



Ofcom and the London 2012 Olympic and Paralympic Games

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Section 1

Introduction and Purpose

- 1.1 We were delighted at the great success of the London 2012 Olympic and Paralympic Games and proud of Ofcom's contribution. We achieved all our objectives and we have received excellent feedback from our stakeholders about our work. In bringing the project to a close we are publishing this document to summarise our contribution to the Games and to make the knowledge we gained available to others with similar responsibilities.
- 1.2 We have also summarised (in Section 3) our research into the pattern of media use by consumers who followed the Games in the UK and overseas.

The scale and scope of spectrum management at the Games

- 1.3 Effective wireless communications are essential for the organisation and delivery of an event like the London 2012 Games. Every function used spectrum intensively and relied on it for critical applications. Examples include:
 - **Wireless cameras and microphones.** Broadcasters seeking the most dramatic sights and sounds of the Games want to be as close as possible to the action and need wireless links to capture them. For example, close-ups of the marathon runners from motor bikes are some of the most exciting images of the Games; and live coverage from helicopters shows the full grandeur of the Ceremonies. This coverage would be impossible without wireless links.
 - **Private Mobile Radio (PMR).** The massive scale of the Games needs all functions to have reliable radio communications. Substantial new PMR networks were needed, for example for the stewards managing the road races, the athletic teams and the organisers' transport function.
 - **Timing and scoring.** Following the progress of an event and communicating the final result depends in many cases on wireless links. For example, wireless links allow the location of boats in the sailing events to be tracked and displayed for spectators.
 - **Services for the audience.** Wireless links deliver audio description services for hearing and visually impaired spectators and sports presentation content for the whole audience.
 - **Satellite uplinks.** Getting pictures and sound to the billions of people in the worldwide audience relies on satellite systems as well as other communications links.
 - **Mobile phones.** The mobile network operators delivering their planned coverage and capacity for public mobile service rely on the frequencies they use remaining clear of interference.
- 1.4 Wireless links have to be carefully planned to ensure they work at full capacity and to avoid interruption by harmful interference. The scale of this work for the 2012 Games was greater than Ofcom has delivered before.
- 1.5 We normally make about 10-12,000 technical assignments across the whole UK over a year. Each one of these requires an expert analysis of the user's requirement, the

spectrum available to fulfil it and the interference implications to and from neighbouring frequencies and users.

- 1.6 In 2012, in addition to this normal level of assignments, we made 17,000 technical assignments for the users accredited to the Games, while also meeting the needs of the thousands of additional spectrum users in London during the Games. Many of these assignments were in frequency bands not normally used for programme making and special events (PMSE), and we had to do significant technical planning to determine the parameters within which assignments could be made in these bands.
- 1.7 Once spectrum is assigned to a user Ofcom responds to any complaints of harmful interference. We normally have 32 experts available for this task. We had to expand the team to 120 in the light of the scale of the Games, the range of locations where they were taking place and the priority which we needed to give to dealing with any interference. This was a smaller team than at previous Olympic Games; but the task of recruiting and training the people and the logistics of equipping and deploying them required a significant increase in Ofcom resources. We are grateful to the individuals and organisations who made their expertise available to help us at the Games
- 1.8 We began work even before London was awarded the Games in 2005, and our preparations represented a major strand of our work from 2008 until the Games themselves. The success of wireless communications at the Games reflected Ofcom's capability in delivering a large scale project of this kind.

Capabilities for delivery

- 1.9 Ofcom developed and deployed a range of operational capabilities to support the Games. The key elements included:
 - Governance, reporting and project management processes reflecting the needs of a major operational delivery project, including the stage gate and project lifecycle processes to provide assurance of operational readiness for Ofcom and the Government.
 - Creating an organisation structure focused on people's Games time roles well in advance of the Games themselves. This focused attention on the responsibility for delivery which every team member had, even during the planning and development phase of the project.
 - A collaborative partnership with other organisations which contributed to the overall delivery of the Games, including LOCOG¹, GOE² and SPGOG³. This involved careful consideration of how, in carrying out its statutory functions, Ofcom should properly take into account the operational imperatives of the Games.
 - The conscious development and training of a culture focused on delivery, which brought together colleagues from 11 countries and many organisations in a cohesive task-focused team.
 - A dedicated logistics team which allowed us to control over the deployment of assets and people to best effect while ensuring best value for money.

¹ The London Organising Committee for the Olympic and Paralympic Games

² The Government Olympic Executive

³ Spectrum Planning Group for the Olympic Games

Section 2

Background

2.1 On 6 July 2005, London was chosen to host the Games of the XXX Olympiad and the XIV Paralympiad between 27 July and 9 September 2012.

Government Guarantees

2.2 As part of London's bid for the Games, the then Secretary of State for Trade and Industry gave two binding guarantees concerning spectrum to the International Olympic Committee.

2.3 Guarantee 15.8 stated:

By early planning and understanding all the frequency requirements (including broadcasters, teams, organisers, police, security and emergency services etc.), Ofcom will organise a full frequency plan for the Games and will arrange all the spectrum licences in good time in support of the plan. This will guarantee access to spectrum for all the licensees. ... The Secretary of State for Trade and Industry has guaranteed on behalf of the UK Government the allocation of the frequencies required for the organisation of the Games

2.4 Guarantee 15.9 stated:

The Secretary of State for the Department of Trade and Industry has guaranteed on behalf of the UK Government to the waiving of fees payable for the allocated frequencies required for the Games.

2.5 Ofcom recognised that spectrum requirements that fell outside the guarantees were also critical to the success of the Games and needed to be addressed as part of a full spectrum plan. At the same time Ofcom's normal spectrum management activities, both providing licences for spectrum users and dealing with incidents of harmful interference, would need to continue during the Games and be enhanced to support the heavy demand for spectrum at that time.

2.6 Ofcom's spectrum responsibilities therefore fell into four key areas:

- organising a full spectrum plan;
- arranging all the spectrum licences and the systems needed to deliver them in good time in support of the plan;
- resolving cases of harmful interference caused by or to spectrum use associated with the London 2012 Games; and
- ensuring that Ofcom's business-as-usual (BAU) spectrum activities were able to support the higher volumes of transactions associated with the Games

2.7 Under Guarantee 15.9 the Government waived any spectrum fees which might be charged to users covered by the guarantees. The longstanding policy of Ofcom and the UK Government is that licence fees for access to spectrum should be paid at market rate. The Government therefore made provision to pay, on behalf of the guaranteed users, any fees which would otherwise have been charged on spectrum they used for the Games during the Games period and at Games locations. In practice, this meant relieving public sector bodies who made spectrum available for

the Games period from the relevant proportion of their fees, which were paid instead by DCMS (DTI's successor in holding lead responsibility in Government for policy on spectrum).

Ofcom's approach

2.8 Preparing for and delivering these responsibilities to the Games was a uniquely large and demanding project for Ofcom. Our approach was founded on three basic principles:

- A stand-alone project team. Ofcom's support for spectrum used at special events is generally provided through our BAU structures, enhanced where necessary. In the case of the London 2012 Games the scale, scope and profile of the project led the Board to create a stand-alone project team to ensure clear accountability for delivery and a transparent focus on the activities needed for success. The project enlisted capabilities from all departments of Ofcom.
- A separate project budget. An overall budget for the project was created for the financial years 2008/9 to 2012/13 and embedded in Ofcom's funding settlement with Government. A long-term budget framework and continuous close attention to financial performance within it gave the project funding certainty and flexibility to deploy resources where they would minimise risk.
- A commitment to working in close partnership with LOCOG. Ofcom continued to have regard to our BAU activities during the Games but, in common with many other organisations, we made it a priority to work with LOCOG and to ensure that we took utmost account of the overall needs of the Games.



Figure 1 - Ofcom's London 2012 Team

Governance

- 2.9 The project operated under an internal Olympics Programme Board, reporting to the Operations Board chaired by the Chief Operating Officer, and overseen by the Ofcom Board and its Risk and Audit Committee⁴.
- 2.10 The programme was divided into four phases: Design, Build, Operational Readiness and Delivery. Formal processes of approval to transition from one phase to the next were put in place. For the final transition, from Operational Readiness to Delivery, the Programme Board examined 31 stands of work in 5 functional areas and certified each one as operationally ready.
- 2.11 Externally, both LOCOG and the UK Government were key stakeholders with a vital interest in the successful delivery of Ofcom's work and in meeting the Government's guarantees. Ofcom contributed to the project governance of these external stakeholders, alongside LOCOG's other Technology Partners and as part of the GOE programme board.

Risk Management

- 2.12 Ofcom's spectrum management role was essential to the success of the Games and the impact of any significant problems would be high. The Ofcom Board therefore created governance processes for the project which placed risk management at its heart.
- 2.13 Project management and reporting was focused to a high degree on the management of risk and our assessment of risks and mitigating actions was used to guide the project team and to prioritise its work. Our governance structures reinforced this, and throughout the programme strategic and operational actions ensured the lowest possible level of risk was carried into the Games.
- 2.14 Some of the principal risks and their mitigation were:
- Early spectrum planning and cross government co-ordination through SPGOG, along with investment in spectrum management systems minimised the risk of incorrect spectrum assignments.
 - Ofcom worked with LOCOG and their partners to identify any risk of interference to spectrum for critical applications and implemented mitigating actions to minimise them – for example reserving some frequencies for rapid assignment if required to keep critical users operating.
 - ICT systems were critical in both field and back office operations during the Games and the risk of system downtime and failures was mitigated with improvements to resilience, backup systems and enhanced support agreements.
 - The pattern of team deployment was based on risk analysis of spectrum use at the events.

⁴ The structure and roles of these committees are set out at <http://www.ofcom.org.uk/about/how-ofcom-is-run/>

Stakeholders

- 2.15 Ofcom worked very closely with a number of key stakeholder groups in meeting the needs of the Games. We very much appreciated the co-operation of all those with whom we worked.
- 2.16 Much of the spectrum capacity used to meet the needs of the Games was made available by public sector spectrum users, including the Ministry of Defence, Home Office, Department for Transport and its agencies and others. Private sector spectrum users also made frequencies available which were of great value to the Games. The Cabinet Official Committee on UK Spectrum Strategy (UKSSC) formed a sub-committee, SPGOG, led by Ofcom which co-ordinated the use of public sector spectrum to help meet the needs of the Games.
- 2.17 A key challenge for the Games was to meet the requirements of the public – in venues and elsewhere – for cellular and WiFi services. In addition to basic voice and text services, the London 2012 Games were the first to have also to meet the full demands of social media and a large population of smartphones and tablets. These multimedia capabilities had a potentially high impact on the capacity of networks to support them. The ambition of the BBC to provide, for the first Games ever, live coverage of all events online created an expectation of very high demand for public network services.
- 2.18 In the light of these concerns the key stakeholders worked together to ensure that everything possible was done to deliver an excellent service to the public. We understand many operators made large investments in infrastructure to create the capacity needed. They also introduced important innovations in the technical means by which environments with a very high density of demand can be effectively serviced. In the event, performance of the public networks in the Games venues and elsewhere was generally excellent during the Games period.

Section 3

Consumer research

Introduction

- 3.1 This section examines television viewing of the London 2012 Games and presents new research on UK adults' cross-platform media consumption of the Games (e.g. on television, radio, mobile and tablet) and the reasons for using certain devices. The analysis provides a follow-up to the research on people's intentions to follow the Games, published in August this year, in Ofcom's *Communications Market Report 2012*⁵.
- 3.2 A more detailed presentation covering this research is available on the Ofcom website⁶

Key points

- **More than 51 million viewers watched television coverage of the Olympic Games and 31 million people watched the Paralympic Games, making the events the most-watched Games ever on UK television.** The opening and closing ceremonies for the Olympic Games drew the biggest audiences, each peaking at around 27 million viewers.
- **According to Ofcom's research, television was the most-used medium to follow Olympic coverage, with 78% of UK adults saying they watched on television.** Around half (52%) of UK adults followed coverage online on any device. This rose to 64% among 18-24s and 66% among 25-34s.
- **Younger audiences were the most likely age group to use mobile devices to follow the Games.** Forty-five per cent of 18-24 years olds and 48% of 25-34 year olds used a mobile phone to stay up to date with the Games; while 44% of 18-24 year-olds and 34% of 25-34 year-olds used a tablet.
- **Twenty-three per cent of adults who used tablets to follow the Games cited high quality pictures and the viewing experience as reasons for using this device.** 'Being available at any time of the day' (32%) and 'choice of things to watch' (21%) were the other top reasons given for using a tablet. Thirty-five per cent of adults who used a mobile to follow the Games cited availability at any time of day as a reason for using this device. Twenty-seven per cent cited convenience as a reason and 17% cited immediacy.

Growth in Olympic and Paralympic audiences since 2004

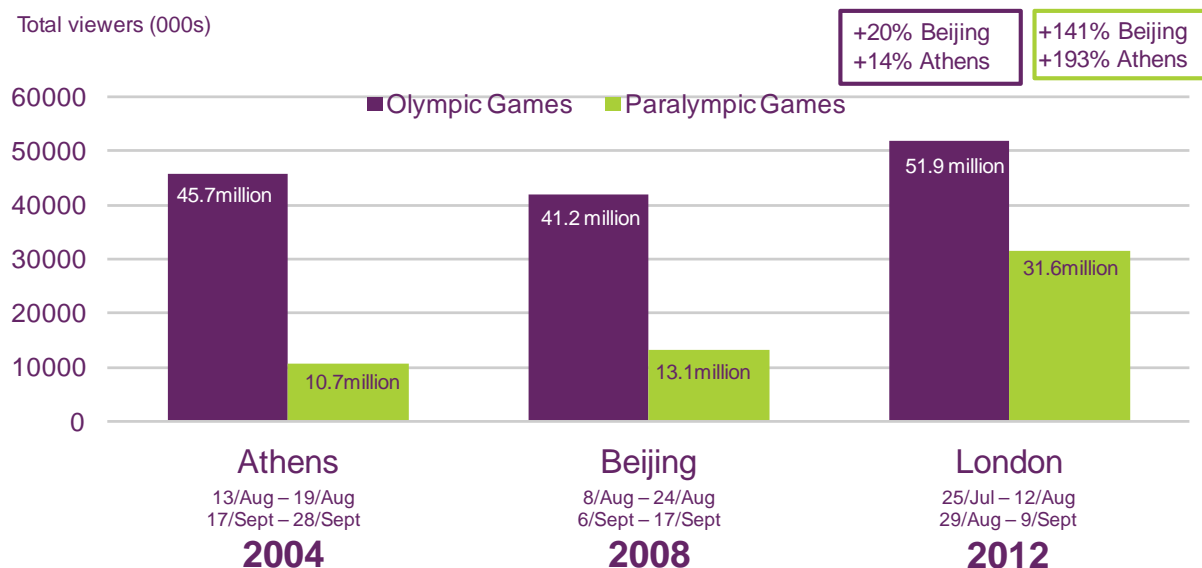
More than 51 million viewers (90% of UK people 4+) watched coverage of the Olympic Games and 31 million watched Paralympic coverage on TV

- 3.3 The London 2012 Games was the most-watched Games ever, with over 51 million viewers in the UK watching at least 15 continuous minutes of Olympic coverage. This

⁵ <http://stakeholders.ofcom.org.uk/market-data-research/market-data/communications-market-reports/cmr12/>

⁶ <http://stakeholders.ofcom.org.uk/market-data-research/market-data/communications-market-reports/cmr12/international/>

represented 20% more people aged 4+ than the Beijing Games, and 14% more than the Athens Games. At 31 million people, the Paralympics attracted 141% more viewers than the Beijing Games and 193% more than the Athens Games.

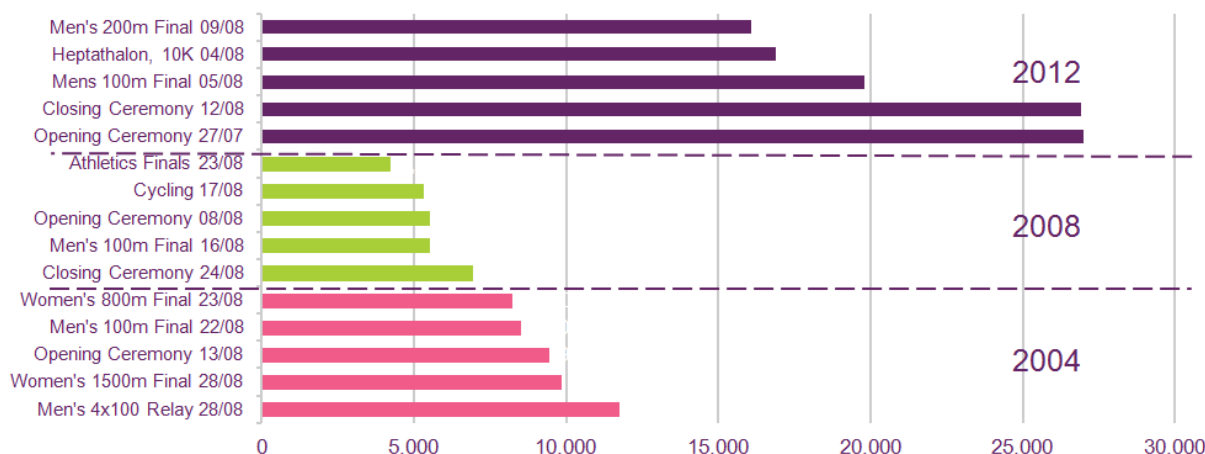


Source: BARB/Infosys+ (15 minutes + consecutive reach. Individuals 4+)

Figure 2 - Viewers of more than 15 consecutive minutes of Games on TV: 2004 - 2012

Both the opening and closing ceremonies for the Olympic Games 2012 attracted peak audiences of around 27 million viewers

- 3.4 The opening and closing ceremonies of the Olympic Games achieved the largest audiences, each peaking at around 27 million viewers. The closing ceremony attracted 35% more viewers than the next-highest audience in 2012: the men’s 100m final, at 19.8 million viewers.
- 3.5 All of the top five half-hour slots outperformed the top five slots of the last two Olympic Games. The smallest audience of the 2012 top five (the men’s 200m final) had 35% more viewers than the highest audience in 2004 (the men’s 4x100 relay).



Source: BARB/InfoSys+ Individuals 4+

Average audience (000s)

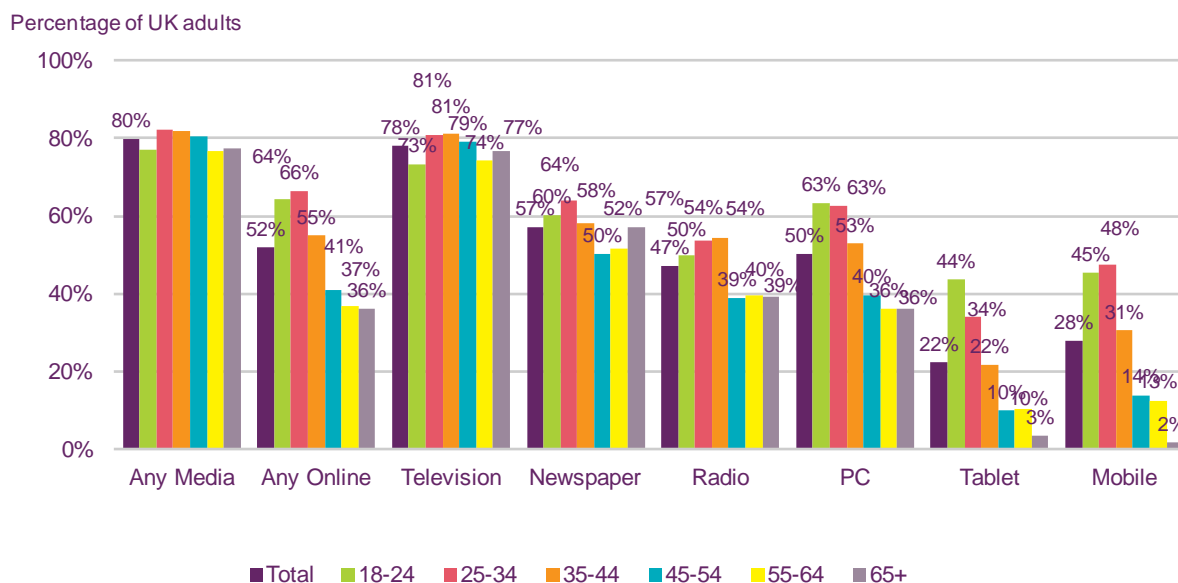
Figure 3 - Top five Olympic Games half-hour slots, by average audience

Traditional and digital devices and services used to follow the Games

While television was the most-used medium among UK adults, following the Games online via a PC was popular with those aged 18-34

- 3.6 Ahead of the Games, we reported in Ofcom's *Communications Market Report 2012* that 77% of adults said that they were likely to follow the Games on any medium, 74% on television⁷.
- 3.7 After the Games, we undertook new consumer research which confirmed that television was the most-used medium for following the Games, with 78% of UK adults aged 18 and over reporting that they watched the Games on TV (see Figure 4 below). The other media we measured added only 2% additional reach; illustrating the popularity of television as the main source for following the Games.
- 3.8 Four in five adults in the UK reported following the Games on TV; over half used a PC to do this while 41% used catch-up TV. More than one in four (28%) used a mobile phone to follow the Games and one in five (22%) used a tablet.
- 3.9 While television was popular with all age groups, a more nuanced picture emerged in relation to consumption on PCs, tablets and mobiles. Almost two in three (63%) 18-24 year-olds and 63% of 25-35 year-olds followed coverage on a PC/laptop, while slightly more than two in five adults aged 35+ were likely to do this.
- 3.10 Mobile devices such as tablets and mobile phones showed even greater differences in use by age; more than two in five (44%) 18-24 year olds and one in ten (10%) 55-64 year olds used a tablet to follow the Games. Similarly, close to half (45% and 48% respectively) of UK adults aged 18-24 and 25-34 used a mobile phone to follow the Games, while slightly more than one in ten (13%) adults aged 55-64 and 2% of adults aged 65+ used a mobile to follow the Games.

⁷ <http://stakeholders.ofcom.org.uk/market-data-research/market-data/communications-market-reports/cmr12/>

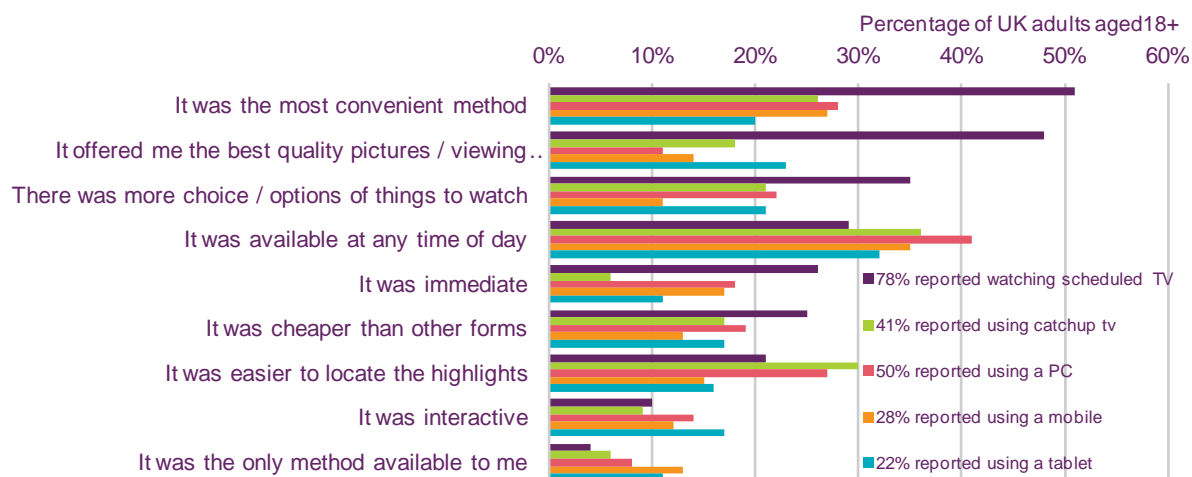


Source: Ofcom market research, September 2012
 Q. In which of the following ways did you personally follow coverage of the London 2012 Olympic and/or Paralympic Games and how often did you do follow the Games in this way?
 Base: All respondents who watched any Olympic or Paralympic coverage (n = 797) Rebased to all adults (n=1000)

Figure 4 - Type of media used, by age

The most-cited reason for using digital devices and services was ‘being available at any time of day’

- 3.9 Reasons for choosing to watch the Games on TV were convenience (51%), highest-quality pictures (48%) and choice of things to watch (35%). Reasons for choosing to watch the Games on a PC were availability (41%) convenience (28%) and ease of locating the highlights (27%). Similarly, for those who used catch-up on TV, the most common reason given for using this device was availability at any time of day (36%). The other top reasons for these devices were ‘ease of finding the highlights’ (30%) and ‘convenience’ (26%).
- 3.10 With mobile phones and tablets the stories were slightly different. For those who used mobile phones, while availability (35%) and convenience (27%) remained top, the third most popular reason was that it was immediate (17%). People who chose tablets to keep up with the Games gave availability (32%) as a reason, but also cited best-quality pictures/ viewing experience (23%) and choice/option of things to watch (21%) as reasons to use the device for the Games.



Source: Ofcom market research, September 2012

Q. Why did you choose to follow the Games using this method?

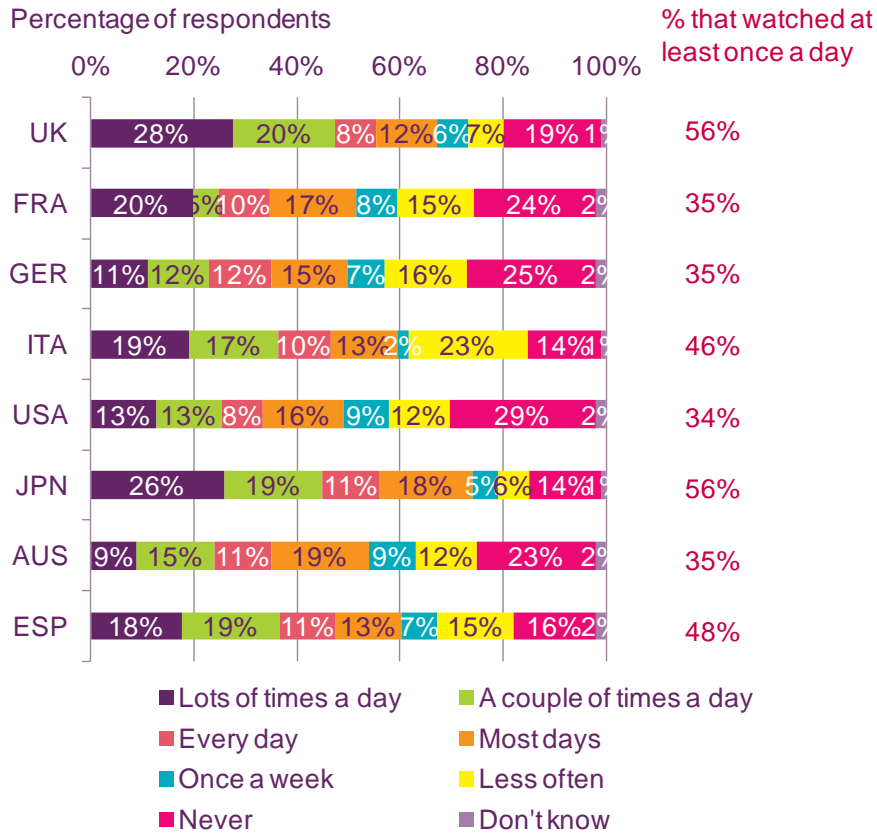
Base: All respondents who watched any Olympic or Paralympic coverage using this method (n = 832)

Figure 5 - Reasons why people watched the Games using specific devices and services

International Comparisons

Viewers in the UK and Japan followed coverage of the Games most frequently

- 3.11 Of the countries we surveyed, respondents in the UK and Japan followed coverage of the Games most frequently. In the UK, 28% of respondents watched or listened to it several times every day, and 26% did so in Japan. In both countries, 56% of respondents watched or listened at least once a day. Many respondents also watched or listened to coverage several times every day in Italy (19%) and Spain (18%).
- 3.12 Respondents were least likely to watch or listen to any Games coverage in the US (where 29% did not follow it), and in Germany (25%), France (24%) and Australia (23%). Japan and Italy had the smallest proportions of respondents who did not follow the Games at all (14%).



Source: Ofcom consumer research, September 2012
 Q.G3 Approximately how often did you follow coverage of the Olympic and/or Paralympic Games, either through watching television coverage, listening to radio coverage or accessing coverage online via any of your devices?
 Base: All respondents (n = 9152)

Figure 6 - Frequency of following coverage of the Games using television, radio or online

Section 4

Spectrum acquisition and licensing

Overview of strategy and process

4.1 The requirement for spectrum for the Games was much greater than our normal operational arrangements could meet. Our overall approach was to develop a new and specialised spectrum management solution to be used for users covered by the Government’s guarantees (ie the Olympic Family) and for other Games critical services (such as transport and security). Spectrum for other users (ie those not covered by the Government’s guarantees) was managed through our existing operational arrangements, which we enhanced to respond to the higher demand and more complex planning needed during the Games.

4.2 To deliver spectrum planning and licensing our task was first to acquire and define the available spectrum resource; and second to undertake the detailed planning and distribution of assignments⁸ to the individual users. The five stages of this process are set out in Figure 7.

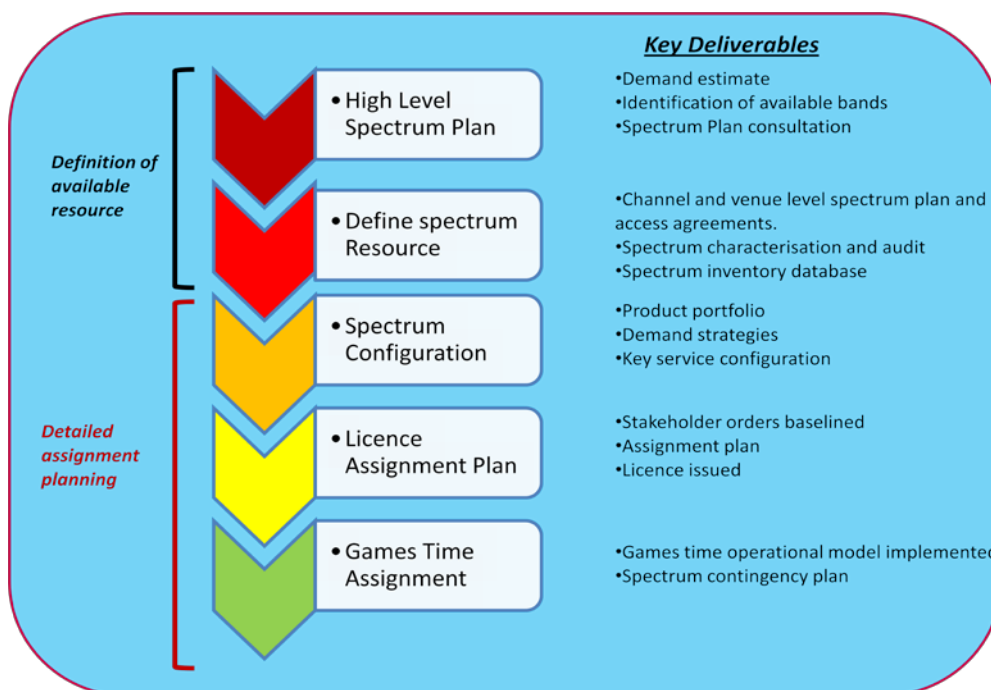


Figure 7 - Overview of Spectrum Planning and licensing process.

4.3 The organisational design of the spectrum activity involved a split of responsibilities between LOCOG and Ofcom. In summary these involved:

- **LOCOG** leading on stakeholder management and communication, requirement capture, recommending prioritisation between users and the provision and management of the on-line order portal;

⁸ An ‘assignment’ is a channel at a location at a time.

- **Ofcom** leading on spectrum acquisition, spectrum planning and spectrum licensing.
- 4.4 We worked closely with LOCOG to mitigate any problems which might arise from this division of labour. We created a single Spectrum Team, with the requirement capture and demand validation activity supported by staff with a high level of expert knowledge and who were also close to the detailed planning activity.

High level Spectrum Plan

- 4.5 Ofcom commissioned research into the likely demand for spectrum resources and took account of demand at the Beijing 2008 Games. On this basis, and in the light of the spectrum resources which could be made available by public-sector users and others, Ofcom developed, and widely consulted on, a Spectrum Plan for the London Games. In October 2009, Ofcom published a Statement setting out the spectrum plan for wireless communications at the Games. An update to this statement was issued in October 2010, and a further statement on 2.6GHz in December 2010 which completed the Plan. Ofcom published final confirmation of the Plan in February 2012.⁹
- 4.6 The Spectrum Plan set out the frequency bands available to the Games and encouraged spectrum users to adapt their requirements to match the available spectrum. Bands conventionally used for Programme Making and Special Events (PMSE) purposes were used so far as possible while maintaining access for the normal business users (recognising that they too were likely to have increased demand during the London 2012 Festival).
- 4.7 In meeting the very substantial additional demand the Plan benefited from the availability of the UHF spectrum released by the closure of analogue TV services in London in April 2012. This was used for wireless microphones, in ear monitors (IEM) and the WCATV¹⁰ service. The London Games was also fortunate in the availability of the 2.6 GHz band which is being prepared for auction in Q1 2013. This was used for wireless cameras at the Games.
- 4.8 Further spectrum needed to support the Games was sourced from public sector users who were able to rearrange operations, training and exercising activities to facilitate access to spectrum during the Games; and from commercial users who were able to co-ordinate their usage with the requirements of the Games.

Defining the spectrum resource

- 4.9 Ofcom defined the technical parameters under which use could be permitted within the spectrum made available by others. For example, we defined what type of use was permitted, at what locations (e.g. airborne, mobile, fixed), and under what technical conditions. Discussions also defined contingency plans in the event that spectrum had to be returned unexpectedly, though this was not in the event required.
- 4.10 It was equally important to understand the characteristics of spectrum we were using and the conditions under which Games users would be sharing access. This allowed us to define the risk profile of the spectrum. We worked with those who had made

⁹ All these documents are at <http://stakeholders.ofcom.org.uk/spectrum/olympics/>

¹⁰ Wireless Community Access Television – a service offered by Olympic Broadcasting Services (OBS) which provided continuous live video streams of Games coverage to handheld receivers in the venues.

spectrum available to understand how likely it was that the sharing environment might change and we used this to inform decisions on what applications were assigned to specific bands and channels. We also validated our assessment of the sharing environment through extensive monitoring and measurement.

- 4.11 Where there were specific requests from Games users for particular spectrum bands we worked with the authorised users of those bands to see if they could be made available, based on our detailed assessment of the specific sharing scenario.
- 4.12 The high level band plan used for the Games is at Annex 1.

Spectrum configuration

- 4.13 While it was fortunate that additional spectrum was available to London in 2012, the high level of demand meant that this had to be utilised as efficiently as possible. Ofcom used predictive modelling to maximise the opportunity for re-use between different users and uses (both Games and other) of each band while ensuring appropriate quality of service was maintained for all. Where necessary Ofcom supported computer modelling with field measurement: this proved particularly important for very congested bands (such as UHF and the 2GHz wireless camera bands) where we were also able to test co-channel reuse between specific systems and locations in the lead up the Games.



Figure 8 - The Ofcom Spectrum Access Team

- 4.14 Broadcast support applications such as radio microphones and IEM systems generally operate in the UHF Television bands (470-862 MHz), utilising the “white space” in the local television coverage map. This white space, along with the spectrum cleared as a result of digital switchover, was heavily utilised during the Games. In London, for example, assignments were made in 248.3 MHz of spectrum (equivalent to 31 TV channels).

- 4.15 Some channels proved extremely popular with stakeholders due to the popularity of certain tuning ranges in equipment. In order to accommodate this demand, we had to re-use frequencies in different locations, taking into account the layout of venues and the impact of different building characteristics on radio propagation. As an example of the level of “packing” achieved, the two 8 MHz TV channels 42 and 43 each accommodated just under 100 microphone assignments – compared to our original estimate of only 14 microphones per TV channel.
- 4.16 The tools Ofcom used for planning assignments at the Games were extensions to its Spectrum Management System. They were designed to optimise assignment patterns, ensure efficient coordination between use inside and outside venues, and avoid intermodulation products (IPs). IPs are a potential cause of interference which may be particularly problematic where a large number of systems are co-located
- 4.17 In addition, Ofcom conducted an extensive measurement “audit” of actual usage in each of the bands planned for the Games, using our network of wireless sensors in the Games venues and elsewhere (see section 5.4).

Licence Assignment Plan

- 4.18 Ofcom defined 13 “Products” for licensing. The total number of licences¹¹ issued and frequency assignments¹² made for the Games period is in Figure 9.

Product	Licences	Assignments
Wireless Camera	452	631
Wireless Microphone	1958	6052
Talkback	946	3037
Land Mobile Radio	1412	3026
Telemetry and Telecommand	331	444
In Ear Monitor	496	1468
Maritime Mobile Radio	18	44
Microwave Mobile Link	116	134
Fixed Link	76	90
Permanent Earth Station	20	n/a
Transportable Earth Station	28	1439
WCATV	4	5
Games PMR Network (Apollo)	1	206
Total Games	5858	16576
Outside venue clearances in coordination zones	n/a	13237
Total Frequencies Licensed		29813

Figure 9 - Licences issued and assignments made to users at Games time

- 4.19 End users registered their requirements through LOCOG, providing details of the services they needed, the location(s) of their installation, the technical parameters of their equipment and the duration of their requirement. Ofcom matched these

¹¹ In some cases separate licences were issued for Ceremonies, Olympic and Paralympic Games.

¹² Duplex pairs counted as two frequency assignments.

requirements with available spectrum and issued the appropriate wireless licences to users. In practice user requirements and spectrum plans evolved iteratively through discussion between stakeholders, LOCOG and Ofcom. These discussions helped establish the nature and criticality of requirements, as this was often material to the final spectrum arrangement for particular systems.

- 4.20 Nearly 6,000 licences were issued to more than 250 organisations occupying over 1 GHz of spectrum. 17,000 assignments were within the Games venues and 13,000 for applications outside the venues.
- 4.21 An example of the complexity of the licensing process was in providing coverage of the cycling and other road races. This involved assigning frequencies for high power video links for TV coverage from the air, with their associated talkback and telemetry services. These links were essential to broadcasters' coverage of the events and had to be resilient against interference and co-ordinated with other wireless camera use on the ground
- 4.22 Examples of demand for and occupancy of key frequency bands used for the Games are set out in Figures 10 and 11. These show the number of available channels and the number of assignments made in some of the most popular bands for PMSE: wireless cameras and video links above 1 GHz, and PMR, talkback and telemetry systems in VHF and UHF. Demand was focussed on bands such as 1.9 – 2.7 GHz and 450 – 470 MHz where equipment is most readily available.

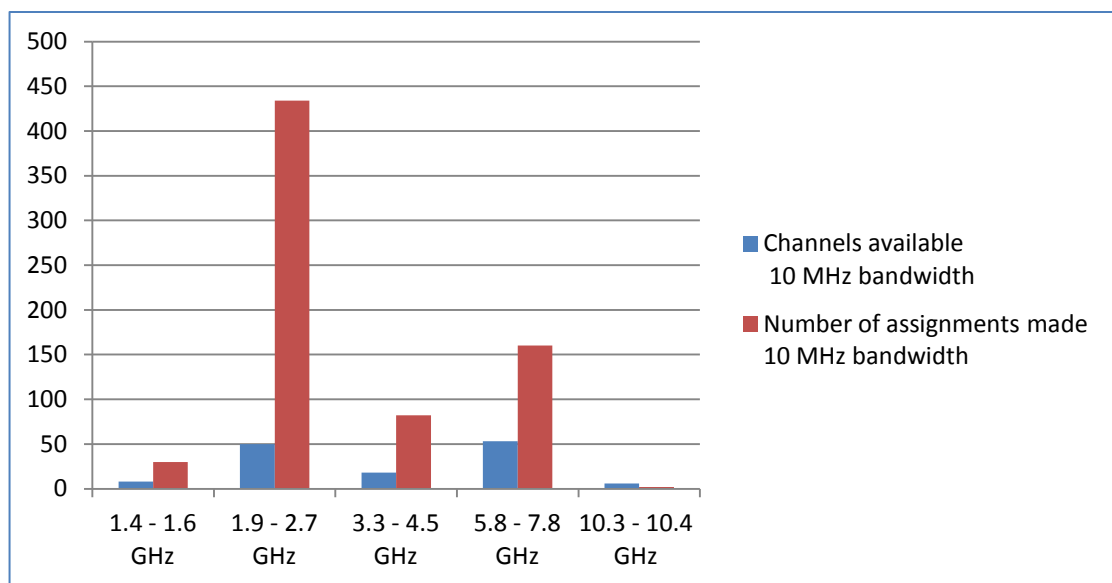


Figure 10 - Video Link Usage above 1 GHz

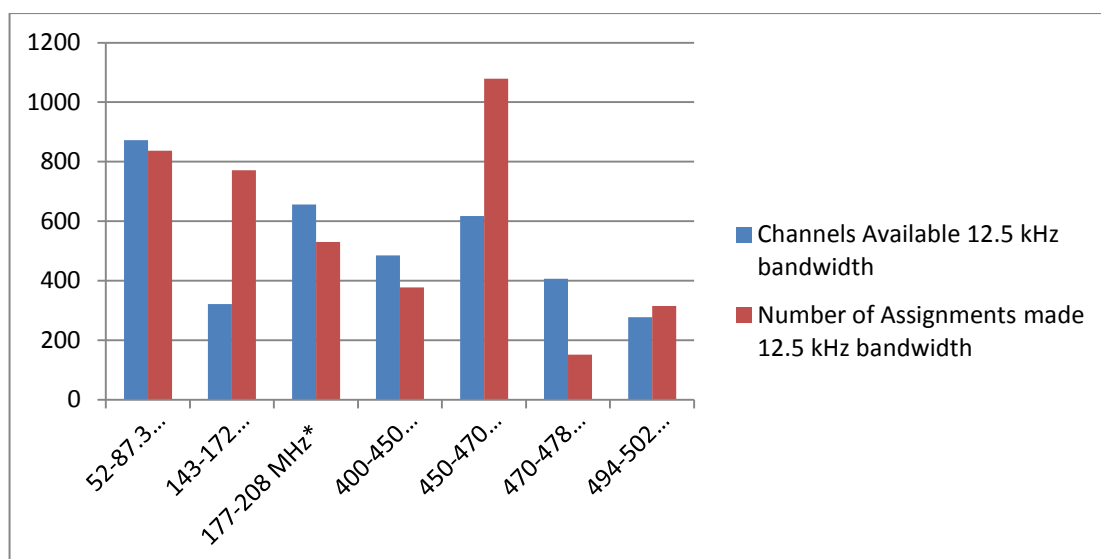


Figure 11- Communications usage in selected VHF and UHF bands

Games time assignment

- 4.23 We developed a contingency plan approach to support requests for an alternative assignment in the event of harmful interference. We reserved a small number of cleared channels that could be assigned without delay for the use of most licence products and equipment types.
- 4.24 For video links, where spare capacity was at a premium in the 2 GHz band, we developed a way to accommodate any late or alternative assignment requests for both guaranteed and non-guaranteed stakeholders in channels reserved for short-term bookings or shared service.
- 4.25 We recognised that these arrangements would not be adequate for all eventualities and that any complex change would require the intervention and support of a technical planning co-ordination expert. Consequently we ensured relevant experts were available or on call during higher risk periods (such as the Ceremonies).

Communications

- 4.26 We worked with LOCOG to communicate to visiting spectrum users essential information about the licensing regime in the UK and the processes for obtaining spectrum authorisation. Figure 13 is an example of the documentation we prepared to help with this communications task¹².

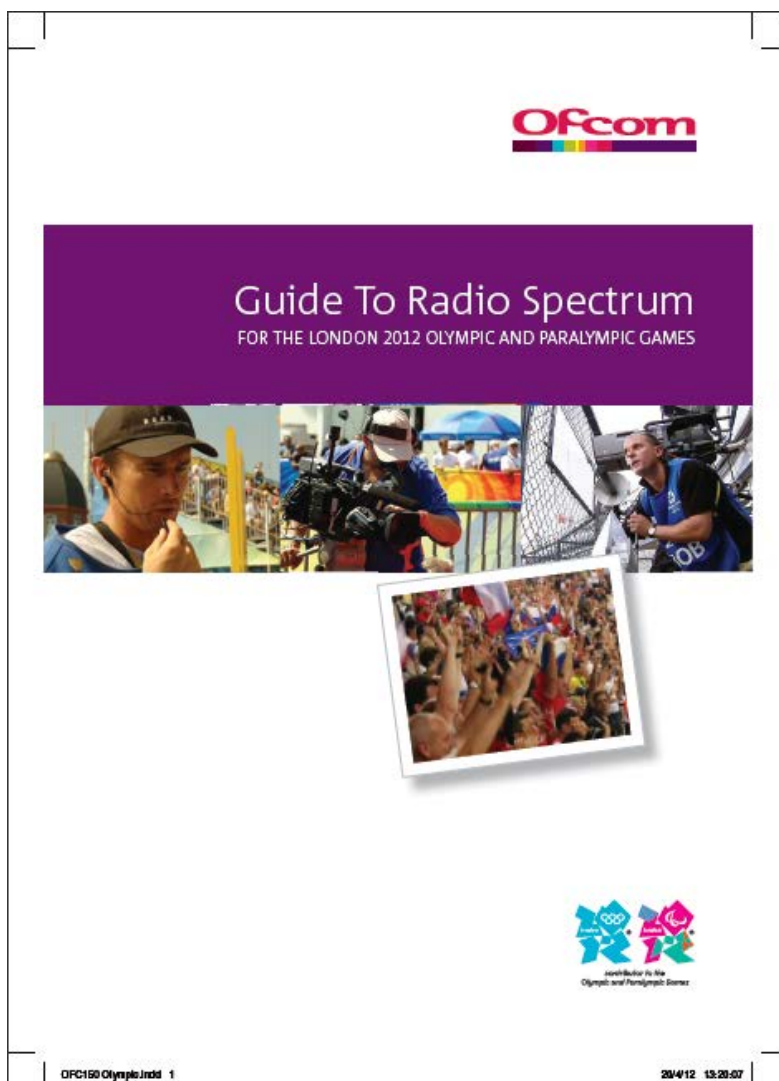


Figure 12 - Brochure for visiting spectrum users at the Games

Section 5

Spectrum Assurance

- 5.1 Ofcom was responsible for dealing quickly and effectively with reports of harmful interference during the Games and we deployed a team of 120 spectrum engineering experts to do this work. These colleagues worked on shifts to cover all key times for the Games, so there were 30-40 engineers on duty during the Games operating periods.
- 5.2 We strongly believe that prevention is better than cure and we therefore sought to minimise the number of interference cases that the team would need to deal with. We did this by encouraging best practice in rigging and site engineering; by proactive monitoring of key frequency bands to spot issues before they caused problems; and by organising an equipment inspection and labelling regime (“testing and tagging”).

Preventative measures

- 5.3 Ofcom encouraged users to meet best practice in site engineering and rigging when making their fixed wireless installations. All recipients of wireless licences were issued with a guide to technical best practice in radio engineering.¹³ Nevertheless a significant proportion of the cases which were reported as interference at Games time were diagnosed as being the result of faulty equipment or incorrect installation practice.
- 5.4 Ofcom deployed a network of remote receiving equipment for spectrum monitoring and direction-finding. The components of this network were:
- Nine Angle of Arrival (AOA) based receivers on trailers which could be re-located when necessary. These were primarily used for direction-finding where interference was reported. They were particularly suitable for detecting narrowband and unmodulated signals.
 - Sixty seven Time Difference of Arrival (TDOA) based sensors were installed in fixed locations within Games venues and at other key locations. They were used for spectrum monitoring and data gathering across a wide range of frequencies; and for geo-locating emissions. They were particularly suitable for locating the source of wideband modulated signals.
 - The AOA and TDOA equipment was networked and could be remotely accessed by individual engineering staff, the Games Technical Operations Centre or from Ofcom’s National Management Centre at Baldock.
 - The teams of field engineers deployed in venues to respond to interference reports were equipped with handheld spectrum analysers and directional antennas (see Figure 13). They were an essential tool in pinpointing the characteristics and source of potentially interfering signals.

¹³ <http://stakeholders.ofcom.org.uk/binaries/spectrum/olympics/Eng-Code-of-Practice.pdf>



Figure 13 - Ofcom Field Engineer

- 5.5 TDOA sensors were used extensively from both LOCOG’s Technology Operations Centre (TOC) at Canary Wharf and from Ofcom’s National Management Centre at Baldock to help triage cases and deploy engineers in the most efficient manner possible. They proved a very valuable tool in the overall interference resolution process, and allowed Ofcom to have a significantly smaller field force than that deployed at previous Games and represent a valuable legacy for future Ofcom operations.
- 5.6 All items of wireless equipment were required to have a “tag” to enter the Games venues. The tag confirmed that the equipment had been inspected by Ofcom engineers for compliance with the details of its associated licence. Equipment was checked with a portable spectrum analyser for conformity with the frequency and occupied bandwidth specified in its licence; and for any spurious emissions. Major wireless users were certified against batch sampling or certified to test and tag their own equipment. Ofcom conducted 8,000 tests itself and issued 60,000 tags. Different tag designs were used to indicate which venues or events items of equipment were entitled to enter.

Incidents and incident management

- 5.7 Despite our preventative measures some cases of interference would inevitably be encountered and Ofcom organised to respond to these against demanding targets which reflected the urgency and importance of dealing with any interference to Games communications.
- 5.8 Reports of interference at the principal Games venues were dealt with by eight cluster teams. A cluster team consisted of three venue engineers, and a Cluster Manager. Typically, there were three teams in each cluster to cover shifts.



Figure 14 - Venue clusters

- 5.9 Each cluster was responsible for an area which included a number of venues. Figure 14 shows the distribution of clusters and the BAU teams who supported the football venues outside London. Details of the clusters and their venues are set out in Annex 2.
- 5.10 Users suffering interference reported the problem to the TOC which managed all technology incidents for the Games. Ofcom had staff in the TOC 24 hours per day. They assigned issues to cluster teams to deal with and maintained oversight of progress. Reporting and progress management used the Games-wide incident management system ITSM.
- 5.11 Overall, as a result of the careful technical work in preparation for the Games the number of incidents of harmful interference was relatively low. 177 cases were handled during the Olympics and 42 during the Paralympics.
- 5.12 Cases were assigned a severity level from 1 (highest) to 4 (lowest) depending on their potential to impact the Games. We also recorded service requests such as

requests to monitor a specific band. No severity 1 cases related to spectrum were reported. The pattern of other cases by date and their severity is shown in Figure 15.

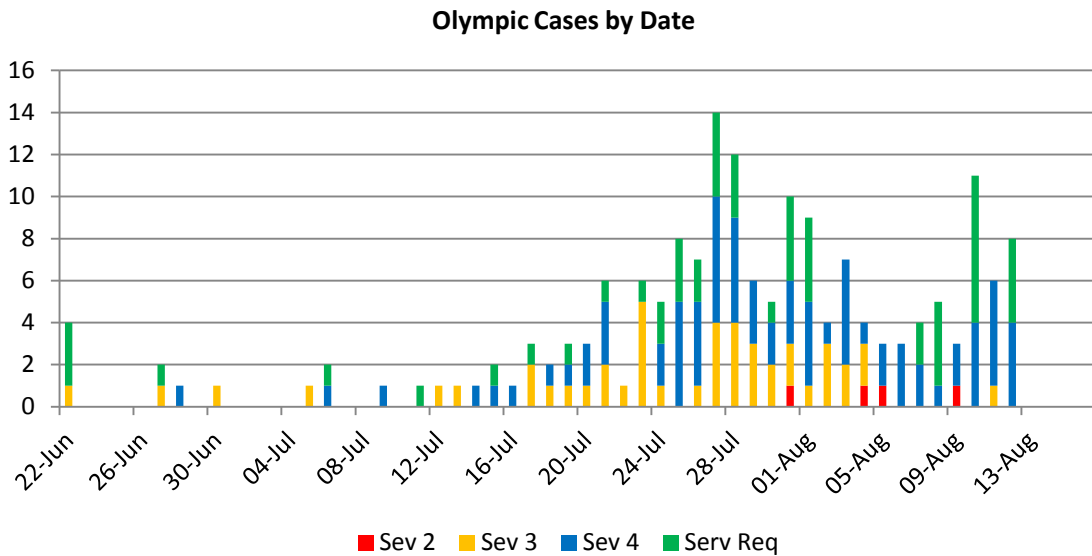


Figure 15 - Olympic cases by date

5.13 The reduced size and complexity of the Paralympics is reflected in the activity levels shown in Figure 16.

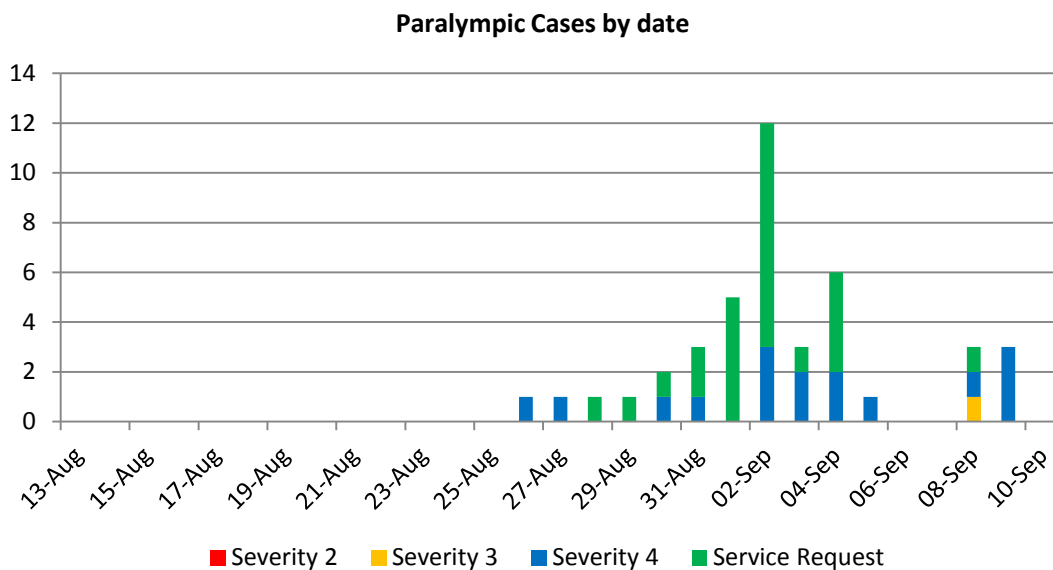


Figure 16 - Olympic cases by date

5.14 All incidents were handled successfully and there was no significant impact on the Games from spectrum problems.

5.15 Many of the incidents we handled were caused by poor site engineering by spectrum users. In total, 15% of cases reported to Ofcom as interference were due to either faulty equipment or poor site engineering. In a further 44% of cases problems were experienced between correctly licensed users due to inadequate equipment specifications or mistakes in when or where they were operated. For example,

equipment was often not adequately filtered or shielded from adjacent channel transmissions, and the problems were resolved by adjusting the receivers. The pattern of causation of incidents is shown at Figure 17

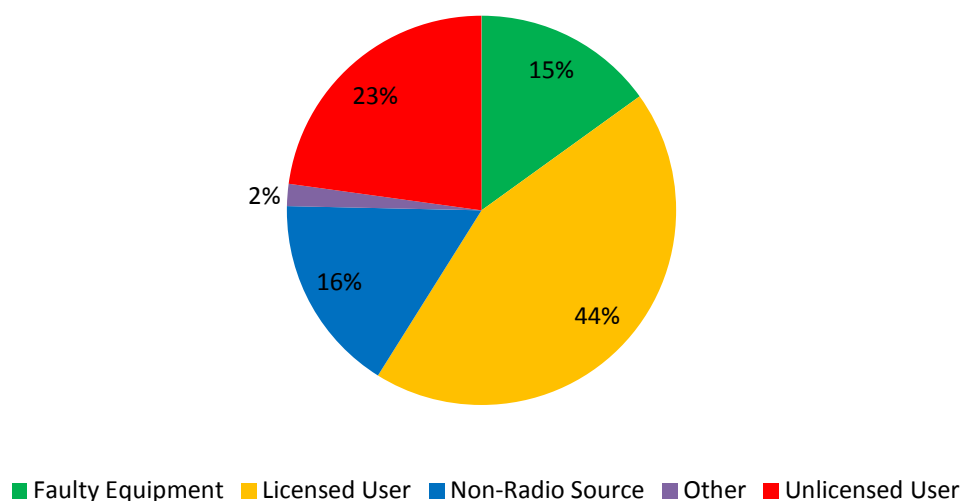


Figure 17 - Causes of interference

- 5.16 In addition to the eight in-venue teams supporting clusters, we also deployed an Out of Venue team. This team responded to interference complaints affecting key stakeholders outside the venues and attended potential “hotspots” within London such as the West End and Westminster where we believed unlicensed use might occur.
- 5.17 A separate, nation-wide BAU team was available to resolve any interference issues arising at Games venues that did not have dedicated support such as the Football stadiums in Manchester, Cardiff, Glasgow, Newcastle and Coventry, and the locations where Torch Relay events were held.
- 5.18 The Out of Venue team handled 137 cases during the Games period. With our emphasis on prevention rather than cure, the majority of these were the result of proactive inspection rather than reacting to cases of interference.

Section 6

People

6.1 It was clear from an early stage that Ofcom would need to supplement our normal team to perform our functions for the Games. The pattern of our requirement for people to contribute to our Games activities over time is set out in Figure 18.

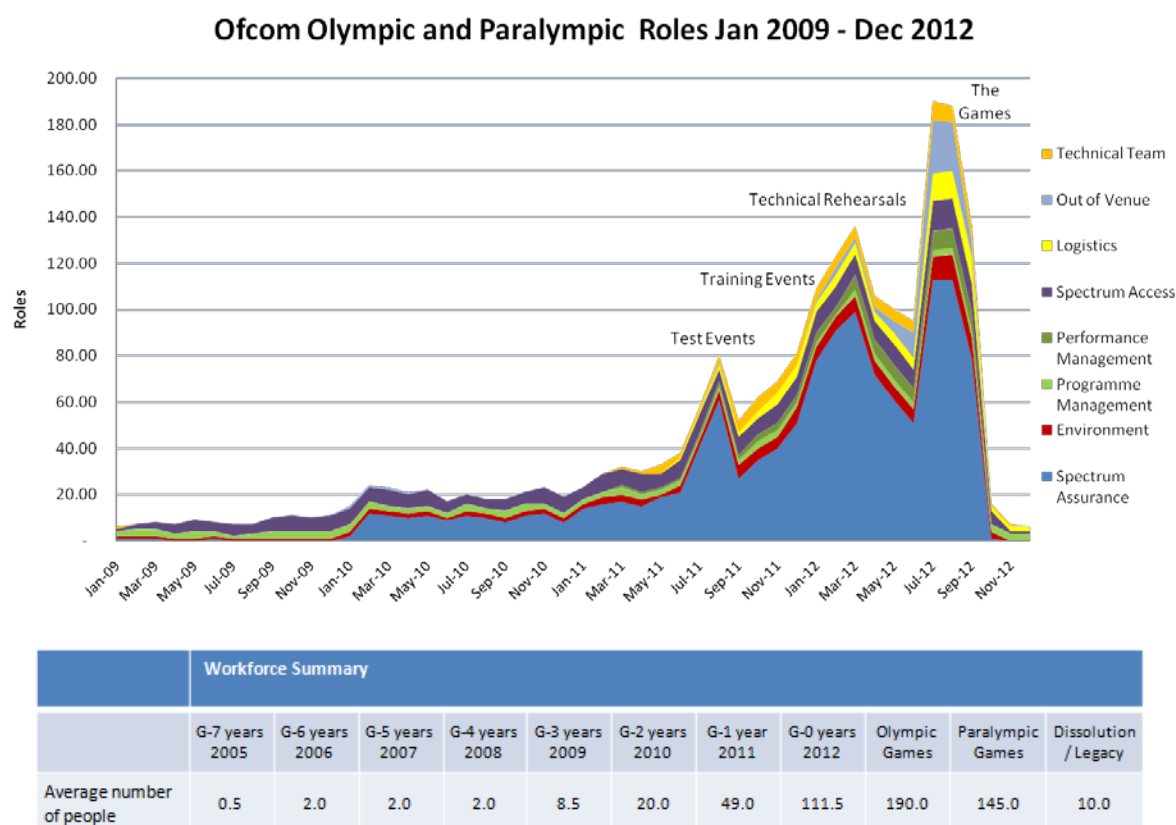


Figure 18 - Olympic and Paralympic roles

6.2 During the initial planning period we accommodated the necessary level of staffing within Ofcom’s normal resources. However the peak of demand during the Games was largely driven by the need for radio engineering experts to manage interference in the field. It was essential that we had a much higher than normal number of skilled people ready to respond to any interference problems which might have an impact on the Games. Induction and training for these experts, attendance at the test events in 2011 and 2012 and the Games themselves were major peaks in the numbers of people involved in the project.

6.3 To meet this need we were able to draw on a pool of people with these skills in the UK and overseas. These included members of the following spectrum regulatory organisations in other European countries:

- Belgian Institute for Postal Services and Telecommunications – Belgium (IBPT)
- Finnish Communications Regulatory Authority – Finland (FICORA)
- National Frequency Agency – France (ANFR)

- Federal Network Agency – Germany (BNetzA)
- Commission for Communications Regulation – Ireland (ComReg)
- Electronic Communications Office – Latvia (ECO)
- Radiocommunications Agency – Netherlands (RA/AT)
- Norwegian Post & Telecomms Authority – Norway (NPT)
- National Communications Authority – Portugal (ANACOM)
- Post and Telecom Authority – Sweden (PTS)

6.4 In addition, we were delighted to be able to work with Ofcom alumni, secondees from UK Government agencies, radio amateurs and other expert colleagues from the UK. We are sincerely grateful to all these colleagues and their organisations for making their skills available to help us.

6.5 The people involved in our Games time team worked demanding shift patterns to cover all the requirements of the Games. Our working hours during the Games are set out in Figure 19.

Function	Working hours
Spectrum licensing	0700-2300
Technology Operations Centre	24 hours
Field engineers	2 hours before and one hour after events
Programme management and reporting	0700-1900 and on call
Logistics	24 hours

Figure 19 - Working hours at Games time

Section 7

Testing and Exercising

7.1 End to end testing of Games Time systems and processes was a fundamental element of Ofcom's readiness plan, and constituted a significant element of the effort in the two years prior to the Games. Test Events provided an opportunity to test our operational processes and the command, control and communications (C3) structures which we used. After each test event we reviewed our experience and drew lessons for improvement. It was not feasible to test everything exhaustively so testing was organised to focus on:

- those things we did not usually do
- areas where we were significantly expanding capacity or increasing complexity
- areas where operational risk was medium to high.



Figure 20 - The Ofcom team in training

7.2 There were three key methods of testing:

- Table Top Exercises, both internal to Ofcom and as part of cross-Government exercises. These allow processes to be validated and possible scenarios played through at a theoretical level.
- Simulated Exercises. Ofcom participated in multi-agency "Command Post" Exercises and LOCOG Technical Rehearsals which simulated the C3 activities around plausible scenarios in real time over several days.

- Live Sporting and other Events. These were principally LOCOG hosted sporting events but we were also able to learn from the experience of the Royal Wedding in 2011 and the Jubilee in 2012 with the presence of many overseas broadcasters.

7.3 The great majority of events were LOCOG Test Events, organised in three clusters;

- Cluster 1 (May – September 2011) - 17 events
- Cluster 2 (October 2011 – March 2012) - 16 events
- Cluster 3 (April 2012 – May 2012) – 11 events

Ofcom participated in all these events. They were of significant value in developing and testing Games Time processes and procedures, and at the same time provided an opportunity for the operational teams to become familiar with the Games venues and the colleagues they would be working with there.

Section 8

Logistics

- 8.1 All logistics for the programme were provided centrally. This helped ensure cost control and consistency of standards. It minimised the amount of time our operational teams had to spend on non-operational activities; and it ensured effective asset management for Ofcom.
- 8.2 The principal components of the logistics task included accreditation, accommodation, catering, equipment, travel, uniform and vehicles.



Figure 21 - Transport was a major task of logistics (Park North Team)

- 8.3 Ofcom engineers wore Ofcom's own uniform. The uniform consisted of a jacket, high visibility vest, t-shirt, trousers, baseball cap, water bottle, umbrella and backpack. This distinctive uniform for Ofcom helped communicate our role to spectrum users, security forces and LOCOG colleagues.

Section 9

Carbon Footprint

- 9.1 As part of London’s commitment to be the first Green Games, Ofcom agreed to estimate the energy related carbon footprint of its contribution to the Games. We agreed to create a retrospective carbon profile of our work from 2008 to the end of the Games. This showed the energy usage of employees working on the Ofcom Games programme.
- 9.2 We did this on the basis of the number of full-time equivalent (FTE) people who contributed to the programme, together with the energy consumption of equipment used by the field force during the Games and the distance travelled by our vehicle fleet on Games business.
- 9.3 On this basis, we estimate that our carbon footprint over the Games period totals 760.29 tonnes, as set out in Figure 22.

Source	Tonnes CO ₂	Notes
Ofcom carbon footprint	673.22	Based on average carbon per FTE
Energy consumption of equipment	1.38	Sensors and spectrum analysers
Vehicle fleet	85.69	Games-related journeys
Total	760.29	

Figure 22 - Games-related carbon footprint

- 9.4 We have no equivalent figures from previous Games. Ofcom’s experience therefore sets a benchmark for our colleagues organising spectrum services for future Games.

Section 10

Legacy

Transfer of knowledge

- 10.1 Ofcom is keen to make the knowledge we gained in our work for the London Games available to others with similar responsibilities. We contributed to the formal Transfer of Knowledge to Rio de Janeiro in November 2012 and addressed a conference on spectrum management for the Games with colleagues from the Brazilian Government and Regulator.
- 10.2 The London Games benefitted from a number of innovations which contributed to the success of spectrum management in 2012. Ofcom and LOCOG have recommended that successor cities should consider adopting elements of the London model, including:
- A recognition of the importance of spectrum for the safe and successful delivery of the Games, with an appropriate profile and level of resourcing in both the organising committee and the spectrum regulatory agency
 - Positioning the spectrum regulator as one of the technology partners for the organising committee
 - Co-ordination of all Government agencies (eg military, police, transport) to provide a coherent cross-Government approach to the different pattern of spectrum use needed at Games time.
 - The mobile network operators working together to provide the infrastructure which supported public mobile services in the key Games locations.
- 10.3 We are also working with colleagues in other European countries to share knowledge and experience with those responsible for future major events. We are contributing to the responsible groups in CEPT¹⁴ and ITU-R¹⁵; and we are in dialogue with our colleagues in Russia responsible for the Sochi 2014 Winter Games.

Technical legacy

- 10.4 Ofcom invested in new infrastructure to support the 2012 Games. The specification of this investment kept firmly in mind the legacy which it would create for Ofcom and our customers.
- 10.5 Key elements of this technical legacy include:
- The network of remote receivers for monitoring and direction-finding. These have been re-deployed from their Games locations to provide a UK wide monitoring capability
 - Handheld spectrum analysers for field measurement and equipment testing. Our field force is now equipped with modern and highly portable equipment to assist with technical investigations.

¹⁴ European Conference of Postal and Telecommunications Administrations

¹⁵ International Telecommunications Union Radiocommunications Sector

- Improvements to our spectrum management system for technical assignments and licensing. In meeting the requirements of the Games we have developed additional flexibility and functionality within our spectrum management systems,

Capability legacy

- 10.6 We are preparing our own capabilities to support the Commonwealth Games in Glasgow in 2014 and major UK events thereafter. The capabilities we developed for London 2012 will be deployed to support Glasgow 2014, notably in planning and licensing the spectrum needed for the Games; in deploying a large team of spectrum engineering experts for interference management; and in using our spectrum monitoring and direction-finding network.

Section 11

Conclusion

- 11.1 The London 2012 Games ran smoothly and delivered an outstanding experience for the public. Ofcom is delighted to have contributed to this success.
- 11.2 Preparing for and fulfilling our role at the Games was a challenging task. Nevertheless we believe that we delivered an excellent service to spectrum users at and around the Games. This success reflects our strength in operational delivery.
- 11.3 The experience of working for the Games has allowed us to learn lessons and improve further our operational processes and capabilities. This will be of significant value in discharging our responsibilities for future major events in the UK, such as the Commonwealth Games in Glasgow in 2014, the Rugby World Cup in England in 2015 and the World Athletics Championship in London in 2017.

Annex 1

Annex 1 - High Level Spectrum Plan

Band (MHz)	Start Frequency (MHz)	End Frequency (MHz)	Main application	Likely Ground Based Tx ERP (dBm)	Likely Airborne Tx ERP (dBm)	Channel bandwidth (MHz)	Usage Ground (G) Airborne (AB)
0.009 - 0.325	0.009	0.325	TELEMETRY AND TELECOMAND	-	-	-	G
30.647 - 30.653	30.6470	30.6530	IN EAR MONITOR	37	-	0.006	G
30.987 - 30.993	30.9870	30.9930	IN EAR MONITOR	37	-	0.006	G
40.672 - 44.906	40.6720	44.9060	IN EAR MONITOR	0	-	0.016	G
47.55 - 48.8	47.5500	48.8000	TALKBACK	37	-	-	G
48.2 - 52.8	48.2	52.8	AUDIO LINK	37	-	0.2	G
48.4 - 52.95	48.4	52.95	AUDIO LINK	37	-	0.05	G
52 - 52.95	52	52.95	TALKBACK	37	-	0.0125	G
52.95 - 53.75	52.95	53.75	AUDIO LINK	37	-	0.2	G
53.75 - 55.75	53.75	55.75	AUDIO LINK	37	-	0.025 / 0.1	G
55.75625 - 67.99375	55.75625	67.99375	AUDIO DISTRIBUTION SERVICE MASS CAST (IN EAR MONITORS) LAND MOBILE RADIO	37	-	0.0125	G
60.75 - 62.75	60.75	62.75	LOCAL BROADCAST SERVICE AUDIO LINK	37	-	0.05 / 0.1	G
68.08125 - 87.49375	68.08125	87.49375	LAND MOBILE RADIO	30 or 37	-	0.0125	G
70.5 - 71.5	70.5	71.5	LAND MOBILE RADIO	30 or 37	-	-	G
74.55 - 74.79	74.55	74.79	TALKBACK	10	-	0.06	G
74.670005 - 74.730005	74.670005	74.730005	TALKBACK	10	-	0.01125	G

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Band (MHz)	Start Frequency (MHz)	End Frequency (MHz)	Main application	Likely Ground Based Tx ERP (dBm)	Likely Airborne Tx ERP (dBm)	Channel bandwidth (MHz)	Usage Ground (G) Airborne (AB)
74.68125 - 74.71875	74.68125	74.71875	TALKBACK	37	-	0.0125	G
75.2625 - 75.3	75.2625	75.3	TALKBACK	37	37	0.0125	Mostly G
76.80625 - 76.84375	76.80625	76.84375	TALKBACK	37	-	0.0125	G
78.18375 - 78.25875	78.18375	78.25875	TALKBACK	37	-	0.0125	G
80 - 81.5	80	81.5	LAND MOBILE RADIO	30 or 37	-	0.0125	G
86.80625 - 86.84375	86.80625	86.84375	TALKBACK	37	37	-	Mostly G
137.9625 - 165.9625	137.9625	165.9625	MARITIME	30 or 44	-	0.0125	G
140.9875 - 141	140.9875	141	TALKBACK	37	-	0.0125	G
141 - 141.4875	141	141.4875	TALKBACK	37	37	0.0125	G / AB
143 - 144	143	144	LAND MOBILE RADIO	30 or 37	-	0.0125	G
146 - 148	146	148	LAND MOBILE RADIO	30 or 37	-	0.0125	-
152 - 156	152	156	LAND MOBILE RADIO	30 or 37	-	0.0125	G
168.3125 - 168.8375	168.3125	168.8375	LAND MOBILE RADIO	30 or 37	-	0.0125	G
169.4 - 169.475	169.4	169.475	TELEMETRY AND TELECOMAND	27	-	-	-
173.2 - 173.35	173.2	173.35	TELEMETRY AND TELECOMAND	10	-	-	-
173.7 - 175.1	173.7	175.1	WIRELESS MICROPHONE	10	-	-	-
173.9875 - 174.4125	173.9875	174.4125	LAND MOBILE RADIO	TBD	-	-	-
175.15 - 210.1	175.15	210.1	WIRELESS MICROPHONE	10	-	0.2	-
181.69375 - 181.80625	181.69375	181.80625	TELEMETRY AND TELECOMAND	5	-	0.0125 / 0.025	G
183.50625 - 184.30625	183.50625	184.30625	LAND MOBILE RADIO	37	-	-	-
189.69375 - 189.80625	189.69375	189.80625	TELEMETRY AND TELECOMMAND	37	-	-	-
191.6 - 191.8	191.6	191.8	AUDIO LINK	30	-	0.2	-

Band (MHz)	Start Frequency (MHz)	End Frequency (MHz)	Main application	Likely Ground Based Tx ERP (dBm)	Likely Airborne Tx ERP (dBm)	Channel bandwidth (MHz)	Usage Ground (G) Airborne (AB)
191.6 - 210.1	191.6	210.1	IN EAR MONITOR/WIRELESS MICROPHONE	10	-	0.2	G
193.2 - 207.5	193.2	207.5	LAND MOBILE RADIO	30 or 37	-	-	G
199.6 - 200.2	199.6	200.2	AUDIO LINK	20	-	-	-
211.91875 - 212.19375	211.91875	212.19375	TALKBACK	37	-	0.0125	G
215.26875 - 215.49375	215.26875	215.49375	AUDIO LINK	37	-	-	G
385 - 400	385.01225	399.4375	LOCOG network only	up to 47	-	0.025	G
406.3375 - 429.88125	406.3375	429.88125	TALKBACK	30 or 37	-	0.0125	G
414 - 414.15	414	414.15	TALKBACK	0	-	0.0085	G
414.0625 - 414.0875	414.0625	414.0875	LOCOG network only (Excel)	up to 47	-	0.025	G
414.0875 - 414.1125	414.0875	414.1125	LOCOG network only (Southbank)	up to 47	-	0.025	G
414.1625 - 414.1875	414.1625	414.1875	LOCOG network only (Excel)	up to 47	-	0.025	G
414.325 - 414.35	414.325	414.35	LOCOG network only (Athletes Village)	up to 47	-	0.025	G
414.7 - 414.725	414.7	414.725	LOCOG network only (Athletes Village)	up to 47	-	0.025	G
419.00625 - 419.01875	419.00625	419.01875	TELEMETERY AND TELECOMAND	30	-	0.0125	G
424.0625 - 424.0875	424.0625	424.0875	LOCOG network only (Excel)	up to 47	-	0.025	G
424.0875 - 424.1125	424.0875	424.1125	LOCOG network only (Southbank)	up to 47	-	0.025	G
424.1625 - 424.1875	424.1625	424.1875	LOCOG network only (Excel)	up to 47	-	0.025	G
424.325 - 424.35	424.325	424.35	LOCOG network only (Athletes Village)	up to 47	-	0.025	G
424.7 - 424.725	424.7	424.725	LOCOG network only (Athletes Village)	up to 47	-	0.025	G

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Band (MHz)	Start Frequency (MHz)	End Frequency (MHz)	Main application	Likely Ground Based Tx ERP (dBm)	Likely Airborne Tx ERP (dBm)	Channel bandwidth (MHz)	Usage Ground (G) Airborne (AB)
425.3125 - 425.5625	425.3125	425.5625	AUDIO LINK	37	-	-	G
427.7625 - 428.0125	427.7625	428.0125	TALKBACK	37	-	0.0125	G
431.61875 - 438.9875	431.61875	438.9875	TALKBACK	30 or 37	-	0.0125	G
433.05 - 434.79	433.05	434.79	TELEMETRY AND TELECOMAND	0 or 10	-	-	G
442.2625 - 442.5125	442.2625	442.5125	TALKBACK	37	-	0.0125	G
446.425 - 446.5125	446.425	446.5125	TALKBACK	37	-	0.0125	G
446.5125 - 447.5125	446.5125	447.5125	TALKBACK	37	-	0.0125	G
448.9 - 449.46875	448.9	449.46875	LAND MOBILE RADIO	37	-	0.0125	-
450 - 470	450	470	LAND MOBILE RADIO TALKBACK TELEMETRY AND TELECOMAND	30 or 37	30 or 37	0.0125	G / AB
454.9875 - 455.4625	454.9875	455.4625	TALKBACK	37	37	0.0125	Mostly G
457.25 - 457.475	457.25	457.475	TALKBACK	37	37	0.0125	Mostly G
458.5 - 459.1	458.5	459.1	TELEMETRY AND TELECOMAND	37	-	-	-
461.23125 - 461.25625	461.23125	461.25625	TALKBACK	37	-	0.0125	-
462.75 - 463	462.75	463	TELEMETRY AND TELECOMAND TALKBACK	37	-	0.0125	-
467.2625 - 469.875	467.2625	469.875	TALKBACK	37	37	0.0125	Mostly G
470 - 862	470	862	IN EAR MONITOR WIRELESS MICROPHONE	10	-	0.2	G
863 - 865	863	865	IN EAR MONITOR WIRELESS MICROPHONE	10	-	0.2	G
869.4 - 869.65	869.4	869.65	TELEMETRY AND TELECOMAND	27	-	-	G

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Band (MHz)	Start Frequency (MHz)	End Frequency (MHz)	Main application	Likely Ground Based Tx ERP (dBm)	Likely Airborne Tx ERP (dBm)	Channel bandwidth (MHz)	Usage Ground (G) Airborne (AB)
870 - 872	870	872	TELEMETERY AND TELECOMAND	33	-	-	G
872 - 876	872	876	TELEMETERY AND TELECOMAND	33	-	-	G
915 - 917	915	917	LAND MOBILE RADIO	33	-	-	G
917 - 921	917	921	TELEMETERY AND TELECOMAND	33	-	-	G
1215 - 1350	1215	1350	WIRELESS CAMERA	20	-	10	G
1427 - 1452	1427	1452	WIRELESS CAMERA	24	-	10	G
1980 - 2010	1980	2010	WIRELESS CAMERA	20	-	10	G
2010 - 2110	2010	2110	WIRELESS CAMERA	-	40	10	AB
2170 - 2200	2170	2200	WIRELESS CAMERA	20	-	10	G
2200 - 2300	2200	2300	WIRELESS CAMERA	20	-	10	G
2350 - 2380	2350	2380	WIRELESS CAMERA	20 or 37	37	10	G / AB
2365 - 2390	2365	2390	WIRELESS CAMERA	-	36	10	AB
2390 - 2410	2390	2410	WIRELESS CAMERA	20	-	10	G
2400 - 2480	2400	2480	BLUETOOTH WIFI	20	-	1 / 20	G
2480 - 2500	2480	2500	WIRELESS CAMERA	20	-	10	G
2500 - 2690	2500	2690	WIRELESS CAMERA	-	40	10	AB
2700 - 2905	2700	2905	WIRELESS CAMERA	20	-	10	G
2915 - 2925	2915	2925	WIRELESS CAMERA	-	40	10	AB
2942 - 2962	2942	2962	WIRELESS CAMERA	-	40	10	AB
2965 - 2980	2965	2980	WIRELESS CAMERA	20	-	10	G
2985 - 3005	2985	3005	WIRELESS CAMERA	20	-	10	G
3005 - 3045	3005	3045	WIRELESS CAMERA	-	40	10	AB

OFCOM AND THE LONDON 2012 GAMES

Band (MHz)	Start Frequency (MHz)	End Frequency (MHz)	Main application	Likely Ground Based Tx ERP (dBm)	Likely Airborne Tx ERP (dBm)	Channel bandwidth (MHz)	Usage Ground (G) Airborne (AB)
3060 - 3080	3060	3080	WIRELESS CAMERA	20	-	10	G
3100 - 3410	3100	3410	WIRELESS CAMERA	20	-	10	G
3410 - 3440	3410	3440	WIRELESS CAMERA	20	40	10	G / AB
3500 - 3580	3500	3580	WIRELESS CAMERA	20	40	10	G / AB
4832 - 4852	4832	4852	WIRELESS CAMERA	20	-	10	G
5472 - 5925	5472	5925	WIRELESS CAMERA	20	-	-	-
5470 - 5725	5470	5725	WIFI	30	-	-	G
5725 - 5875	5725	5875	TELEMETRY AND TELECOMAND	0	-	-	G
6426 - 7125	6426	7125	MICROWAVE LINKS	62	-	18	G
7110 - 7250	7110	7250	WIRELESS CAMERA / MICROWAVE LINKS	-	40	10	AB
7300 - 7425	7300	7425	WIRELESS CAMERA / MICROWAVE LINKS	40	-	10	G
8460 - 8500	8460	8500	WIRELESS CAMERA / MICROWAVE LINKS	40	-	10	G
10300 - 10360	10300	10360	WIRELESS CAMERA / MICROWAVE LINKS	-	40	10	AB
24150 - 24250	24150	24250	TELEMETRY AND TELECOMAND	20	-	-	G
24250 - 24500	24250	24500	TELEMETRY AND TELECOMAND	33	-	-	-
34699.85 - 34700.15	34699.85	34700.15	TELEMETRY AND TELECOMAND	0	-	0.3	G
61000 - 61500	61000	61500	WIRELESS CAMERA	TBD	-	-	-

Annex 2**Annex 2 - Field engineering clusters and venues**

Cluster Name	Venues
Olympic Park South	Olympic Stadium, Aquatics centre, Water Polo Arena
Olympic Park North	Velodrome, BMX, Basketball Arena, Handball Arena, Hockey Centre, Eton Manor, Main Athletics Village, International Broadcast Centre (IBC), Main Press Centre (MPC)
Central London	Lords Cricket Ground, Horse Guards Parade, Hyde Park, The Mall
South River Zone	Greenwich Park, Royal Artillery Barracks
River Zone	Excel Centre, North Greenwich Arena (O2 Centre)
West London	Wimbledon, Earl's Court, Wembley Arena, Wembley Stadium
M25/Outer London	Eton Dorney, Lee Valley, Hadleigh Farm, Royal Holloway Village, Brands Hatch, Hampton Court Palace
Weymouth and Portland	National Sailing Academy