



## **Response to Ofcom Consultation: Award of available spectrum: 2500-2690MHz, 2010-2025MHz**

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### **Background**

JFMG Ltd is the dedicated band manager for programme-making, entertainment, special events and related activities. It is a privately owned company created specifically to ensure continued and equitable spectrum access to all areas of the programme-making industry.

JFMG has successfully coordinated the use of spectrum, issued licences and collected licence fees on behalf of Ofcom since 1997. The spectrum managed ranges from 47MHz to 48GHz and requires expert knowledge of the specific bands, their uses and their compatibility with other radio services. In the UK, the professional use of radio for programme making and entertainment purposes is referred to as Programme Making and Special Events (PMSE).

The spectrum award includes current PMSE bands and adjacent spectrum, namely 2500 – 2690MHz, 2025 – 2110MHz and 2483.5 – 2500MHz, particularly used for Wireless Camera applications including:-

Television studio production

Television coverage of news, sport or other public events including state occasions

As the dedicated band manager JFMG Ltd facilitates the successful running of events, provides on-site consultancy services and is committed to leading the industry through the transitional period ahead.

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### **Introduction**

The Consultation Questions within the 2.6GHz and 2010MHz discussion document relate to aspects of the award design and technical conditions for new services. The JFMG response does not address these issues, but instead deals with the management of interference to adjacent Wireless Camera receivers, covered in the discussion document.

Programme makers already attempt to use Wireless Cameras close to high power UMTS base stations operating above 2110MHz but adjacent channel interference to PMSE can make channels unusable. The award is likely to result in similar scenarios at a further two spectrum boundaries so JFMG is looking to find a way forward that minimises the impact on programme makers yet retains the maximum number of high quality channels for Wireless Camera operations.

Outside the scope of this consultation there is a wider issue of the quantity of available spectrum suitable for the growing demand for Wireless Camera operations. JFMG would like to work with Ofcom to identify further frequency bands where these opportunities may lie to increase the pool of spectrum available to programme makers.

## Response

Ofcom studies have now further investigated the mitigating effect of adjacent channel filters, revising the optimistic conclusions of the earlier Mason work. Performance measurements by ERA of Wireless Camera receivers in the presence of adjacent channel interference now more closely match similar measurements made by JFMG. Ofcom infer from the ERA measurements an ACS performance improvement of up to 11dB for PMSE receivers, through the use of an adjacent channel filter. These results rely upon the performance of PMSE Receiver B which ERA believes has poor selectivity, at least in the adjacent channel. For Receiver A, with better selectivity, the benefit of the additional adjacent channel filter is very small. ERA quote the additional ACS benefit of using the filter as only 1.5dB for an adjacent WiMAX interferer (Receiver A with Filter B). The case made for improving ACS using adjacent channel filtering therefore heavily relies upon the relatively poor adjacent channel performance of one manufacturer's product.

Ofcom are also not clear whether the out of band emissions from potential adjacent services have a distorting effect on the ACS measurements carried out by ERA. They consider the results to be biased by the impact of out of band emissions from the adjacent channel and would expect far better ACS performance as a consequence. It must be borne in mind however that the test signal used by ERA to simulate the interfering signal is not realistic. A practical service could radiate up to around 15dB more signal level into the adjacent PMSE channel and still remain within the permitted 802.16-2004 spectrum mask.

Ofcom acknowledge the limitations in adjacent channel filtering to mitigate interference into the PMSE receiver and include it as one of six possible mitigation measures that programme makers can employ. Unfortunately the effectiveness of the other five measures is also limited and they are operationally impractical for a number of reasons:-

1. *'Place PMSE receivers to avoid direct line of sight with base stations and mobile stations'*

The separation distances that are required between adjacent channel base stations and PMSE receivers need to be substantial to avoid adjacent channel interference. These distances are greater than that to the nearest base stations based on the current density in built up areas. Even away from populated areas events being covered by programme makers also attract temporary base stations nearby, specifically to serve the substantial numbers of spectators.

A much smaller separation distance will be required between PMSE receivers and mobile stations but multiple handsets are liable to be used in much closer proximity to PMSE receivers. It is therefore also impractical to try to co-ordinate PMSE receivers with mobile stations.

2. *'Improve directionality of PMSE receiver systems'*

Wireless cameras are mobile by definition and require receive systems that permit the transmitter movement over a wide area. Directional antenna systems would therefore restrict the flexibility of Wireless Camera operations. Some benefit could be gained moving directional receive antennas further from the action but it would also result in the link being more vulnerable to adjacent interference from lower wanted received signal levels. It would also be impractical and over complex to implement remote receivers within the operational environment. Wireless Camera operations obviate the need to use cable for operational and for Health and Safety reasons. Rigging remote receivers reintroduces the need for cable runs.

3. *'Lower the modulation of transmission and improve robustness'*

Whilst relatively low data rates are used for the broadcast transmission of DVB-T services Wireless Camera links require much higher data rates as contribution sources to the production

chain. They can suffer greater visible degradation compared to other higher quality picture sources as they pass through the various components of the production process. More robust forms of modulation with reduced data rates are therefore often unsuitable.

Additionally there is the increasing requirement for Wireless Cameras to transmit High Definition (HD) pictures. There is a greater data requirement for HD pictures which precludes the more robust modulation modes and their lower data rates.

4. *'Deploy diversity receivers'*

Multiple receivers are already used by programme makers to improve link reliability, employing various diversity techniques. They are generally placed to suit the application but it is unlikely that a number of receivers could all be placed to avoid direct line of sight with base stations.

5. *'Use other channels'*

The implication of using alternative channels is to create unofficial guard bands out of entire channels and reduce the total quantity of spectrum available to PMSE. With this award the number of 10MHz channels for Wireless Cameras will reduce by nineteen in the range 2500 – 2690MHz. Demand for channels is increasing and forecast to rise in the future. The loss of further channels to become unofficial guard bands would likely be resisted by programme makers.

6. *'Possibly use receiver filters'*

The potential benefit of using adjacent channel filters has been shown to be marginal when used with well engineered PMSE receivers. Practical filters cannot significantly attenuate out of band transmissions whilst simultaneously passing the wanted signal, as shown in the ERA report. There may however be a benefit in using receiver filters with a greater frequency separation from high power interferers.

## **Mitigation Proposal**

Of the mitigation proposed by Ofcom the only practical measure to have a significant impact on the adjacent channel performance of the Wireless Camera receivers are adjacent channel receiver filters. On their own however they are not sufficient to protect Wireless Camera receivers from adjacent channel interference. As a consequence JFMG propose managing the potential adjacent channel interferer issues through a combination of adjacent channel receiver filters and modified band plans to give additional frequency separation from adjacent channel interferers. These will address the existing adjacent channel issues and those that will arise from the spectrum award.

Importantly they do not reduce the remaining number of channels available for Wireless Cameras.

The Ofcom discussion document [Para A8.12] proposes, as a reasonable assumption, a minimum improvement in ACS for second adjacent channels of 40dB. This is based on filter responses from the ERA report for 12.5MHz separation from the PMSE centre frequency. A 5MHz guard band achieves the same total 12.5MHz separation from the PMSE centre frequency. Taking the JFMG measured ACS performance for a typical Wireless Camera receiver as -46dB, close to the figure obtained by ERA, the reduction in required separation distance employing a filter and a 5MHz guard band is assessed below. A simple free space path loss model has been employed to determine the minimum distance from a base station at which a PMSE receiver will fail at its minimum receive level.

|                            |                   |
|----------------------------|-------------------|
| Frequency                  | 2500 MHz          |
| Base station ERP           | 26 dBW            |
| PMSE Min Rx level          | -110 dBW (-80dBm) |
| Min Coupling Loss          | 136 dB            |
| ACS                        | -46 dB            |
| Minimum path loss          | 90 dB             |
| <b>Separation distance</b> | <b>300 m</b>      |

Table 1: Wireless Camera receiver operating adjacent to a UMTS interferer @7.5MHz

|                            |                   |
|----------------------------|-------------------|
| Frequency                  | 2500 MHz          |
| Base station ERP           | 26 dBW            |
| PMSE Min Rx level          | -110 dBW (-80dBm) |
| Min Coupling Loss          | 136 dB            |
| ACS (improved by 40dB)     | -86 dB            |
| Minimum path loss          | 56 dB             |
| <b>Separation distance</b> | <b>6 m</b>        |

Table 2: Wireless Camera receiver operating adjacent to a UMTS interferer @12.5MHz with an adjacent channel filter

Improving the ACS by a factor of 40dB the required separation distance between a base station and PMSE receiver can be reduced to less than 10m, which in practical terms should permit unrestricted Wireless Camera operation. Additionally if the adjacent channels are chosen for the uplink path the separation distances will also remain tiny, virtually removing the risk of interference to the PMSE receiver.

## Practical implementation of the 5MHz Guard bands

### 2500MHz

Wireless Cameras operate in the range 2483.5 – 2500MHz and within the 16.5MHz there is capacity for one 10MHz channel currently centred on 2495MHz. Anticipating the award the channel will be moved, instead centred on 2490MHz. This permits a 5MHz guard band below 2500MHz. The additional frequency separation that results, combined with an adjacent channel filter, aims to protect PMSE operation from adjacent channel interference.

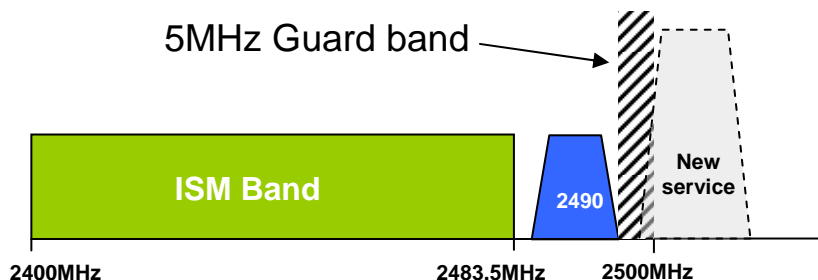


Figure 1: Revised Band plan showing the new 2490MHz channel to replace 2495MHz and 5MHz Guard band in PMSE spectrum

## 2025 - 2110MHz

The band 2025 – 2110MHz is crucial to programme makers for Wireless Cameras as it can be assigned for airborne operation unlike the band 2200 – 2290MHz which is restricted to low power Wireless Camera operations. Programme makers have made substantial investment in equipment on which they now heavily rely. The existing issue of interference to PMSE on 2105MHz from 3G base stations is serious and measures to overcome it have been considered by JFMG and the industry for some time. On the introduction of the band 2025 to 2110MHz, given that it cannot be divided exactly into 10MHz channels, the industry chose a band plan with a nominal guard band 2025 – 2030MHz and the first channel centred on 2035MHz.

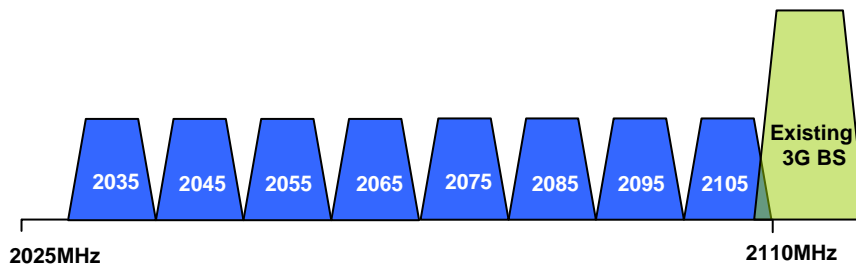


Figure 2: Current band plan and adjacency of 3G Base stations to Programme Making at 2110MHz

Now that the effectiveness of adjacent channel filtering is better understood it is proposed to revise the band plan to move the 5MHz guard band adjacent to 2110MHz. Coupled with the use of adjacent channel filters the new top channel centred on 2100MHz should remain protected from adjacent channel interference to much greater degree.

This solution critically does not reduce the number of channels available to PMSE but does place the lowest channel, centred on 2030MHz, adjacent to the award spectrum. Having created a 5MHz guard band in PMSE spectrum below 2110MHz a further 5MHz guard band is proposed below 2025MHz in the award spectrum. There remains 10MHz within the range 2010 – 2020MHz for new services, sufficient for WIMAX or UMTS services.

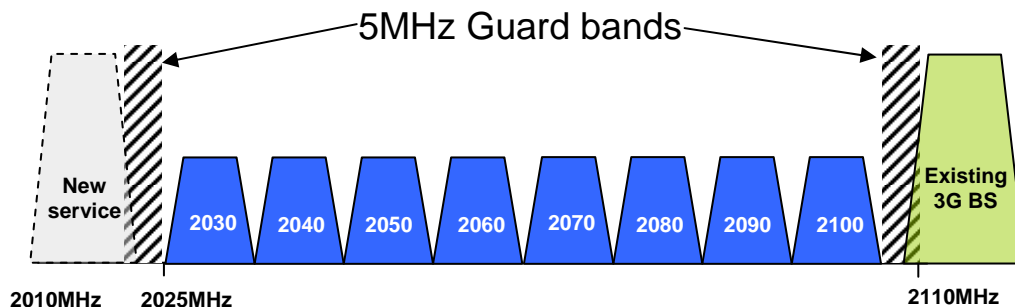


Figure 3: Proposed revised band plan to address 3G Base stations above 2110MHz and new services below 2025MHz

## Summary

The demand by programme makers for spectrum suitable for Wireless Cameras continues to increase. With this spectrum award there is the potential for further spectrum to be lost to PMSE due to adjacent channel interference. It has been accepted by programme makers for some time that the nineteen 10MHz channels in the band 2500 – 2690MHz would be lost and seventeen replacement 10MHz channels in the ranges 2025 – 2110MHz and 2200 – 2290MHz were consequently made available to programme makers. The spectrum award risks compromising a further three 10MHz Wireless Camera channels from these new bands and if that were to happen the remaining capacity would be further reduced.

Ofcom have thoroughly investigated the PMSE adjacent channel issues related to this spectrum award. Using these findings JFMG have devised proposals that aim to secure PMSE spectrum which remains in great demand for Wireless Cameras.

- Three 5MHz guard bands and adjacent channel filtering are proposed to mitigate a potentially catastrophic impact on three 10MHz channels in great demand for Wireless Cameras operations
- In two cases the guard bands can be found within PMSE spectrum, in one case the guard band needs to come from the award spectrum, 5MHz from a total award of 205MHz. Use of this guard band spectrum could be facilitated by a guard-band manager.
- There is now the opportunity to practically assess the benefit of filters and a 5MHz guard band between existing 3G base stations and Wireless Camera operations at the 2110MHz boundary before the spectrum is awarded