BASIC DETAILS

Consultation title: Digital dividend: cognitive access. Consultation on licence-exempting cognitive devices using interleaved spectrum

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Question 1. The executive summary sets out our proposals for licence-exempting cognitive devices using interleaved spectrum. Do you agree with these proposals?

Cognitive access offers potential for improved utilisation of the UHF spectrum and is attractive if devices can be deployed without causing interference to DTT and radio microphones. DTT is the dominant TV platform in the UK and it is crucial to the success of digital switch over. It is used in 67% of UK households, i.e. over 17 million homes. DTT signals will suffer a loss-of-noise margin in the presence of interference ultimately resulting in service failure. Indeed, the susceptibility of the signals to impulsive interference, contributed to the collapse of ITV digital.

Cognitive detection using sensing is potentially attractive, but a specification for detection of a single DTT or PMSE signal would not be sufficient to prevent interference on its own. For the sensing technique to be viable, the cognitive device must have sufficient RF dynamic range to detect an incumbent in the presence of 2 or more higher level signals, e.g. from other incumbents (DTT or PMSE), other white space devices or new services in the DDR cleared spectrum (e.g. 800MHz mobiles). Tests by the FCC indicate that prototype devices struggle to detect DTV signals at the required levels, and performance degrades significantly in the presence of other higher level signals[1]. Simple RF linearity analysis suggests a 25dB improvement in RF performance is required to make the detection technique viable in typical deployments[2]. Even if these difficulties could be overcome, another concern would be the detrimental effect of using a cognitive device in close proximity to other items of electronic equipment whose near field emissions are not insignificant and could de-sensitise cognitive detection.

If detection is to be permitted it is essential that the detection specification should be set in terms of field strength (-114dBm equates to 17dBµV/m at 500MHz for a 0dBi antenna). Conducted tests ignore antenna performance and the effects of self interference. Type approval testing in a G-TEM cell or similar would be necessary to ensure compliance. The test must also check the dynamic range of the cognitive device[3] to ensure performance is maintained in the presence of higher level signals.

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[1] FFC White Space Device Tests - Executive Summary (http://hraunfoss.fcc.gov/edocs_public/attachmatch/DA-08-2243A2.doc) –

"*Several tests were performed with DTV signals present in adjacent channels. These tests showed that in the presence of moderate-to-strong signals in a first adjacent channel, the detection threshold sensitivity of all of the devices was severely impacted. For some of the devices, the degradation in the detection sensitivity was as much as 60-70 dB. In some cases, the degradation was such that the detection threshold could not be measured. This could impact significantly the ability of the devices to reliably detect TV signals within stations' service areas.*"

[2] The most likely high level interferers are 800MHz mobiles (EIRP ~30dBm) and other white space devices (EIRP ~20dBm). Assuming 55dB path loss (10m minimum separation), DTT/PMSE detection would be required in the presence of signals up to -25dBm in level. For a 3dB degradation in detection threshold, a cognitive receiver would require a 3rd order intermodulation intercept point of +20dBm, some 25dB greater than that typically achieved with conventional DTT UHF tuners.

[3] A suitable test would consider detection of DTT at 17dBµV/m in the presence of two noise like interferers, 107 dBµV/m in level, each 8MHz wide at offsets of N+k, N+2k (e.g. 16MHz and 32MHz offsets for k=2).

Geolocation looks far more viable than detection and this has emerged as the preferred technique at stakeholder workshops. With correct design of the database, this approach is unlikely to cause interference to DTT or PMSE. However, some of the proposed transmitter parameters in the executive summary are of concern as they are based on incorrect assumptions about path loss and victim receiver C/I performance. Mobile TV receivers and PMSE receivers will be particularly susceptible to blocking problems as path losses between victim receivers and cognitive transmitters will be lower than for roof-top DTT reception. These concerns will be discussed further in the body of this consultation response.

Detection

Question 2. Do you agree that the sensitivity level for DTT should be -72 dBm?

TV networks are planned to take account of variations in signal strength that occur due to local terrain irregularities. The UK is divided into square pixels, each 100m by 100m, and within each pixel there will be a random variation of signal strength. The statistics of the signal variations are characterised by a log-normal distribution. Measurements have shown that the standard deviation of the distribution is typically 5.5dB, and a location correction factor of 9dB is required to ensure reception in 95% of locations within the pixel[4]. Therefore, the proposed detection threshold should be reduced from -72dBm, to -81dBm to account for the statistical variations expected at 10m height within the planning pixel.

Note a DTT sensitivity level of -81dBm is consistent with the DTG D-book performance targets for domestic DTT receivers. For the UK switch-over mode (64-QAM rate 2/3), a minimum sensitivity of -79.6dBm is specified. Typical receivers will exceed the DTG target, achieving -81dBm sensitivity and ensuring reception for 95% of locations within the planning pixel.

We note that the DTT sensitivity value of -72dBm has been calculated at 550MHz from a planned field strength of 50dBμV/m, a 12dBi antenna gain and 2dB feeder loss. At 800MHz, the feeder loss will be 3dB higher, (typically 5dB) and the antenna aperture will be 3dB lower. The signal level, neglecting location variations, for 50dBμV/m field strength will thus be 6dB lower, i.e. -78dBm.

Question 3. Do you agree with an additional margin of 35 dB resulting in a sensitivity requirement for cognitive devices of -114 dBm?

The hidden node margin of 35dB is appropriate for suburban deployment of cognitive devices at 1.5m outdoors. It is based on the ERA's DTT reception survey and ray

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[4] For further information, see "The Chester 1997 Multilateral Coordination Agreement relating to Technical Criteria, Coordination Principles and Procedures for the introduction of Terrestrial Digital Video Broadcasting (DVB-T)", European Conference of Postal and Telecommunications Administrations, Chester, 25 July 1997 (http://www.ero.dk/132D67A4-8815-48CB-B482-903844887DE3)

tracing simulations (ERA Report 2009-0011[5]). If deployment of cognitive devices is restricted to use outdoors, this hidden node margin would be adequate, albeit the sensitivity may need to be 9dB lower to account for the variations of signal strength within a planning pixel.

In practice, devices will be deployed indoors where signal strengths will be much smaller with the added potential to suffer near field emission interference from common household electronic equipment. A cognitive device working indoors would cause significant interference to a victim DTT receiver if broadcasting co-channel to the DTT signal. ERA report 2009-0011, Figure 45 suggests that signal strength indoors would be attenuated between 20 to 30dB compared to outside the building at 1.5m. This additional factor has not been taken into account, as it has been assumed that indoor operation would only cause interference to indoor TV reception, which would be unprotected. Assuming a DTT noise floor of -98dBm, based on DTG target sensitivity, a path loss of 118dB is required between the cognitive device operating at 20dBm EIRP and the DTT antenna for a 3dB loss in sensitivity. This level of antenna isolation is unlikely to be achieved and a much lower detection threshold (< -141dBm) is necessary to allow indoor deployment of cognitive devices, whilst preventing interference to loft-mounted or roof-mounted TV antennas.

Question 4. Do you agree with a maximum transmit power level of 13 dBm EIRP on adjacent channels and 20 dBm on non-adjacent channels?

The proposed adjacent channel EIRP limit of 13dBm makes the following assumptions:

- The minimum planned DTT signal will be -72dBm, which neglects locational variations (typically 9dB, for 95% locations).
- There is a minimum path loss of 55dB between white space device and victim DTT antenna, which neglects loft antennas and operation of white-space devices in adjacent loft conversions. There is an additional discrepancy in the consultation document calculations as a feeder loss of 5dB has been used to calculate the antenna isolation, but a lower feeder loss of 2dB was used to calculate the minimum received level of -72dBm. This introduces a 3dB error, favouring increased whitespace EIRP.
- The white space device will be at 1.5m outdoors, 45 degrees off axis to the DTT antenna.
- The DTT receiver C/I performance exceeds -30dB, which is 3dB better than the target performance set by the DTG.

Furthermore, the following considerations have been ignored:

- The DTT receiver is non-linear and blocking effects due to DTT receiver non-linearity result in C/I performance that degrades at higher signal levels.

[5] "Analysis of hidden node margins for cognitive radio devices potentially using DTT and PMSE spectrum", B.S Randhawa, Z. Wang, O. Parker, January 2009 http://www.ofcom.org.uk/radiocomms/ddr/documents/eracog.pdf

- The use of aerial distribution amplifiers will further degrade C/I performance and reduce the level at which non linear behaviour becomes important, by up to 19dB[6].

There are a number of usage scenarios where the assumptions made by Ofcom would not apply and a reduction in white space device EIRP will be required to protect DTT reception:

Scenario (Adjacent channel operation)	DTT Sensitivity (dBm)	DTT / Cognitive antenna isolation (dB)	DTT C/I (dB)	Maximum Cognitive Tx Power (dBm)
Ofcom condoc reference	-72	55	-30	13
95% location variation, DTG C/I target	-81	55	-27	1
Loft operation, no location variation, DTG C/I target	-72	42	-27	-3
Loft operation, 95% location variation, DTG C/I target	-81	42	-27	-12

The scenario where a loft-mounted white space device[7] (e.g. an access point) interferes with a loft mounted DTT antenna is the worst case and requires a reduction in output power between 16 and 25dB.

For non adjacent channels, the target receiver C/I performance is typically 11dB better, i.e. <-38dB for QEF. The following values are then appropriate:

Scenario (Non adjacent channel operation)	DTT Sensitivity (dBm)	DTT / Cognitive antenna isolation (dB)	DTT C/I (dB)	Maximum Cognitive Tx Power (dBm)
Ofcom condoc reference	-72	55	-38	21
95% location variation, DTG C/I target	-81	55	-38	12
Loft operation, no location variation, DTG C/I target	-72	42	-38	8
Loft operation, 95% location variation, DTG C/I target	-81	42	-38	-1

It should be noted, however, that DTG target C/I performance for N+9 interferers reduces to -31dB. To address this, white space device EIRP must be reduced by 7dB or N+9 channel restrictions must be applied.

Scenario (N+9 channel operation)	DTT Sensitivity (dBm)	DTT / Cognitive antenna isolation (dB)	DTT C/I (dB)	Maximum Cognitive Tx Power (dBm)
No allowance for location variation	-72	55	-31	14
95% location variation, DTG C/I target	-81	55	-31	5
Loft operation, no location variation, DTG C/I target	-72	42	-31	1
Loft operation, 95% location variation, DTG C/I target	-81	42	-31	-8

Receiver linearity effects may impose further constraints. The DTG have recently defined a simultaneous, non-ACI protection test where interferers are applied at

[6] "Conducted and Radiated Measurements to Quantify DVB-T, UMTS and WiMAX Interference into DTT", B.S Randhawa, Z. Wang, I. Parker, May 2008 http://www2.ofcom.org.uk/consult/condocs/clearedaward/era.pdf

[7] Assuming 6m separation between DTT loft antenna and a cognitive device deployed in a loft conversion with 8dB penetration loss for the dividing wall, the path loss from cognitive device to TV antenna (12dBi) would be 42dB.

channels N+2 and N+4 at a level of -25dBm. The target performance agreed with manufacturers is -28dB. This would imply a white space device EIRP limit of between -11dBm (loft protected) or 2dBm (loft unprotected). This test however, is quite new, and the margin by which typical receivers exceed the target is unknown. Nevertheless, receiver linearity and intermodulation effects should not be neglected.

Question 5. Would it be appropriate to expect DTT equipment manufacturers to improve their receiver specifications over time? If so, what is the best mechanism to influence this?

This question implies that all would be well if manufacturers could produce enhanced performance equipment. However, it is the protection of existing equipment that is the main issue and having mechanisms in place to ensure that certain aspects of RF performance do not get worse as manufacturing costs are trimmed.

The optimisation of cost, power consumption and RF performance is complex. The adjacent channel C/I performance of DTT receivers is partly determined by the performance of the IF SAW filters in the tuner and any additional digital filtering implemented in the demodulator after the ADC. Another factor is linearity which is closely related to power consumption and heat dissipation. The C/I performance achieved in domestic DTT tuners matches and often exceeds that set by professional receivers and further improvements seem unlikely. The introduction of the extended bandwidth mode in DVB-T2 may results in a reduction in C/I performance, as the DVB-T2 signal occupies a greater fraction of the UHF channel.

Manufacturers have played an active role within organisations such as the DTG to achieve realistic and consistent RF performance targets for DTT equipment. We only have to compare the RF performance of DTT equipment to that of DAB, DRM or FM radio equipment allowed into the market place to see how well that approach works.

Question 6. Do you agree that the reference receive level for wireless microphones should be -67 dBm?

This level is appropriate for radio microphones in studios. For outside broadcasts, lower signal strength and reduced fade margin may be tolerated to facilitate rigging. A reference level of -77dBm would be appropriate (14dB fade margin).

Question 7. Do you agree with an additional margin of 59 dB for wireless microphones?

In calculating the hidden node margin for radio microphones, ERA has assumed that a 25dB co-channel protection ratio (white space device interferer into PMSE victim) will be sufficient to protect the radio microphone from white space device interference. This figure is somewhat arbitrary; the modulation and bandwidth parameters for white space devices have not been defined and it is too early to know if the 25dB protection ratio is adequate. Should a larger protection ratio be necessary, the hidden node margin will be greater. Furthermore, the 20dB allowance for body loss assumes one layer of bodies between the radio microphone and the white space radio device which may not always be appropriate.

Question 8. Do you agree with a sensitivity requirement for -126 dBm (in a 200 kHz channel) for wireless microphones?

This is appropriate for studio use, subject to the co-channel protection ratio issue discussed in Question 7. For outside broadcasts, a lower sensitivity is appropriate given typical antenna rigging constraints, and -136dBm would be appropriate.

Different sensitivity requirements will be appropriate for digital radio microphones. The typical digital radio microphone receiver provides full performance audio (110dB SNR) at -96dBm. A reference level of -76dBm (20dB fade margin) or less would be appropriate for this digital implementation, corresponding to a detection sensitivity of -135dBm.

Question 9. Do you agree with a maximum transmit power level in line with that for DTT? Are there likely to be any issues associated with front end overload?

The analysis of paragraph 5.37 is based on a PMSE receiver C/I performance of -70dB. The C/I performance for a cognitive interferer into PMSE receiver will be a function of the spectrum of the cognitive transmitter. This is as yet unknown, but the performance of PMSE receivers in the presence of DTT interferers is a useful indicator. Work by the ERC on DVB-T compatibility with PMSE[8] assumes a receiver C/I performance of -35dB. This would result in a cognitive transmitter power limit of 0dBm in a 200kHz bandwidth, equivalent to 16dBm /8MHz, if overload effects are neglected. We understand that Ofcom have commissioned a programme of receiver C/I measurements and the results of these measurements will be important in determining if the proposed transmitter levels are likely to cause interference to radio microphone receivers.

Receiver non-linearity and overload are likely to be the dominant issue. We have no data on PMSE receivers, but professional UHF tuners for DTT typically achieve a third order input intercept of <-5dBm. Assuming an operating point of -67dBm, and a co-channel protection ratio of 25dB, front end intermodulation products resulting from third order non-linearity need to be suppressed to a level no greater than -92dBm. Assuming an intercept of -5dBm, the cognitive signal should be no greater than -34dBm at the PMSE tuner. Given a path loss of 32dB (1-2metres), the maximum transmit power would be -2dBm.

Question 10. Do you agree that the sensitivity level for mobile television receivers should be -86.5 dBm?

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[8] ERC Report 88. *"Compatibility and Sharing Analysis between DVB-T and Radio Microphones in bands IV and V"*, Naples, February 2000: http://www.erodocdb.dk/Docs/doc98/official/pdf/REP088.pdf

This will depend upon the DVB-H mode used for transmission. Assuming a receiver noise figure of 3dB and a demodulator implementation margin of 2dB, the following sensitivity levels would apply:

Modulation	Code Rate	Sensitivity
QPSK	1/2	-97.1 dBm
QPSK	2/3	-95.3 dBm
QPSK	3/4	-94.3 dBm
QPSK	5/6	-93.3 dBm
QPSK	7/8	-92.5 dBm
16-QAM	1/2	-91.4 dBm
16-QAM	2/3	-89.1 dBm
16-QAM	3/4	-87.7 dBm
16-QAM	5/6	-86.7 dBm
16-QAM	7/8	-86.3 dBm
64-QAM	1/2	-85.8 dBm
64-QAM	2/3	-83.7 dBm
64-QAM	3/4	-82.2 dBm
64-QAM	5/6	-80.9 dBm
64-QAM	7/8	-80.1 dBm

A sensitivity of -97dBm is appropriate for QPSK rate ½ mode and it is conceivable that such rugged modes might be deployed to improve coverage or reduce network costs.
However, calculations of improvement in sensitivity by reduction of receiver noise figure can be misleading. They are only valid if the antenna noise temperature is 290K. The antenna noise temperature for a mobile receiver is likely to be much greater than 290K because the antenna will probably be much closer to local sources of EM noise. The expected improvement in sensitivity is likely to be less than calculated.

Question 11. Do you agree with an additional margin of 20 dB for mobile television?

An additional margin is required to cover the case where the cognitive device is deployed indoors and causes interference to a mobile TV receiver operating outdoors. As discussed in the response to question 3, the ERA ray tracing of DTT propagation at 1.5m through houses shows typical variations of 30dB, with worst case shielding increasing to 40dB. Given this, the margin of 20dB appears insufficient to protect mobile TV.

Question 12. Is it likely that mobile television will be deployed in the interleaved spectrum? If so, would it be proportionate to provide full protection from cognitive access?

Mobile TV receivers may be deployed in either interleaved or cleared UHF spectrum, depending upon the cost of the spectrum at auction.

The dominant interference problem will tend to be front-end overload from cognitive devices. These will be received by the mobile receiver at levels up to -15dBm, based on a minimum separation of 2.8m, 20dBm EIRP and a 0dBi receive antenna. To maintain reception of a wanted signal at -86dBm, with a C/N of 15dB, the 3rd order intercept requirement of the mobile receiver would be +28dBm. This is at least 33dB greater than the typical performance of a professional DTT receiver and would be exceedingly difficult to engineer in a low power device.

We note that Ofcom has made assumptions on mobile C/I performance that appear to be based on ERA's survey of fixed receivers. The consultation document suggests a mobile TV C/I of -40dB for the adjacent channel, improving to <-50dB for non adjacent channels. It is unlikely that low power, compact tuners for a mobile device will achieve this performance. The DTG-D book guidelines specify the following requirements for fixed receivers:

	Interferer Level (dBm)	C/I (failure)	C/I (QEF)	
DTT ACI (N±1) protection (dB)	-25	-29	-27	dB
DTT Non-ACI (N±2) protection (dB)		-40	-38	dB
DTT Non-ACI (N±3) protection (dB)		-45	-43	dB
DTT Non-ACI (N±M) protection (dB), M≥4, M≠9		-49	-47	dB
DTT (N+9) Protection (dB)		-33	-31	dB
DTT Simultaneous non-ACI (N+2) & (N+4) protection (dB)	-25	-30	-28	dB

Mobile receivers will tend to use silicon tuners offering reduced performance compared to fixed receiver using conventional tin-can tuners and higher-Q RF tracking filters.

In principle, the C/I performance for mobile TV receivers using cleared spectrum could be improved relative to devices using interleaved spectrum, reducing the interference probability. However this would require UK-specific, band pass filters. Mobile TV receivers will need to operate across all countries where DVB-H services are deployed and it is unlikely that manufacturers would be prepared to develop anything special for the UK market.

In conclusion, it is difficult to see how mobile TV and cognitive radio devices can coexist in the UHF spectrum.

Question 13. Should we take cooperative detection into account now, or await further developments and consult further as the means for its deployment become clearer?

Co-operative detection may offer some benefit, but characterisation and type approval of devices relying on such techniques would prove difficult. It would be appropriate for mobile client devices to use sensing data from a fixed device, but in all cases, the geolocation database approach is preferred. The operation of such client devices is discussed in FCC 08-260[9], where a fixed device, using both sensing and geolocation databases, registers its spectrum usage on the Internet and controls one or more client devices with no sensing capabilities. This approach appears workable.

Geolocation databases

Question 14. How could the database approach accommodate ENG and other

[9] "Second Report and Order and Memorandum and Order", Federal Communications Commission, November 4, 2008. http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-08-260A1.pdf

similar applications?

The database would need to be updated by the PMSE band manager, so that PMSE assignments could be protected from cognitive devices.

Question 15. What positional accuracy should be specified?

There is a trade off between the resolution of the database (and hence positional accuracy) and the number of channels that can be marked as available. As resolution is improved, the number of available channels will increase. A resolution of 500m may prove sufficient, but a detailed analysis is required. Because higher resolutions might lead to a greater channel availability, it might prove beneficial to provide a higher resolution database (say 100m or 50m) where the size of the database is unimportant to the white space device, and the capacity of the method taken to deliver it to the device is not a constraint.

Question 16. How rapidly should the database be updated? What should its minimum availability be? What protocols should be used for database enquiries?

DTT spectrum usage is essentially static (once switchover and the following 800 MHz reallocation are complete). PMSE usage is dynamic, and users would like to see channels clear of cognitive transmissions within a minute of making a booking.

There are a number of options for distributing this data. The FCC currently favours an Internet-hosted database maintained by an independent third party. This is dependent on the cognitive device having access to the Internet, which would not otherwise be required for all white space applications. For example, a media streaming gateway for distribution of multimedia in the home would not necessarily need a direct Internet connection but this would become a requirement for access to an Internet-hosted database.

An alternative and potentially complementary approach would be to stream the database as a data carousel within a broadcast DVB transport stream. This would enable broadcasters to assert direct control over the services they need to protect. Such mechanisms could be standardised through an industry group such as the DTG. Whitespace devices would then not necessarily need direct Internet access, but could operate given access to the DVB transport stream. This could potentially be carried by DTT, cable or satellite. However because the device might not necessarily be connected to cable or have access to satellite transmissions, and because white space devices will need a UHF tuner for operation, terrestrial distribution of this data using DTT may prove effective. The data carousel could be designed to provide faster updates for PMSE assignments and slower updates for static broadcast assignments. However there are a number of hurdles to overcome before such a system could be implemented :-

1. The White Space device might not be able to receive any DTT service but it still could be in a position where it might be able to interfere with reception on nearby DTT receivers. This would need further analysis to determine whether mitigating strategies could be put in place. In practice, if this technique was complementary to

Internet delivery of the database, it might be workable for a device to rely on DTT delivery for devices not connected to the Internet, and Internet connection when DTT reception was not possible. The device would then be restricted from access to White Space spectrum is it was not able to secure either means of access to the database.
2. There are inevitable cost and infrastructure issues with implementing such a system. Also DTT bandwidth is highly constrained and costly. It is not clear that this could be imposed as an additional requirement on existing multiplex operators. Otherwise, it is not clear how the funding to implement such systems could be realised.
3. Although broadcasters have significant interests in maintaining PMSE operations, it is not clear what business relationship with JFMG might enable the implementation of such systems by the broadcasters on behalf of PMSE operators.

Question 17. Is funding likely to be needed to enable the database approach to work? If so, where should this funding come from?

An Internet-hosted database could be updated and maintained by the broadcasters, Ofcom or a third party funded by Ofcom. Since this technology is intended for low-cost licence exempt use, it is difficult to see how the end user would directly fund the service. However it is also difficult to see why and how broadcasters should fund the service as it is primarily intended in freeing up spectrum for other uses. If Ofcom were unable to fund (e.g. through its spectrum efficiency fund), another option could be a levy on the sale of White Space devices. The Internet based approach has the advantage that devices can log their location and usage of particular channels with the database provider, potentially allowing rogue devices to be traced and deactivated. The FCC has suggested that fixed devices log their identity on the database as part of its white space proposals.

The option of sending the data using a DVB transport stream using a broadcast multiplex could be implemented by the transmission providers who would require the protection it provides to their services. However similar funding issues arise as mentioned in the response to the previous question. Options for funding could include Ofcom’s spectrum efficiency fund or a levy on the sale of White Space devices.

Question 18. Should the capability to use the database for spectrum management purposes be retained? Under what circumstances might its use be appropriate?

This capability should be maintained. The benefits of cognitive devices are as yet unknown and UHF spectrum is a particularly valuable and limited resource. If a higher value technology is developed in future and cognitive devices are not widely deployed, or an alternative technology (e.g. UWB) emerges as an alternative to cognitive access, it would be highly desirable to have the capability to terminate cognitive device access to make way for new services for spectrum management reasons.

Furthermore, there is still some doubt on the viability of white space devices and the interference they may cause. Given this, it is attractive to adopt a cautious approach, carefully controlling channel allocation and EIRP until the compatibility of the technology with DTT and PMSE is better understood.

Question 19. Should any special measures be taken to facilitate the deployment of cognitive base stations?

Defining the permissible transmit power for cognitive devices is a particularly challenging problem. Devices deployed in tower blocks could potentially cause interference for many miles. A device radiating 20dBm EIRP from a tall structure can potentially be decoded with 3dB C/N at a range of 78miles! In practice, terrain clutter and path blocking will drastically attenuate the signal, permitting more rapid channel reuse, but it is difficult to see how a "one size fits all" approach to determining transmitter power can provide an optimum solution. It is far safer to control maximum transmit power as a function of the device location, taking account of position, including the height of the device and assigning a maximum EIRP on a device by device basis. If the device logs its position and channel in the database, it is in principle possible to share the spectrum fairly between a population of devices within a geographical cell.

Beacon reception

Question 20. Where might the funding come from to cover the cost of provision of a beacon frequency?

A network of beacons might be funded by Ofcom or a local operator using whitespace for broadband access. Alternatively the funding could come from a levy on the sale of White Space devices.

Question 21. Is a reliability of 99.99% in any one location appropriate? Does reliability need to be specified in any further detail?

The integration period for the reliability calculations is clearly important. A lower reliability is acceptable for DTT/PMSE protection, provided that the white space devices are fail-safe and cease transmissions when the beacon network is unavailable.

Comparing the different options

Question 22. Do you agree with our proposal to enable both detection and geolocation as alternative approaches to cognitive access?

The BBC does not support Ofcom's proposal to enable both detection and geo-location as alternative approaches to cognitive access. It is clear from stakeholder meetings that the detection approach will be impossible to engineer safely in the immediate future and is not favoured either by equipment manufacturers, broadcasters or radio microphone users. On balance, we believe that the required technology could be developed more quickly if efforts were focussed primarily on a geo-location approach although longer term R&D work on the detection method may at some stage in the future enable a technology that could become effective. Sensing does however have merit for PMSE operation outside the UK, where PMSE assignment data may not be available.

Other important parameters

Question 23. Should we restrict cognitive use of the interleaved spectrum at the edge of these bands? If so, what form should these restrictions take?

This will be dependent on the outcome of Ofcom's DDR auctions and the services deployed in the new spectrum. It is highly likely that MNOs will demand protection at the boundary to any new services in the 800MHz band (i.e. for downlinks operating on CH61) and similar requirements may emerge to protect CH31-37.

The exact requirements will depend upon the RF performance of the terminal equipment deployed in the DDR. As a minimum requirement, it is likely that cognitive access should initially be prevented in CH 30, 38, 39 and 60.

Question 24. Do you agree that there should be no limits on bandwidth?

This is attractive in principle, subject to the availability of satisfactory protocols for fair sharing of spectrum within the available white space. The collision detection techniques adopted in WiFi equipment are unlikely to provide efficient spectrum sharing and further research is required.

Question 25. Do you agree that a maximum time between checks for channel availability should be 1s?

The fundamental requirement is for the MAC protocols to permit fair access to the available white space so the available bandwidth is shared equally between competing white space terminals. A channel availability check every 1s may be appropriate for a collision detect approach, but it is too early to decide if this is the most efficient method of sharing the spectrum. Alternative MAC protocols might include time division multiplexing, which would be particularly feasible given the requirement for GPS. Signals from the GPS receiver could be used both for location and timing references.

Question 26. Do you agree that the out-of-band performance should be -44 dBm?

The figure of -44dBm for PMSE is based on a C/I of 25dB for white space device interference, which cannot yet be verified. The 32dB antenna isolation assumes the cognitive device will be greater than 2m from the PMSE antenna, and the PMSE antenna has no gain.

The figure of -37dBm for DTT is based on a minimum DTT level of -72dBm and a minimum antenna isolation of 55dB. For certain use scenarios, antenna isolation may drop to 42dB and DTT levels may be as low as -81dBm. To properly protect DTT, an out of band requirement of -58dBm would then be appropriate, which is more challenging than the figure of -44dBm for PMSE.

Scenario (Out of band perrformance)	Sensitivity (dBm)	OOB C/I (dB)	Antenna Isolation	Permitted OOB (dBm)	OOB in 8MHz BW
Ofcom DTT condoc reference	-72	20	55	-37	-37
Ofcom PMSE condoc reference	-67	25	32	-60	-44
DTT (95% location variation)	-81	19	55	-45	-45
DTT (95% location variation, loft antenna)	-81	19	42	-58	-58
Mobile DVB-H, QPSK rate 1/2	-97	5	32	-70	-70
Mobile DVB-H 64-QAM rate 2/3	-84	19	32	-71	-71

Its should be also noted that the spectrum of OOB intermodulation products for a noise like block of signal is not flat, and the 16dB correction factor relating OOB level in 8MHz to OOB level in 200KHz will be optimistic at the edge of the white space device spectrum.

Mobile reception requires a more demanding out of band performance limit and also depends slightly on the DVB-H mode used. A limit of -71dBm in an 8MHz bandwidth is appropriate.

Question 27. Is a maximum transmission time of 400ms and a minimum silence time of 100ms appropriate?

See question 25.

Question 28. Is it appropriate to allow “slave” operation where a “master” device has used a geolocation database to verify spectrum availability?

This is considered appropriate and particularly advantageous for portable terminals, where geolocation and sensing techniques would be difficult to engineer. It is likely that devices operating in this mode will quickly emerge in the market place as the FCC have defined this mode of operation in its whitespace proposals.