PSSR target.

5.2 A key factor in achieving the target is access to information in order to match demand for spectrum with potential opportunities for release or sharing. As a general principle, we believe the best way to ensure the fullest information is available is if the management and authorisation of spectrum is aligned as much as possible for public sector and civil use.

5.3 We therefore need to consider the broad issue of Crown use of spectrum i.e. use of frequencies by Crown bodies (such as the MOD) for which no licence is required (due to Crown immunity). The non-licensed nature of these uses can make it difficult for Ofcom to license additional non-Crown uses alongside, because of uncertainties about the precise features of the Crown use.

5.4 We recommend a regularisation of Crown usage (at least in the current and likely future target bands) to make its management more like other non-Crown public sector use. In general, non-Crown public sector spectrum is managed by Ofcom with the rights and protections for public sector use clearly defined and articulated in licences. This allows us to manage sharing and coexistence in particular bands more flexibly and effectively across both civil and public sector spectrum, and avoids duplication of systems and processes

5.5 However, we note there are currently a number of different ways in which spectrum may be managed and authorised and which may continue to be useful in future. These are outlined below. We do not believe legislative changes are necessary in order to drive a change of approach.

How spectrum is managed and authorised

5.6 Spectrum used by the public sector is authorised in a number of ways: Crown use (with no licences), Crown RSA (recognised spectrum access), or through WT Act licences:

Authorisation	Comments
Crown use	No licence is required
Crown RSA[19, 20]	Recognised Spectrum Access (RSA): Crown RSA has legal status under the WT Act. It needs regulations, and is only really necessary where the Crown user wants to trade spectrum. MOD and Department of Health have some RSA licences.
WT Act licence	Licensed under the Wireless Telegraphy Act.

5.7 As shown below, the fees paid by public sector users of spectrum are divided into AIP (Section 28 for Crown RSA or Section 12 for WT Act fees) or cost-based WT Act fees.

[19] *We note that the Public sector also make use of "civil" grants of RSA (i.e. non-Crown). This is primarily the Met Office to provide specific protection to some of their receive-only uses and STFC (on behalf of the radioastronomy community).*

[20] *Crown RSA regulations for the 406-430 MHz band were made in 2007.*

Authorisation	Fees paid
Crown use	Administered Incentive Pricing (AIP) charged to the public sector user under Section 28 of the WT Act. The AIP rate is set to reflect the opportunity cost to another user. Ofcom advises HMT of the rate to be applied in each band. HMT applies charges to Departments as part of their spending review. Payment of AIP is collected by Ofcom on behalf of HMT.
Crown RSA	Recognised Spectrum Access (RSA). Payments are made to Ofcom under the WT Act. However they can be made under Section 28 if granted.
WT Act licence	Fees are paid to Ofcom under Section 12 of the WT Act. Fees may be either: i) AIP based (as above) ii) Cost based

5.8 We are interested in the use of all spectrum by Government and its agencies and contractors. This is summarised for key users below. Sometimes when people speak about "public sector use of spectrum" they focus only on use by Crown bodies. Crown use of spectrum is only one model of public sector use[21].

Authorisation and fees paid by different public sector users of spectrum:

Use (or reservation)	Authorisation	Fees
Most MOD uses, some HO use	Not licensed – Crown use	AIP
Civil and military aviation and NATS	WT Act licence (civil), Crown use (military)	Civil and military[22] pay WT Act licence fees or AIP depending on the spectrum band.
Maritime and Coastguard Agency (for radar and communications)	WT Act licence	WT Act licence fees[23]
Met Office	RSA or Crown use[24]	AIP or RSA charges depending on the spectrum band.
UK Space Agency and Science and Technology Facilities Council (STFC)	RSA or Crown use	AIP or RSA charges depending on the spectrum band. (Passive (RR No.5.340) bands are not subject to charges).
Police (England, Wales, Scotland and Northern Ireland)	WT Act licences[25]	AIP (including charges for reserved bands). AIP charges for Nations pro-rated on population density.
Airwave	WT Act licence	WT Act licence fees.
Fire Services (England, Wales, Scotland and Northern Ireland)	WT Act licences	AIP AIP charges for Nations pro-rated on population density.

[21] *It is worth noting that technically Ofcom cannot issue a Crown Body with a licence – it is not a choice they or Ofcom can make. Either they are a Crown body exempted from the legislation or they are not.*

[22] *MOD pays the WT Act fee via the normal way and receives a "licence" though this has no legal effect. This allows them to record assignments together. Radar fees are cost based and VHF are based on AIP rates.* Distress and safety and radio navigation satellite service spectrum is not subject to charges

[23] *Land based = WT Act licence fees, maritime mobile = Ships WTA licence fees. Distress and safety and radio navigation satellite service spectrum is not subject to charges*

[24] *Need to confirm for some specific Earth Stations*

[25] *Also some Crown exempt and Crown RSA use.*

Prisons (England, Wales, Scotland and Northern Ireland)	WT Act licence	AIP[26] AIP charges for Nations pro-rated on population density.
Network Rail	WT Act licence	WT Act licence fees.
Roads	WT Act licence	Access via exemption regulations e.g. for Intelligent Transport Systems. WT Act licence fees.

5.9 Most public sector users including users in the Nations are licensed by Ofcom under the WT Act and the systems and authorisation and payment of fees works well. Annex 1 provides more detail, and highlights the fact that operational management of the spectrum (within a block licence outlining conditions of use) can be managed either by Ofcom or by the user of the spectrum (whether a mobile operator, the CAA, the Met Office or Network Rail).

Incentives

5.10 There are three main financial levers on Departments to support the delivery of the programme. First, AIP means that Departments should bear the opportunity cost of their access to spectrum and be encouraged to release as much unused or lightly used spectrum as possible. Second, the barrier experienced in the past by Departments in funding technical studies (to investigate the possibility of release/sharing) is being removed, and AIP fees will now be abated to cover these costs. Finally, where supported by a suitable cost benefit analysis, it may be possible to get funding for remediation costs to move a service out of a band more quickly.

Administered Incentive Pricing (AIP)

5.11 Ofcom provides advice to HMT around appropriate AIP rates based on the opportunity cost of public sector use in each band in the range 70 MHz to 15.7 GHz. This is informed by demand for civil and public sector uses, which is heavily influenced by international developments in the ITU process (through WRC preparations and outcomes) as well as the availability of equipment. We will seek to provide more guidance on the likely direction of travel of AIP charges over time.

Funding of technical studies

5.12 The CMU will request detailed information on the bands identified within the revised target. Where additional studies are required to determine the possibility of release/sharing, AIP abatement could be used to fund them.

Remediation costs

5.13 We acknowledge the need to protect existing systems and capabilities. However, where it is determined that it would be appropriate (based on a CBA) to accelerate the remediation of existing equipment before its current end-of-life, it may be possible for Departments to bid for these costs through the usual process.

[26] *Except private Prisons, where WT Act licence fees.*

Section 6

Summary, conclusions and next steps

6.1 A new target for the PSSR programme will be recommended by the CMU for approval by the Secretary of State of the Department for Culture, Media and Sport. The CMU will oversee its delivery. This report provides input into that process.

6.2 Overall, our proposal is not for a radical change to the target for release/sharing, but for an evolution of the PSSR programme, leading to a target higher than the current 500 MHz. We do not recommend any radical change in the list of spectrum bands currently being considered as part of the programme.

6.3 Our recommendations may be summarised as follows:

1. **Retain the target for release/sharing of 500 MHz of spectrum by 2020.** We believe it is important to aim for a simple PSSR target that is easily understood and articulated. The existing target of 500 MHz remains a relevant objective. However, it should not be limited to spectrum below 5 GHz – as now – and should be explicitly focussed on key high value bands (see below).

2. **Establish an additional target for the release of a further 250 MHz of spectrum below 10 GHz by 2022.** We believe a revised PSSR target should reflect the increasing interest in use of higher frequencies e.g. for 5G mobile, fixed links, general backhaul - small cells and macro base stations, financial services, satellite etc. In total, therefore, the PSSR programme should lead to the release/sharing of 750 MHz of high-value spectrum under 10 GHz by 2022, of which 500 MHz will be made available by 2020.

3. **Focus on release of the highest value bands.** Studies in three bands (lower 2.3 GHz, 1427-1452 MHz and 380-385 paired with 390-395[27] MHz) should be initiated to determine the current uses, feasibility of release and to consider the scope and cost of remediation. There should be no new public sector systems deployed in 'high priority' bands while we carry out appropriate technical/demand studies,

4. **Support further sharing between public sector and civil users in other bands.** The possibility of sharing around 100 MHz of the 960–1165 MHz band with PMSE is currently being investigated. There is growing demand for fixed links, and up to 168 MHz of the 7.9 GHz band is being considered for possible sharing. Work on the 406 MHz and 4.8 GHz bands should also be completed. There should also be a focus on encouraging the use of civil bands by public sector users (for services such as fixed links).

5. **Regularise Crown usage where possible, to make it more like other public sector use.** This would allow Ofcom to manage sharing and co-existence in particular bands more effectively across both civil and public sector users. For example, the MOD could use more fixed links in civil bands.

6. **Make better information available on usage and demand.** Underpinning all the discussions around efficient use of spectrum is the collection and maintenance of better information. This work is progressing well, with more information being made available from Departments on the same systems

[27] Currently used by Airwave for TETRA, UK 2 spectrum

used by Ofcom across other spectrum. The CMU/Government need to understand current public sector use and future demand better. We recommend external audits or strategic reviews, commissioned by the CMU.

7. **Make the wider benefits of the programme more explicit.** We believe it would be helpful to define more clearly the wider benefits of the PSSR programme, for public sector as well as civil users. For example, increasing effectiveness and efficiency through managing public sector spectrum more effectively; or defining the benefits to MOD of using less expensive equipment in civil bands rather than military ones.

8. **Promote a cultural shift.** A regime led by the CMU which encourages more efficient use of public sector spectrum (licensing along the lines described in Section 5, together with suitable incentives) will help to drive a cultural change to make the programme effective. For example, work to remediate MOD systems out of bands prioritised for release/sharing needs to become a priority within MOD delivery teams, and not only within the spectrum management team. There should be a move away from a view of 'ownership' of specific spectrum bands to one which ensures efficient access to frequencies - as needed - with appropriate protections for public sector capability and a recognition of growing public sector demand for spectrum in some areas.

Annex 1

Public sector authorisations, management and fees

Use (or reservation)	Authorisation	Operational Management	Fees
Most MOD uses, some Home Office use	Not licensed – Crown use	MOD assigns and records on its database. Ofcom records HO use. MOD also records assignments for HO and sister agencies	AIP charged to MOD under Section 28 and paid to HMT. HO pays AIP for England and Wales. The proportion of access to each band paid by each Dept. is determined by them. Ofcom only determines its proportion of access for civil, non-Crown, uses
Civil and military radar, airspace management and NATS; also covers MOD use of normal VHF aeronautical spectrum	Licences issued by Ofcom but CAA provides a one-stop shop for aviation users (e.g. NATS).	CAA manages the spectrum and air space permissions under joint Direction between DfT and MOD.	Licence fee charged to civil applicants and to MOD on AIP Section 28 basis. DfT/CAA pay radar licence fees to Ofcom, thence to HMT. Aero distress and safety spectrum is not charged for. Radionavigation satellite service (e.g. GPS) is not charged for
Maritime and Coastguard Agency *(an executive agency of the DfT)* 1. Land SAR (Search and Rescue) 2. International and UK maritime SAR (&c) channels (GMDSS) 3. International channel for VTM	Maritime and land-based SAR uses are assignments of normal channels or frequencies under WT Act licences. Maritime mobile under Ship Radio Licences. MCA holds normal CSR licence for VTM (International Ch 25)	MCA holds the Land SAR licence. This authorises use for both land and sea rescues and for MSI[28]. LandSAR Channel usage is coordinated through the inter-agency (MOD, MCA, police, fire MRTs RNLI) SAR Communications Working Group[29].	Via the Land SAR licence, MCA pays for the spectrum. DfT/MCA do not pay Section 28 charges for SAR frequencies yet, as these are included in the LandSAR licence. Distress and safety (GMDSS) spectrum (international Ch 16 and 70) is not charged for

[28] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/377179/MSI_Leaflet_2014_Version__Final_.pdf

[29] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/291770/mca_uksar.pdf

Use (or reservation)	Authorisation	Operational Management	Fees
Met Office *(a BIS agency)*	Not licensed – Crown use except for some earth stations[30]	Met Office manages its own use	AIP charged under Section 28 and paid to HMT by BIS
Police[31] (England and Wales is HO. Police Scotland and PSNI)	Ofcom issues licences including technical criteria. WT Act licences. Also some Crown use and Crown RSA[32] use	Ofcom manages spectrum with forces on behalf of HO and PSNI	Home Office pays an AIP Section 28 fee for use of spectrum for non-Airwave services for all police forces in England and Wales. Police Scotland pay for Scotland and PSNI pay for NI
Airwave	WT Act licence issued by Ofcom for specific purposes in the 380/390 MHz spectrum band. Licence end-dated	Airwave - service providers to police, fire and ambulance services	Airwave under relevant WT Act Licence fee regulations
Fire Services	WT Act licences - each fire brigade has its own licence for non-Airwave services	Ofcom	AIP charged, with each fire and rescue service invoiced individually with payment made directly to Ofcom
Prisons *(NOMS, part of the MoJ for England and Wales, NI Prisons and Scottish Prison Service*	NOMS, and Nations have WT Act licences issued by Ofcom.	NOMS operate a TETRA radio network for HMPs in England and Wales. SG manages spectrum for Scottish Prison Service	AIP charged with WT Act fees and paid to Ofcom by NOMS and Nations. If private prisons wish to opt out of the NOMS network they may use business radio
Network Rail *(Run rail comms infrastructure)*	Ofcom licences in specifically authorised spectrum	Ofcom	Ofcom charges relevant WT Act fee

[30] RSA for 3.6-4.2 GHz, 1.7 GHz and in the 7 GHz bands for which they pay Ofcom directly and is deducted from the AIP payment to HMT.

[31] Scottish Government also works with the police and fire service in Scotland.

[32] Dept of Health, Crown RSA in 410/420 MHz.

Annex 2

Spectrum bands considered for release/sharing

Our approach to setting a revised target

A2.1 In reviewing the existing target and programme with a view to setting a revised target, we first considered which spectrum bands might be of relevance for release/sharing.

A2.2 We noted that on-going work on current and future mobile systems within the International Telecommunication Union (ITU) defines categories of spectrum above and below 6 GHz. It was therefore useful to use this distinction in our assessment, even though we see merit in expressing the revised PSSR target in terms of spectrum above and below 5 GHz.

A2.3 We have identified three areas of analysis, which are discussed in turn below:

Identify target bands below 6 GHz. To align with existing PSSR work-streams, we show which of those bands fall within the current sub-5 GHz target, as well as whether the identified band is being considered for release or sharing. In doing so, we take account of outcomes arising from WRC-15 towards further harmonisation of spectrum.

Identify target bands above 6 GHz. There is increasing interest in bands above 6 GHz for many services including 5th Generation mobile (5G), fixed links (general backhaul - small cells and macro base stations, financial services, satellite etc.). We therefore identify spectrum that could be released or shared above 6 GHz as well.

Identify further bands for initial feasibility studies. There are a number of additional bands that are being discussed internationally. However, there may be challenges given their current use in the UK. We recommend quick scoping studies on these bands to identify if there is a reasonable chance of release or sharing.

A2.4 We also identify the **priority levels, difficulty and target dates** for when we would expect the spectrum to be made available for use by other users.

A2.5 Presentations based on this initial review were made to Departments at a workshop on 8 September 2015. Discussion at the workshop, and subsequent feedback, has helped inform this document. For the MOD, and other parts of the public sector, as well as civil users, an important consideration will be the impact of any changes on international partners, particularly where spectrum use has been harmonised with partners. This is a particular consideration for a number of bands where NATO harmonised military spectrum requirements are taken into consideration..

Bands for consideration in the PSSR target: below 6 GHz

A2.6 In addition to the bands already considered in the existing target and outlined in Section 3 we have considered some revisions/additions. Our summary of the key bands in ascending spectrum order is as follows:

380-385 and 390-395 MHz

A2.7 New services which could share this band might include business radio, utilities, telemetry, telecommand and other Internet of Things applications. The new uses would need to work alongside military uses. It is currently made available for emergency services narrowband TETRA communications, which were identified for possible sharing alongside remaining military use of the frequencies for the same purposes. The spectrum is currently being used by Airwave, and we need to consider what happens when the emergency services contracts and licence end in 2020.

406-430 MHz

A2.8 Recognised Spectrum Access (RSA) regulations were made in 2007/8 for the 406.1-430 MHz range. At WRC-15 new 100 kHz guard bands were established to protect the Cospas Sarsat satellite system, which operates at 406-406.1 MHz as well as new rules for the operation of adjacent terrestrial services. We therefore believe that the way is now clear to consider the sharing and release of further spectrum in the 406.2-430 MHz range. Spectrum in this range is currently used for business radio and could be used more intensively for this service.

960 to 1165 MHz

A2.9 Ofcom is continuing to consider sharing of this band with PMSE for wireless audio applications. Discussions are well underway and we are optimistic about a positive outcome.

1375 to 1400 MHz

A2.10 This could be a longer term option for sharing, but there are significant concerns about the extent of public sector use in this band already. Low priority.

1427 to 1452 MHz

A2.11 At WRC-15 the 1.4 GHz band (1427-1518 MHz) was identified globally for mobile broadband, which will increase demand for the 1427-1452 MHz band. We therefore recommend that this should be considered as a high priority for release. Geographic sharing with incumbent MOD systems is being considered. Protection of passive use for science and earth observation in 1400-1427 MHz at 1421 MHz is a consideration.

Lower 2.3 GHz

A2.12 Given the international interest in this band for mobile use, and that the technical conditions for mobile have already been harmonised across Europe, studies should be conducted as quickly as possible to understand the potential for release/sharing. There is a good understanding of many of the uses in this band gained through the release of the upper part of the band. Work is underway with the MOD and Home Office. In discussions, the Home Office felt that the lower 2.3 GHz (2.302-2.310 GHz) might be suitable for release from their use from 2021 provided alternative spectrum (such as the 2.7-2.9 GHz – see below) was available for migration.

2.7 to 2.9 GHz

A2.13 Following WRC-15, 2.7 to 2.9 GHz is no longer being considered as expansion spectrum for IMT, and we believe it should instead be considered as a potential location for public sector use in the UK. This band is harmonised worldwide for civil and military aviation Primary Surveillance Radars. European studies are currently ongoing to harmonise the technical conditions for PMSE use in this band.

3.1 to 3.3 GHz

A2.14 There is some interest internationally in 3.3 to 3.4 GHz, but we do not currently considered this as a candidate band. Low priority.

4.4 to 4.8 GHz

A2.15 This band could be of interest in the longer term, but it is not yet clear whether there is an opportunity here or not. This band is used for PMSE in a number of European countries.

A2.16 Eutelsat is launching a satellite in the first quarter of 2016, which will use the planned band 4500–4800 MHz for space-to-Earth Fixed Satellite Service and there may be additional opportunities for geographic sharing with NATO services in the band.

4.8 to 4.9 GHz

A2.17 A considerable amount of technical work has already been carried out in this band and a call for inputs has been prepared to assess possible demand. We believe that this band could be used for fixed wireless access services such as urban CCTV and rural broadband. There is also potential to use this band to backhaul services from trains. Japan has led a push for this band to be identified for IMT.

5 GHz licence exempt band (5150-5925 MHz)

A2.18 WRC-15 initiated studies on frequency bands in the 5 GHz range (5150-5925 MHz) for expansion of RLAN/Wi-Fi capacity. The studies will review the regulatory conditions in existing 5 GHz RLAN spectrum to see whether higher power or outdoor use could be permitted. The review will also look into adding new spectrum blocks, if coexistence with radar and Earth observation satellite systems can be ensured. The results will be reviewed at WRC-19.

A2.19 We believe the 5350-5470 MHz and 5725-5850 MHz bands are particularly relevant to the PSSR programme. We are also studying whether we can liberalise the existing 5150-5350 MHz LE band for higher power and outdoor applications as well as 5850-5925 MHz, especially for transport-related uses.

Bands for consideration in the PSSR target: above 6 GHz

7.9–8.4 GHz band

A2.20 A considerable amount of work has already been carried out in this band to identify potential opportunities to licence civil fixed links. Technical studies are underway, and it should be possible to move quickly to implementation provided coexistence rules can be agreed to protect MOD services.

8.5-9 GHz

A2.21 A potential longer term piece of work would be required to consider whether there is any opportunity for sharing between military and civil satellite use in this band.

Possible bands above 6 GHz for 5G mobile

A2.22 As part of the Mobile Data Strategy, we developed a UK position on IMT above 6 GHz as part of our preparations for WRC-15. Our aim was to ensure appropriate spectrum is available to facilitate the rapid rollout of 5G services (lack of spectrum must not be an inhibitor).

A2.23 We believe it is important to have at least one harmonised global band for 5G, and WRC-15 agreed a list of candidate bands for consideration. These will be studied and discussed at WRC-19. It is too early to say which bands will gain significant momentum, but we think it would be worth some initial scoping studies.