Met Office response to Ofcom Consultation: *Spectrum Review: A review of the management of the spectrum currently used for point to point fixed links and other services that share this spectrum.*

Overall comments

The Met Office makes extensive use of radio frequencies for remote sensing and communications, with the vast majority of advances made in weather and climate prediction over recent decades relating directly to the ability to remotely observe the environment through radio usage. Without access to this spectrum, the quality of Earth Observations (EO) and resultant forecasts would be irreparably degraded and with it the ability of the Met Office to fulfill its role in the protection of life and property through forecasts to (eg) aviation, emergency responders and the public. The UK invests considerable sums in observing programmes that rely on access to radio frequencies, notably in relation to satellites, and the return on this investment in terms of socioeconomic value has been shown to be substantial (eg – the EUMETSAT 2nd Generation Polar system alone is forecast to generate likely benefits for Europe of over 60 billion Euros).

The Met Office's particular area of interest in this consultation has primarily stemmed from our previous experience of the management of fixed links in relation to adjacent passive bands, eg – exclusive* passive bands at 31 GHz, 86-92 GHz (*as denoted by RR footnote 5.340). The Met Office was consulted by Aegis on its spectrum usage in relation to their study. However, the specific issue of the need to protect passive band usage when considering the needs of the Fixed Service (FS) does not appear to have received significant recognition in either the Aegis report or this consultation, aside from perhaps (indirectly) through the specific Satellite Services section. In view of this, we have responded below to the questions of greatest relevance to us, ie – mainly in relation to the Satellite Services section.

In summary, the key points that the Met Office would like to make in relation to this consultation are as follows:

- Earth Observations remotely sensed by use of radio frequencies are essential to meteorology, climatology and other scientific study, and long-term reliable access to spectrum used for these purposes must be ensured (especially for RR5.340 exclusive passive bands where the frequencies used are determined by physics and cannot be altered);
- In view of this, the Met Office believes that, in reviewing FS requirements, the UK should take all available steps to safeguard important passive bands, including: full implementation of ECC decisions on the protection of 5.340 bands from adjacent band active emissions; initiation of similar action in Europe to protect the 86-92 GHz passive band; remediation of all in-band interferences to recognised 5.340 passive bands; and review approaches to protecting other passive bands including the 6425-7250 MHz and 31.5-31.8 MHz;
- MetSat is also essential for enabling the collection of EO, thus sufficient protection must be put in place to ensure the full long term coordination of MetSat applications with the FS/other services in the UK, notably extending the grant of RSA at 7750-7850 MHz up to 7900 MHz;
- In view of indications of the variable nature of the implementation of the FS across allocated spectrum, it may also be sensible to review the efficiency of implementation of fixed links in currently allocated bands and rationalise the range of these bands as appropriate, migrating such active services away from passive use where the possibility arises to do so.
- The Met Office believes that the current overarching framework approach to spectrum management needs to be retained in order to protect passive (and other scientific) use, with market forces only applied to band management *within* bands where appropriate.

Satellite services

<u>Question 5(a):</u> What are the main factors (technical or regulatory) that determine preferences for one band over another for satellite applications? Do these factors vary between different types of satellite applications (Mobile, Fixed, Broadcasting and Science services)? In which bands will we see the most significant changes in demand in the next 5 to 10 years, and why?

In terms of this consultation and the bands quoted in Annex 5, most Met Office interest relates to applications of spectrum pertaining to meteorological satellites, specifically including frequencies for:

(1) **Earth Observation** – mainly refers to passive remote sensing, notably *exclusive* passive bands as defined in RR footnote 5.340 (not specifically active remote sensing bands in respect of this consultation);
(2) **MetSat** – mainly refers to PES downlinks (not specifically MetSat uplinks or EESS command & control frequencies in respect of this consultation).

The main factors determining band use vary significantly between these two primary applications (assuming Earth Observation to be a Science Service satellite application). Demand for both types of use is growing, with increasingly sophisticated instruments making ever greater use of bands and relaying increasing volumes of data back to ground-based users. The importance of using spectrum for this purpose is demonstrated in both the EU Radio Spectrum Policy Group (RSPG) Report and Opinion on “a Coordinated EU Spectrum Approach for Scientific Use of Radio Spectrum” (2006) and ITU Report ITU-R RS.2178 on "The essential role and global importance of radio spectrum use for Earth observations and related applications" (formally accepted at WRC-12 - Resolution 673). More specific information on both uses is given below:

(1) Remote sensing frequencies for Earth Observation (notably passive use)

The key reason determining the choice of band for **passive use** is primarily scientific, ie – these are unique spectral lines determined by physical properties (eg - molecular resonance). These frequencies are vital for meteorological and climatological observation and involve the measurement of very weak naturally-occurring emissions. Low levels of interference (from in-band or out-of-band sources) received at the input of the passive sensors may have a degrading impact especially since they are not able to discriminate between the desirable natural and undesirable man-made emissions. Certain key passive bands (though not all) are protected in the Radio Regulations by footnote RR5.340 prohibiting all emissions within these exclusive allocations (though these have not always been universally adhered to by all radio administrations). Indeed, several bands are often required simultaneously to derive a satisfactory measure of a given environmental parameter, thus requiring protection of a number of bands.

In terms of demand for new allocations to passive (or other) earth observation, very little change would be expected over a 5-10 year timescale, though it is vitally important to protect existing passive allocations from the advancing requirements of alternative active use. It should be noted that observation of particular phemonena by passive use of spectrum is not an activity that can simply be moved to an alternative frequency to accommodate market-led active services. Compatibility of active uses of spectrum with passive applications (an issue addressed at several recent WRCs) hence needs to be very carefully managed, including the removal of all in-band active transmissions and the application of appropriate power limits to adjacent-band active radio usage where there may be a risk of harmful interference rendering these important passive spectral windows unusable by the scientific community. Crucially, long-term reliable access to the same bands is essential so that long-term changes in the natural environment can be monitored.

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The main passive EO bands, as affected by FS allocations being considered in this consultation, are as follows:

Frequency and related FS Review band	**Meteorological use** *(ref: BNSC/QinetiQ Survey of Earth observation radio frequency spectrum use and interference threats 2006)*	**Issue**
1400-1427 MHz ("1.4 GHz")	RR5.340 exclusive passive band used primarily for remote sensing by satellite of soil moisture and ocean salinity (SMOS).	While fixed link bands either side are not immediately adjacent, there have been issues of UK implementation of ECC decision protecting 1.4 GHz passive band (and now plans to potentially release immediately adjacent bands in UK to mobile broadband, thus requiring limits on out-of-band emissions).
6425-7250 MHz ("Upper 6 GHz")	Important passive band used primarily for remote sensing sea surface temperature. This band also used to measure: sea surface wind speed, sea ice extent, soil moisture.	Passive use in this band only protected by RR footnote 5.458. No technical coordination with FS or other services.
10.68-10.7 GHz ("11 GHz"*)	RR5.340 exclusive passive band primarily used for remotely sensing surface rainfall rate (plus precipitation over oceans). Used with lower adjacent band (10.6-10.68 GHz) band to also measure: sea surface wind speed, sea surface temperature, soil moisture.	Adjacent to **closed*** 10.7-11.7 GHz band, as referred to in Table A.5.3. Used as part of wider 10.6-10.7 GHz band, but only portion above 10.68 GHz is protected for exclusive passive use. Issues of UK implementation of ECC decision protecting 10.68-10.7 GHz passive band, with some active use currently permitted in-band.
18.6-18.8 GHz ("18 GHz")	Passive use possible across 18.6-19.7 MHz to measure surface wind speed and precipitation.	Allocation only to 18.6-18.8 GHz in RRs, shared with FS.
23.6-24 GHz ("23 GHz")	RR5.340 exclusive passive band. Very important for remotely sensing total column water vapour (used in association with other bands such as 31.3-31.5 GHz). Wider band to 22.21 GHz also used for total cloud liquid water, sea surface temperature.	Lower adjacent passive use shared with 23 GHz FS band. SRRs have also been allowed to operate within the 23.6-24 GHz band, EC decision to time-limit intrusion.
31.3-31.5 GHz ("31 GHz")	RR5.340 exclusive passive band primarily used primarily for remote sensing total column cloud liquid water. This band can also be used to measure: sea surface wind speed, sea surface temperature, sea ice extent, soil moisture.	Immediately adjacent fixed link bands - issues of UK implementation of ECC decision protecting 31.3-31.5 GHz passive band.
31.5-31.8 GHz ("31 GHz")	RR5.340 exclusive passive band *in Region 2 only* – uses as for lower adjacent band.	The ability to use this band for ***global*** remote sensing was seriously undermined by the allocation of Fixed and Mobile service in some Region 1 countries under footnote 5.546.
36-37 GHz ("38 GHz")	Passive band particularly useful for snow applications.	Passive use is shared with FS on a primary basis.
52.6-54.25 GHz ("52 GHz")	RR5.340 exclusive passive band on oxygen absorption spectral line. Very important with upper adjacent 54.25-59.7 GHz band) for temperature sounding (passive use can also extend down to 50.2 GHz).	Adjacent to 52 GHz FS band.
54.25-59.3 GHz ("55/60 GHz")	Passive bands used for remotely sensing oxygen/temperature profiling with adjacent lower 5.340 band.	Shared with fixed and mobile above 55.78 GHz
86-92 GHz ("80 GHz")	RR5.340 exclusive passive band used for detection of strong convection (e.g. thunderstorms), integrated column water vapour. Also used for precipitation, sea ice extent, snow depth.	Immediately adjacent fixed link bands – recommended limits agreed at WRC-12, need ECC decision to more fully protect.

(2) MetSat

MetSat radio communications are an essential part of modern meteorological observation and forecasting. Meteorological satellite programmes are globally coordinated, employing multiple constellations of both geostationary and polar-orbiting satellites. The UK has invested many £millions in the European contribution to meteorological satellites (EUMETSAT) and the long-term assurance of globally harmonised spectrum for MetSat (downlinks and uplinks, as well as EESS command and control functions) is essential to their continued operation.

As opposed to Earth Observation frequencies, MetSat/EESS allocations tend to be more of a compromise between antenna/payload limitations, propagation requirements and the constraints of the regulatory framework (MetSat operations *can* often share with other applications given the right safeguards). Higher frequencies carry the benefit of allowing smaller payloads in terms of antennae (and therefore cost), but issues such as required operational power and atmospheric absorption tend to limit the use of the higher end of the spectrum for this purpose, especially in tropical regions where heavy convective rainfall can significantly attenuate signals (thus lower globally harmonised frequencies must be protected). This is particularly the case for non-geostationary satellites, where the requirement to track polar orbiting satellites dictates that lower frequencies are optimum.

A list of the main MetSat/PES bands affected by FS allocations being considered in this consultation are as follows:

Frequency and related band for review	**Meteorological use**	**Issue**
3600-4200 MHz ("4 GHz")	Meteorological data distribution by Fixed Satellite.	Coordination with FS through award of RSA for direct reception. *(*Note – the UK Space Agency may be better placed to comment on the requirements of the Fixed Satellite Service per se)*
7450-7550 MHz ("7.5 GHz")	MetSat direct reception - used for reception of data from geostationary meteorological satellites.	Used to pass raw data from geostationary meteorological satellites to key ground stations, but not normally used to disseminate data to user ground stations. Needs to be coordinated with FS where reception occurs.
7750-7850/7900 MHz ("7.5 GHz")	MetSat direct reception - used for reception of data from polar orbiter meteorological satellites.	Coordination with FS through award of RSA for direct reception for 7750-7850 MHz, extension of MetSat band to 7900 MHz agreed at WRC-12.

The recent WRC decision on Agenda Item 1.24 to increase the bandwidth for polar-orbiter downlink bands from 7750-7850 MHz up to 7900 MHz (an additional 50 MHz) is evidence that demand for MetSat spectrum is increasing as data volumes increase. It should be noted with reference to the 5-10 year timescale quoted in the question above that satellite applications require much longer development & deployment cycles (as opposed to terrestrial applications such as FS). The development of an operational meteorological satellite system often takes up to 15 years and satellites in the series may then be in operation for more than 20 years. This emphasises the need for national regulators to offer long-term security of space-related frequencies to satellite operators (who cannot react on the shorter timescales typical of terrestrial applications).

<u>Question 5(b):</u> A number of the frequency bands under review are currently used for satellite Permanent Earth Stations (PESs), for example to feed Direct to Home satellite broadcast services. What are the continued and future spectrum requirements for satellite PESs (E-s & s-E) likely to be and in which bands? Please provide evidence to support your views.

The Met Office's particular interest in PESs relates to the bands already listed above under our response to Question 5a ("MetSat"), including all bands currently subject to an Ofcom grant of RSA (namely 3600-4200 MHz and 7750-7850 MHz, plus 1690-1710 MHz). As expressed above, we do not expect particular change to the requirement for these bands in the short-medium term (receipt of timely satellite data via direct reception is essential to our operations), except for the extension of the 7750-7850 MHz band to 7900 MHz.

Access to the Spectrum by other services

<u>Question 11:</u> What issues relating to spectrum access for different services do you think Ofcom should review? How might Ofcom start to rely more on commercial decisions when determining allocations of spectrum in the bands covered by this review?

As commented on in our response to Question 5, the Met Office favours an approach that ensures sufficient protection for satellite/science services bands from fixed (or other active) services operating in-band or in adjacent bands, in particular one that balances the needs of active users with those of passive users. The regulatory framework that dictates broad allocations at both the international and national levels must be maintained and respected, but should market forces be considered appropriate *within* particular FS/other bands to determine actual usage at a national level, then sufficient safeguards must be put in place to prevent harmful out-of-band emissions into passive bands. With regard to MetSat, continued coordination in such bands where there is shared use with FS/other services (eg – PES bands where grants of RSA have been made) must continue to be assured over the long-term (in view of the long development cycles for satellite technology), thus a cautious approach to the market in respect of satellite services must also be taken here.

Given the large amounts of spectrum that are currently allocated to fixed links in the UK and the indication by the Aegis report that some of these bands are not extensively or efficiently used, the Met Office believes it *may in fact be appropriate to review the requirements of the fixed service,* particularly (from our perspective) where they can potentially impact passive band use. Recent examples where passive use has not received sufficient protection in relation to the demands of active services include recent WRC decisions affecting RR5.340 bands in both WRC 2007 (with the ongoing delay in the full implementation of subsequent ECC decisions on 1.4-1.427 GHz, 10.68-10.7 GHz & 31.3-31.5 GHz) and WRC 2012 (only recommended limits for adjacent FS bands in relation to protecting the 86-92 GHz passive band were agreed), as well as the additional decision by RR footnote to share the upper portion of the 31 GHz passive band (31.5-31.8 GHz) on a primary basis with the fixed and mobile services in the UK. Curiously, there appears to be no reference to 31 GHz bands (as defined in the consultation annex) in the Aegis report, thus firm conclusions on the deployment and efficiency of the FS in the band 31.5-31.8 GHz cannot be made. However, if indications that FS band use across the available spectrum is not optimum, then we would call for such use to be gradually migrated elsewhere so that this specific natural window can be restored to former (exclusive) passive use. In one respect, this would be an effective use of market forces – if FS penetration in a given band is low, then this would indicate that this band is not required for FS and can be released for alternative use (eg – returning the 31.5-31.8 GHz to former passive status).

A useful example of the above point can be found in Section 2.3.2 (6 GHz bands) of the Aegis report, where both lower and upper parts of the 6 GHz band are shown to be sparsely populated by fixed links. The upper portion (6430-7100 MHz) is of particular interest to meteorology as it is coincident with an important spectral line used for satellite passive remote sensing of sea surface temperatures. This band is presently only protected by footnote RR5.458 which urges that *"Administrations should bear in mind the needs of the Earth exploration-satellite (passive) and space research (passive) services in their future planning of the bands 6425-7025 MHz and 7075-7250 MHz.")*. Whilst the use of FS over land is intuitively not as damaging to remote sensing use of the 6425-7250 MHz band for this purpose, the Aegis report indicates that the distribution of FS assignments in this band is skewed towards the coastal areas of NW Britain with "over-sea paths connecting offshore islands or oil / gas platforms to the mainland", meaning that coastal EO data would be irreparably damaged.

In conclusion **the Met Office urges the following key points:**

- Whilst the FS may be able to react on timescales of 5-10 years, satellite/science services need long-term assurance of reliable access to spectrum. In order to protect the interests of all stakeholders, including satellite/science-related bands, the current overarching framework approach to spectrum management must be retained – shorter-term market forces should only be applied to band management *within* bands where appropriate.

- In examining the needs of the FS, we seek a commitment to long-term protection of passive frequencies used for EO, steps including: full implementation of ECC decisions on protection of 5.340 bands (relating to the outcomes from WRC-07 affecting the 1.4GHz, 10.6GHz and 31GHz passive bands); initiation of similar action in Europe to protect the 86-92 GHz band by imposing hard limits on adjacent band FS following the outcomes of WRC-12; remediation of all in-band interferences to recognised 5.340 passive bands; and review approaches to protecting other passive bands including the 6425-7250 MHz and 31.5-31.8 MHz;
- Long-term coordination of FS with MetSat should be ensured, notably including extension of the grant of RSA to PES at 7750-7850 MHz up to 7900 MHz (following the recent WRC-12 decision to make an extended 50 MHz allocation at 7850-7900MHz to MetSat);
- There should be a consideration to rationalise the range of bands allocated to the FS (or other active services) where efficient use of these bands is not being made, especially where these may affect passive band use.

***Question 12:* We would welcome views on the potential for more widespread use of market based approaches to the spectrum under review such as third party band management, and the regulatory steps which would need to be taken to facilitate this.**

As referred to in our response to Question 11, the Met Office believes that necessary safeguards for satellite/ science services must be assured where a proposal to operate market approaches to band management are deemed appropriate, especially in relation to passive band use.

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