Ofcom contributions to DCMS Radio & Audio Review

This document was submitted to DCMS in January 2021 as an input to the Government's Radio & Audio Review. While not originally intended for publication, this document is non-confidential and is being made publicly available to coincide with the publication of the Review's final report.

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1. Overview

1.1 The DCMS Digital Radio and Audio Review comprises three working groups (the Devices and Automotive Group, the Listener Group, and the Distribution and Coverage Group) which have been tasked with studying and reporting on specific radio sector areas, and with providing expert advice to the Review's Steering Board.

1.2 These working groups are chaired by industry specialists and will report directly to the overall Steering Board chaired by DCMS.

1.3 Ofcom is not formally participating in the Radio and Audio Review. However, in response to a specific request from DCMS, Ofcom is contributing technical advice relating to spectrum use to the Review including:

a) Ofcom's assessment of broadcast radio network coverage and identifying areas where it is possible to receive FM radio services that are not served by DAB;

b) Identifying which local multiplexes are full and have no room to accommodate further radio services, and what solutions exist to address that shortage of capacity, including whether spectrum could be made available to license additional Local multiplexes;

c) What alternative use(s) could be made of spectrum currently used by analogue radio broadcasting should there be a migration to all-digital broadcasting in the future.

1.4 In order to manage the coverage analysis work efficiently and effectively, Ofcom formed a 'Broadcast Radio Coverage Group' (BRCG) which was responsible for assisting with and reviewing the technical work. The membership of the BRCG included spectrum planners from Ofcom, the BBC and Arqiva. Interested parties from the Review's Distribution and Coverage Group were invited to observe and provide input as required.

1.5 This report forms the deliverables that Ofcom undertook to provide to the Review and is being submitted directly to the DCMS Steering Board. The report contains conclusions and sets out possible remedies, although these should be interpreted as options for consideration and not as formal recommendations for action.

1.6 Our studies found a number of areas across the UK where our tools predict that FM radio services are receivable that are not served by DAB. These coverage differences and potential remedies are detailed in the body and annexes of this report. The identified differences are based on our theoretical analysis comparing the maximum coverage likely to be achieved by FM radio services and comparing that with predicted DAB coverage. This analysis may overstate FM coverage to some extent and some of the coverage differences may not exist in reality.

1.7 The 2012 Radio Review sought to identify solutions to broadly match overall FM and Local DAB coverage figures in each region. This current study has gone further in seeking to identify options to fill any significant remaining deficiencies in DAB coverage. This study was more detailed than the 2012 one and could result in DAB coverage exceeding FM coverage in some areas because of the different network designs.

1.8 We identified that 16 of the 57 Local multiplexes (28%) are full and a further seven have very limited capacity to carry additional services. Almost all of these multiplexes carry only services that operate using the longstanding DAB standard, rather than using the more efficient DAB+. The shortage of capacity could be eased by adoption of the DAB+ standard by a greater number of programme services. While services broadcast in DAB+ are not receivable on older receivers, DAB+ is being increasingly adopted by radio services on the DAB platform and the number of compatible receivers continues to increase and usage of older receivers is declining. Additional spectrum could potentially be available in a limited number of areas, provided it is not needed for small-scale DAB, although would not provide a remedy in two-thirds of the areas where multiplex capacity is in short supply.

1.9 Spectrum that is currently used by analogue radio broadcasting could in principle be used by a variety of alternative technologies, including Internet of Things, White Space Devices or remote device telemetry. There is at present no obvious leading contenders, nor any known significant demand. Countries where a full or partial switch-off of FM services is planned or happening (Norway, Switzerland and parts of Italy) have not made public their plans for future use of that spectrum, other than Norway who will continue to use for localised broadcasting services in the short term.

1.10 The results from Ofcom's technical studies will also feed into workstreams specific to the Distribution and Coverage Group which will be cross-linked with costing exercise reviews.

1.11 It should be noted that the work and final conclusions of the Distribution and Coverage Group and the DCMS Radio and Audio Review may not align with Ofcom's current or future policies in relation to broadcasting or spectrum use. Ofcom will however take account of those conclusions in developing its future policies where appropriate.

2. Key Deliverables

2.1 In response to a request from DCMS for Ofcom to provide technical advice to the Review, Ofcom presented the DCMS Steering Board with a paper in February 2020 that outlined its proposed contributions to the Radio and Audio Review.

2.2 The document confirmed which workstreams Ofcom planned to manage and deliver. Through discussion with the Distribution and Coverage Group, Ofcom agreed that some tasks would be carried out by Ofcom exclusively, while others would also be mirrored by members of that group (noting that there may be a diversity of views), while some further tasks would be more appropriately carried out by members of the Distribution and Coverage Group directly.

2.3 Ofcom's contributions consist of the following three workstream areas, which form the basis of this report.

Comparison of current FM and DAB coverage

2.4 Ofcom committed to reviewing the coverage currently being provided by the UK's analogue (FM) radio networks compared to its digital (DAB) networks. Where significant DAB coverage deficiencies were found, we would seek to identify potential technical solutions to 'fill-in' these areas of coverage shortfall. The networks included in this coverage comparison would include National BBC and Commercial services as well as Local radio services, and both indoor and road coverage would be considered.

2.5 Specifically, technical analysis would be performed to produce comparisons for both indoor and road coverage of the following radio broadcasting networks:

a) Coverage achieved by the BBC's National DAB multiplex compared with coverage achieved by the BBC's Radio Two FM transmitters (which is comparable to that for other National BBC FM services);

b) Coverage achieved by the Digital One Commercial National DAB multiplex compared with coverage achieved by the Commercial Classic FM analogue network (representing National Commercial DAB services and analogue FM coverage respectively)

c) Coverage achieved by the Local DAB multiplexes compared with coverage achieved by the BBC's Local FM transmitters;

d) Coverage achieved by the Local DAB multiplexes compared with coverage achieved by the Commercial Local FM Local transmitters.

2.6 Following completion of these comparisons, we said that the results would be used to identify potential solutions for 'filling-in' areas of significant coverage shortfall through extensions to the coverage of existing DAB multiplexes or potentially other measures.

DAB multiplex capacity constraints

2.7 Ofcom also undertook to review current and potential future multiplex occupancy levels across the UK, and thereby identify areas where access to DAB for broadcasters may be constrained by lack of capacity (either now or in the future).

2.8 We said that an assessment of how potential capacity constraints might be addressed would take account of:

a) Likely future demand for DAB carriage from programme services;

b) Migration to DAB+;

c) Potential for existing multiplexes to carry more services (subject to audio quality considerations and signalling repetition rates);

d) Additional capacity being made available by the launch of small-scale DAB;

e) Potential for licensing additional Local multiplexes.

Alternative uses of Band II and MW spectrum

2.9 Finally, Ofcom undertook to assess the possible re-use of spectrum in the FM band (87.5-108 MHz) and AM band (MW 530-1600 kHz) by considering potential demand and potential uses for this spectrum should these bands be released following a future migration to an all-digital radio broadcasting environment in the UK.

2.10 We said that the workstream would include a study to identify whether there are examples or plans for the re-use or alternative uses of Band II (FM) spectrum outside the UK, and that the report would include descriptions of any examples found.

3. Coverage Workstream Methodologies

Comparison of current FM and DAB coverage

3.1 This workstream was the main focus of Ofcom's technical analysis and was managed through the Broadcast Radio Coverage Group (BRCG).

3.2 Ofcom defined the BRCG's scope of work by setting the following key deliverable tasks. These tasks needed to be completed in order to prepare for and facilitate the technical calculations required for the coverage comparison analysis.

Prediction Software Tool

3.3 *Scope:* review the software tools available to Ofcom and decide which product best provides Ofcom spectrum planners the ability to conduct the radio coverage prediction and analysis work.

3.4 The primary goal was to establish which prediction software tool would best serve for the work Ofcom had committed to provide for the DCMS Radio and Audio Review.

3.5 Ofcom compared the FM and DAB planning tools that were available and accessible to the spectrum planning organisations (Ofcom, BBC and Arqiva).

3.6 The aims of this comparison were to highlight differences between the software products, to distinguish between the planning parameters and modelling assumptions, and to consider which tool would be best suited to producing the required coverage predications.

3.7 Given time constraints, Ofcom considered only planning tools that had been used for Broadcast Radio planning in the past (to avoid spending significant time and resources on the validation of new tools).

3.8 The specific tools compared were the UK Planning Model (UKPM) and HTZ Communications (formerly known as ICS Telecom). UKPM is a tool which all three planning organisations have historically used for planning DTT and DAB networks, while HTZ Communications is currently used by Ofcom for planning DAB and analogue radio.

3.9 Following a detailed technical review, during which predictions produced by the UKPM and HTZ Communications were compared, Ofcom determined that HTZ Communications would be used for the coverage comparison workstream.

Technical Parameter Datasets

3.10 *Scope:* review the technical parameters for both FM and DAB networks to ensure all data is up-to-date and accurate and create final datasets for the coverage prediction work.

3.11 The BRCG members agreed that it was crucial for predictions for the coverage comparison workstream to be based on an agreed set of baseline parameters which contained accurate transmission characteristics for existing transmitter sites. This would ensure that the network predictions were calculated and assessed consistently and accurately.

3.12 It was agreed that Ofcom, the BBC and Arqiva would share and assess their existing FM and DAB network files to ensure correct alignment of these datasets.

3.13 Arqiva provided the latest version of their DAB TVD files (a text file containing the core technical parameters for each transmitter site) and its associated version history document. This file was considered to represent the networks' 'as built' parameters most accurately.

3.14 The information in this file was checked against BBC data, other Arqiva records and against Ofcom's public radio transmitter dataset 'TxParams' (information published on Ofcom's website containing details of the technical parameters of all analogue VHF, MF, and DAB transmitters currently on-air).

3.15 Ofcom spectrum planners also cross-referenced this data with information recorded in Ofcom's internal database. The resulting list of discrepancies was investigated, and following review with the BRCG members, amendments were applied which resulted in a consolidated DAB network parameter file.

3.16 A similar exercise was conducted in respect of data representing the FM networks. The BBC reviewed the data that it holds and provided update files to the BRCG. Ofcom cross-referenced this data with the information recorded in its internal databases. Where appropriate, Ofcom updated its records, and these updates will be reflected in a future updated release of the public TxParams dataset.

3.17 These amended datasets defined the UK FM network and DAB network transmitter site technical parameters that would be used to carry out the network coverage analysis work.

Prediction Model Settings

3.18 *Scope:* review and confirm the prediction software tool model settings to ensure the correct parameters are available and compare to those applied at a previous review carried out during 2012.

3.19 Members of the BRCG carried out a detailed review process which compared the prediction model settings currently used by each planning organisation within the different prediction software tools.

3.20 Data files and parameter settings were exchanged, and test case analysis was used to ensure the model settings applied were accurate.

3.21 To ensure the coverage prediction results would be broadly consistent with the results from the previous 'Radio Review 2012'[1] (acknowledging that a different software tool was used in 2012), Ofcom confirmed which technical planning parameters and modelling assumptions would be applied to the prediction calculations. This technical information can be found in an Annex to this report (Annex 1).

[1] 'DAB Coverage Planning: Report to Government' and supporting annexes, published 2 May 2012: https://www.ofcom.org.uk/tv-radio-and-on-demand/information-for-industry/radio-broadcasters/coverage/dab-coverage

FM & DAB Network Field Strength Analysis

3.22 *Scope:* import the technical parameter datasets into the prediction software tool and complete technical analysis runs to provide field strength level outputs for the FM & DAB networks.

3.23 To carry out this analysis, the transmitter site technical parameter datasets were imported into the HTZ Communications prediction software tool and the agreed prediction model parameter settings were applied.

3.24 For the assessment of Local DAB network coverage, analysis was carried out in respect of population and road lengths within the Local DAB licence area. Any coverage falling outside of the relevant Local DAB licence area was not considered.

3.25 In order to compare the DAB coverage with the equivalent FM services, the FM coverage for each Local DAB licence area was defined. For each local area, the noise-limited coverage of the FM transmitters was predicted, and a composite coverage prediction was generated. One coverage prediction was produced for the commercial service(s) in the area, and a separate coverage prediction was produced for the BBC service. A list of the assignments used to generate these composite coverage predictions was recorded.

3.26 The composite coverage field strength levels used to define road FM coverage for 'A' roads and motorways was 42dBµV/m. The composite coverage field strength level used to define usable indoor FM coverage was 48dBµV/m.

3.27 The DAB coverage for each Local multiplex area was predicted using the 50%-time propagation coverage of the Local multiplex's transmitters. This was power-summed to give the noise-limited wanted coverage. Co-block transmitters were predicted for 1% propagation conditions.

3.28 The coverages of the transmitters in other co-block areas were then power summed to give a composite interference environment.

3.29 Interference-limited coverages at 99%-time and 80%-time for each local DAB multiplex was then produced at the following field strengths:

- 54dBµV/m to define 99% locations road coverage;
- 63dBµV/m to define indoor useable (80% locations) coverage;
- 67dBµV/m to define indoor robust (95% locations) coverage.

3.30 Field strength analysis for the National coverage assessments was calculated using a different process. The National FM services were defined by the noise-limited coverage of the BBC Radio 2 service for BBC coverage and Classic FM for Commercial coverage. We chose BBC Radio 2 coverage as its coverage is comparable to that for other National BBC FM services.

3.31 The National DAB services are implemented via a single frequency network (SFN) using one DAB frequency block to transmit the services across the whole of the UK[2]. Within these

[2] The Digital One network operates on a separate frequency in Scotland

national networks the transmitters can cause interference to distant parts of the network during periods of enhanced propagation. This causes the effective coverage of network to 'breathe' over time. We therefore needed to predict the interference-limited coverage for our analysis.

3.32 For the National DAB services, Ofcom compared BBC FM with BBC DAB and Classic FM with Digital One. The field strength levels for these FM and DAB networks were calculated within HTZ Communications. Scotland, Wales and Northern Ireland were separated into individual areas. England was further separated into smaller sub-areas (seven in total) in order to calculate coverage on a more granular level.

3.33 The SDL National DAB network has less extensive coverage than either the BBC or Digital One networks. Furthermore, while the Digital One network carries the Classic FM analogue service there are no simulcasts of National FM services on the SDL network. We therefore considered that a review of SDL deficiencies to be outside the scope of our work and if there were any commercial need to extend the SDL coverage, the Digital One coverage would be a good template for that.

Coverage Percentage Figures Output

3.34 *Scope:* apply population dataset information (from census data based on household population) to the field strength analysis results to produce percentage coverage results.

3.35 Once the field strength analysis was complete, the FM and DAB coverage data was exported (as vector shape files) and imported into the MapInfo geographic information system (software tool) for detailed analysis.

3.36 Several MapInfo files needed to be produced to assess the coverage within a given area. In all cases, a polygon shape of the licensed area was required. The population within the licensed area and the roads within the licensed area were then applied. Datasets of population and roadmap vector data were used for this part of the exercise.

3.37 Ofcom had considered the different types of data available such as Total Population, Adult Population and Households Population.

3.38 Ofcom's preference was to align with the previous Radio Review work from 2012 and all subsequent prediction work produced by Ofcom which had used 2011 census data. A decision was communicated to the BRCG and a document was circulated containing 2011 census data based on adult population which provided the baseline dataset that Ofcom would apply to the FM and DAB network coverage analysis for this work.

Comparison of FM and DAB Coverage

3.39 *Scope:* compare FM coverage results with DAB coverage results for a given geographic location or licence service area and review the adult population and road length data produced from the technical analysis.

3.40 Ofcom's methodology for Local areas was to firstly identify the population and roads served by FM services. All population and roads within the licence area that were unserved

by FM were then deleted from the analysis. This resulted in separate files for BBC and Commercial FM containing data on served population and roads.

3.41 In Scotland, Wales and Northern Ireland the BBC provides two 'Nations' FM services, and where applicable files were produced for both of these services.

3.42 The interference-limited Local DAB coverages were then compared with the FM served coverages for population and roads. Any data where DAB coverage matched FM coverage was deleted.

3.43 This resulted in files containing data for only the population and roads that are served by FM but not served by DAB.

3.44 These results were then assessed for each Local DAB licence area and each significant deficiency was recorded in a table providing road length or population figures based on the assessed area.

3.45 For the National services, the UK coverages were separated into four areas: England (comprising seven smaller sub-areas), Scotland, Wales and Northern Ireland.

3.46 The same methodology which was used for Local DAB licence areas was also applied to identify areas which are served by BBC Radio Two FM but not by the BBC National DAB multiplex, and areas served by Classic FM but not by the Digital One DAB multiplex. In both cases, results were produced in the same format.

Summary of Deficiencies

3.47 *Scope:* review the results of the FM / DAB coverage analysis and determine which locations within the UK have a DAB coverage deficiency (shortfall) in respect of population and/or road lengths.

3.48 Coverage differences between DAB and FM networks were considered, and DAB coverage deficiencies were reviewed for both the Local services and the National services.

3.49 We categorised deficiencies by defining thresholds for the numbers of unserved adult population and lengths of roads.

3.50 These thresholds were set to disregard locations that had 'marginal' deficiencies. The aim was to draw out only those locations that had more significant coverage differentials, and which could realistically be considered for coverage shortfall solutions.

3.51 For the Local DAB licence areas, the threshold criteria for removing deficiencies were any coverage results with a population under 5000 adults and under 1% of the licence area AND any road lengths under 5km and under 1% of the licence area were removed.

3.52 A secondary stage of filtering was then applied to the resulting data by categorising the results as either 'red' or 'amber' status depending on the following criteria:

- Red Cases: over 5km and over 1% of road length AND over 5000 adults and over 1% population

- Amber Cases: over 5km but under 1% of roads (or vice versa) AND over 5000 adults but under 1% population (or vice versa)

3.53 This approach was applied to reduce the number of deficiency cases to a manageable level in advance of the next stage of the process, which was to consider possible solution options.

3.54 For the National services, a similar methodology was applied but with a minor variation: in this case the reduction criteria were applied for BBC services (BBC FM vs BBC DAB) and Commercial services (Classic FM vs Digital One).

3.55 The threshold criteria to reduce the number of deficiency cases remained the same for the Digital One network. Any clusters of deficiencies under 5000 adults and/or road lengths under 5km were not considered for possible solution options.

3.56 For the BBC network, a slightly different approach was applied: here, the population threshold was modified by removing deficiencies of less than 1000 adults. The reason for this decision was to align with a previous coverage extension programme for the BBC DAB network which considered clusters of around 1000 adult population deficiencies.

3.57 The red and amber filtering which had been applied to the Local DAB licence areas was not required for the National services as the percentage of licence area figures was not a relevant factor for National services.

Review of Potential Remedies

3.58 *Scope:* review the identified coverage deficiency cases and record potential remedies that could help to resolve coverage shortfalls in the Local DAB and National DAB networks.

3.59 Ofcom organised a number of technical workshops that were attended by spectrum planners from Ofcom, Arqiva and the BBC to review the deficiency cases and to identify possible solution These members from the BRCG have extensive knowledge of the broadcasting networks and together were well placed to propose credible solution options.

3.60 The aim of the workshops was to review and consider each deficiency case which had emerged from the coverage assessment work. These cases represented the most significant deficiencies across the Local DAB and National DAB networks.

3.61 Technical options that could potentially resolve population and/or road length deficiencies in DAB coverage were recorded.

3.62 It was recognised that there would be several options to consider. Some cases could require a new service to be transmitted from existing DAB or DTT sites, or alternatively from an entirely new site. Some cases had a single solution that could solve several deficiency cases in the same area.

3.63 For the Local DAB licence areas, a small number of cases were expected to be resolved by ‘Phase 2’ transmitters which are included in the Government’s Local DAB expansion plan. These will need to be built by the relevant Local licensees to be eligible to apply for their Local DAB multiplex service licence to be extended.

3.64 Other technical solutions were also considered such as transmitter power increases at existing DAB sites or alternative coverage from other DAB services.

3.65 A full overview of the results from this exercise are provided in the next section of this report.

3.66 Other options, such as relying on coverage of DTT multiplexes carrying radio services or considering 4G carriage of radio services were outside the scope of the Ofcom study and were considered to be in the domain of the Distribution and Coverage group studies.

4. Coverage and Deficiency Remedies: Results

4.1 This section contains a summary of the deficiency cases that were identified by Ofcom's spectrum planners as well as a summary of outputs from the deficiency solution option workshops for both Local and National DAB services.

4.2 Details of the areas which were assessed, as well as a breakdown of the deficiency cases (both pre-filtering and post-filtering based on size of deficiency) are provided. A detailed summary of how solution options were assigned to individual deficiency cases is also provided.

Local DAB Coverage Comparison Results

4.3 The Local DAB services were separated into the four nations: England, Wales, Northern Ireland and Scotland.

4.4 Tables 1 and 2 below list the Local DAB licence areas considered in the coverage assessments.

Table 1: Local DAB licence areas in England

FM-DAB Coverage Assessments_ENGLAND		
Berkshire & N Hampshire	Kent	Oxfordshire
Birmingham	Lancashire	Peterborough
Bournemouth	Leeds	Plymouth
Bradford & Huddersfield	Leicestershire	Somerset
Bristol & Bath	Lincolnshire	South Hampshire
Cambridge	Liverpool	South Yorkshire
Cornwall	London	Stoke-on-Trent
Coventry	Manchester	Suffolk
Derbyshire	Morecambe Bay	Surrey
Essex	Norfolk	Sussex
Exeter & Torbay	North Cumbria	Swindon & Wiltshire
Gloucestershire	North Devon	Teesside
Hereford & Worcestershire	North Yorkshire	Tyneside
Herts, Beds & Bucks	Northamptonshire	Wiltshire
Humberside	Nottinghamshire	Wolverhampton & Shropshire

Table 2: Local DAB licence areas in Wales, Northern Ireland and Scotland

FM-DAB Coverage Assessments_WALES	FM-DAB Coverage Assessments_N.IRELAND	FM-DAB Coverage Assessments_SCOTLAND
Mid & West Wales	Northern Ireland	Aberdeen
NE Wales & West Cheshire		Ayr
NW Wales		Edinburgh
NW Wales		Glasgow
SE Wales		Inverness
Swansea		Tayside
		Central Scotland

DAB coverage was compared with FM coverage for the following services in each region:

- England Local DAB services were compared to relevant Local BBC FM and Commercial FM services
- Wales Local DAB services were compared to BBC Radio Wales FM, BBC Radio Cymru FM and Local Commercial FM services
- Northern Ireland Local DAB services were compared to BBC Radio Ulster/Foyle FM and Local Commercial FM services
- Scotland Local DAB services were compared to BBC Radio Scotland FM, BBC Radio nan Gàidheal FM and Local Commercial FM services

4.5 A coverage comparison assessment was carried out for each Local DAB licence area. The resulting raw data formed our 'pre-filtered' deficiency cases. The threshold criteria outlined in sections 3.51-3.53 were then applied, resulting in 'post-filtered' data.

4.6 Table 3 below shows the number of deficiency cases that were identified for each Local DAB region for pre-filtered deficiency cases and post-filtered deficiency cases.

Table 3: Total number of Local DAB deficiency cases for each UK region (road length and adult population combined)

Local DAB Service Region	pre-filtered deficiency cases	post-filtered deficiency cases
England	781	348
Wales	108	71
Northern Ireland	15	11
Scotland	172	94
TOTAL	**1076**	**524**

National DAB Coverage Comparison Results

4.7 The National DAB services were separated into the four Nations: England, Wales, Northern Ireland and Scotland. England was further split into smaller sub-areas.

4.8 Table 4 below contains the names chosen to describe the England sub-areas.

Table 4: list of sub-areas in England considered for the National services

FM-DAB Coverage Assessments_ENGLAND sub-areas		
South West England	London & South East	East of England
South Midlands	West Midlands	East Midlands
	Northern England	

4.9 Although the network configuration for National DAB services is very different to the Local DAB services, the same methodology for coverage assessment comparisons was applied.

4.10 DAB coverage was compared with FM coverage for the following services in each Nation:

- BBC DAB was compared to BBC Radio 2 FM
- Digital One was compared to Classic FM

4.11 The data from the coverage comparison assessment was recorded in the same format as for the Local DAB coverage assessments. This resulted in pre-filtered deficiency cases and post-filtered deficiency cases. However as explained in sections 3.55-3.57, a slightly modified reduction threshold criterion was applied to the National services.

4.12 Table 5 below contains the number of deficiency cases that were identified for each National DAB nation and contains data for both pre-filtered deficiency cases and for post-filtered deficiency cases.

Table 5: total number of National DAB deficiency cases for each UK region (road length and adult population combined)

National DAB Service Region	pre-filtered deficiency cases		post-filtered deficiency cases	
	BBC	Digital One	BBC	Digital One
England	81	181	76	138
Wales	43	46	42	43
Northern Ireland	22	10	22	10
Scotland	22	14	20	9
TOTAL	**168**	**251**	**160**	**200**

4.13 A comparison of Tables 3 and 5 shows that there is a significant difference in the number of Local DAB deficiency cases and the National DAB deficiency cases that we identified.

4.14 It should however be noted that the regions for the National DAB coverage assessment consist of much larger areas than the Local DAB licence areas. In addition, some cases of road length deficiencies were clustered together and were recorded as a single deficiency during the National DAB assessments. This is because it would not have been practical to record each individual road length deficiency.

4.15 It should also be noted that the reduction threshold criteria for the Local DAB areas were applied after the assessment work, which resulted in high pre-filtered case numbers. The National DAB regions were assessed with the reduction threshold criteria already applied. If clusters of coverage deficiencies were under the threshold limits, they were not considered. This resulted in lower pre-filtered case numbers (compared to the Local DAB areas) and only slight reductions post-filter.

Deficiency Solution Options Workshop Outputs

4.16 The objective of the workshops was to review the post-filtered data and record possible solution options for each deficiency case.

4.17 The Local DAB services were considered separately from the National DAB services as the respective network coverage assessments had been measured against different comparisons.

4.18 Spectrum planners from Ofcom, the BBC and Arqiva collectively reviewed each case and then determined what the best technical option would be to resolve each specific coverage deficiency.

4.19 The options recorded were not the result of an exhaustive technical planning exercise (which would usually be expected to provide more precise coverage solutions). Instead, the options were based on the ‘network knowledge’ of the spectrum planners (and their respective organisations). This process was intended to produce indicative solutions based on the available data and engineering judgements, and which would improve coverage in most cases.

4.20 In some instances, a solution option was listed which would be likely to solve several different deficiency cases within a particular area.

Deficiency Remedy Options: Local DAB

4.21 The Local DAB network deficiency cases were reviewed first. It was apparent that the most common potential remedies would be to consider either a new transmitter site or to use an existing DAB or DTT transmitter site to enhance the coverage of the local service. Other technical solutions were also considered such as power increases at existing DAB sites or possible alternative coverage from neighbouring DAB services.

4.22 The solution options were recorded in a spreadsheet in a consistent format. In cases where the use of an existing DAB site was considered, an indication of whether a new antenna (NA) was likely to be required or whether an existing antenna (EA) could be used was included in the spreadsheet. An indicative power level was also recorded.

4.23 Presentation of the assessment outputs and workshop results in this manner enabled the data to be filtered and processed in a flexible way.

4.24 An 'option rating' system was also assigned to each case to help categorise each deficiency and its respective solution option. The criteria used to derive the option ratings are described below:

- **Rating 1:** Large population or long road length cases were deemed the highest priority to address;
- **Rating 2:** Lower population or road lengths and cases where the deficiencies reduced at 80% locations coverage;
- **Rating 3:** Locations which are already served (by alternative or overlap coverage from an adjacent local multiplex), or where it was deemed technically difficult to serve or identify a new transmitter site candidate;
- **Rating 4:** Locations where coverage enhancements have already been identified as part of Local DAB expansion/licence renewal conditions: therefore, no separate solutions are required in these cases.

4.25 Table 6 below contains the number of deficiency cases that were assigned to each option rating for each Local DAB region.

Table 6: total number of different option ratings assigned to the Local DAB deficiency cases

Local DAB Service Region	Deficiency Solutions Workshop - Option Ratings			
	Rating 1	Rating 2	Rating 3	Rating 4
England	48	96	55	8
Wales	1	20	18	11
Northern Ireland	2	0	0	2
Scotland	14	12	6	10
TOTAL	**65**	**128**	**79**	**31**

4.26 This data includes all Local DAB comparison results for both population and road deficiencies. If a solution was listed for both population and road length at the same location the option rating has only been counted once.

Deficiency Solution Options: National DAB

4.27 The National DAB network deficiency cases were reviewed separately. The same methodology was applied for the consideration of possible solutions and the results were

recorded in the same format. The BBC National DAB network was considered separately from the Digital One network.

4.28 The option rating system assigned to each case to help identify the difference between each deficiency and its respective solution option was again applied to the National networks with a slight variation to Rating 3 and Rating 4 as below:

- **Rating 1:** Large population or long road length cases were deemed the highest priority to address;
- **Rating 2:** Lower population or road lengths and cases where the deficiencies reduced at 80% locations coverage
- **Rating 3:** Locations deemed too technically difficult to serve or too difficult to identify a new transmitter site candidate
- **Rating 4:** No solution required - workshop investigation concludes deficiency lower than predicted

4.29 Table 7 below contains the number of deficiency cases that were assigned to each option rating for each National DAB region.

Table 7: total number of different option ratings assigned to the National DAB deficiency cases

National DAB Service Region	Deficiency Solutions Workshop - Option Ratings			
	Rating 1	Rating 2	Rating 3	Rating 4
England	39	77	14	67
Wales	20	40	12	7
Northern Ireland	5	9	14	5
Scotland	6	17	7	4
TOTAL	**70**	**143**	**47**	**83**

4.30 This data includes all National DAB comparison results for both population and road deficiencies. If a solution was listed for both population and road length at the same location the option rating has only been counted once.

4.31 In general, decisions on which cases to assign to option Ratings 1 or 2 respectively were made according to the quantitative criteria below. However, in some instances, a degree of engineering judgement needed to be applied by the spectrum planners when deciding whether specific cases should be allocated to Rating 1 or to Rating 2, and such cases were discussed during the workshops.

4.32 The general criteria used to differentiate between Rating 1 and Rating 2 were as follows:

- **Rating 1:** Adult Population cases greater than 10,000 and Road Length cases greater than 20km
- **Rating 2:** Figures less than 10,000 or 20km OR if the adult population dropped significantly at 80% locations coverage

4.33 Detailed lists of post-filtered deficiency cases for the Local and National network comparison results (which includes data on the road length and/or population numbers identified for each deficiency) can be found in Annexes to this report.

4.34 Annex 2 and Annex 3 contain the results from the deficiency solution options workshops (for the Local DAB services and the National DAB services respectively) which also contain the possible solution options (with option ratings).

5. DAB Multiplex Capacity Constraints

5.1 To identify areas where access to DAB for broadcasters is constrained by a shortage of multiplex capacity, Ofcom first reviewed current multiplex occupancy levels across the UK.

5.2 In order to assess the potential for existing multiplexes to carry more services, Ofcom analysed its internal database of multiplex information to determine current occupancy levels (i.e. the proportion of total data capacity which is currently in use on each multiplex in November 2020) for the Local multiplexes. We then identified which multiplexes were at full (or close to full) capacity. We classified multiplexes in four categories and the results and explanation of the categories is set out in table 8 below.

Table 8: Local multiplex occupancy levels

Category	No. of multiplexes	Notes
Full	16	The multiplex is not capable of accommodating further audio services. We take this as meaning that fewer than 18 capacity units remain unused, which is the minimum amount of capacity used by any audio services on the DAB platform.
Very limited availability	7	Multiplexes in this category have somewhere in the range 18 – 62 capacity units available which could accommodate one or two additional audio services operating at relatively low bitrates. These services almost certainly need to operate in DAB+ to provide an acceptable audio quality.
Limited availability	10	Multiplexes in this category had 110-167 capacity units available, and could accommodate at least one 112kbit/s stereo DAB service as well as additional services at a lower bitrate or operating in DAB+
Good availability	24	Multiplexes in this category had 168 capacity units or more available and could accommodate two 112kbit/s stereo DAB service and in most cases more services

5.3 This analysis shows that around 40% of the 57 Local multiplexes currently on-air are either full or have a very limited amount of capacity available.

5.4 Of the multiplexes identified as full or with very limited capacity, almost all[3] operate using the MPEG-1 Audio Layer II audio encoding standard (the original audio codec for DAB,

[3] One multiplex (The London 1 multiplex) carries some DAB+ services, although 80% of its capacity is occupied by DAB services.

which has been in use since the networks were first established). One option would be for those multiplexes to move to the more efficient DAB+ standard (which uses the more recent HE-AAC v2 audio codec). Migration to DAB+ could enable each multiplex to carry approximately twice as many services for an equivalent sound quality, which could provide a possible solution for the areas where multiplexes are full.

5.5 Most older DAB receivers and some cheaper new models are not compatible with DAB+ services, despite the Government's minimum receiver specification setting out that receivers must be capable of receiving DAB+ services to be able to carry the digital 'Tick Mark' logo. A full migration of all existing services to DAB+ could therefore have a negative impact on some consumers who are using older receivers.

5.6 There are however clear signs that DAB radio services are now moving to DAB+. Analysis of the UK's National multiplexes shows that 50% of programme services on these multiplexes are operating using DAB+. Six of the local multiplexes have also started to carry DAB+ services. This would suggest the market is itself moving to delivering DAB+ services without any evidence of widespread listener detriment and without regulatory intervention. This appears to strengthen the case for considering more widespread use of DAB+, which could alleviate current constraints on capacity resources and would cater for future demand for DAB carriage from new stations.

5.7 Details of capacity availability by local multiplex area is given in Table 9 below.

Table 9: Capacity availability by individual local multiplex

Local multiplex area	Capacity available	DAB+ adoption
Bradford and Huddersfield	Full	No
Edinburgh	Full	No
Glasgow	Full	No
Inverness	Full	No
Lancashire	Full	No
Leeds	Full	No
Liverpool	Full	No
Manchester	Full	No
Mid and West Wales	Full	No
Northern Ireland	Full	No
South Yorkshire	Full	No
Swansea	Full	No
Tayside	Full	No
Teesside	Full	No
Tyne and Wear	Full	No
Wolverhampton Shropshire	Full	No
Birmingham	Very limited	No
Bournemouth	Very limited	No
Humberside	Very limited	No
Leicestershire	Very limited	No
London 1	Very limited	Partial
Plymouth	Very limited	No

South East Wales	Very limited	No
Aberdeen	Limited	No
Cambridge	Limited	No
Central Scotland	Limited	No
Essex	Limited	No
Hereford and Worcester	Limited	No
London 3	Limited	No
NE Wales & West Cheshire	Limited	Partial
North West Wales	Limited	No
Nottinghamshire	Limited	No
South Hampshire	Limited	No
Ayr	Good availability	No
Berks & N Hants	Good availability	No
Bristol	Good availability	No
Cornwall	Good availability	No
Coventry	Good availability	No
Derbyshire	Good availability	No
Devon	Good availability	No
Gloucestershire	Good availability	No
Herts Beds Bucks	Good availability	No
Kent	Good availability	No
Lincolnshire	Good availability	Partial
London 2	Good availability	Partial
Norfolk	Good availability	No
North Yorkshire	Good availability	Partial
Northamptonshire	Good availability	No
Oxfordshire	Good availability	No
Peterborough	Good availability	No
Somerset	Good availability	No
Stoke-on-Trent	Good availability	No
Suffolk	Good availability	No
Surrey	Good availability	Partial
Sussex	Good availability	No
Swindon	Good availability	No
West & South Wiltshire	Good availability	No

5.8 Ofcom also considered whether there is spectrum available which could allow additional Local multiplexes to be licensed in the areas where multiplexes are currently full. We considered where spectrum exists that could support additional Local multiplex services that would provide coverage similar to existing Local multiplexes.

5.9 There is only very a limited number of unused frequency blocks in the 10B to 12D range that the UK has international rights to use at relatively high power for Local DAB.

5.10 The UK does not have international rights to use the six frequency blocks identified for small-scale DAB[4], and it is therefore not feasible to use those frequencies for further Local radio multiplex services using the same kind of transmitter network as is used by the existing Local radio multiplex services (i.e. using a small number of relatively high-power transmitters).

5.11 Applying the availability of spectrum in blocks 10B to 12D to the areas where Local DAB multiplexes are full or have very limited capacity, suggests that a spectrum-based measure could potentially be a remedy in only around one-third of cases (i.e.7 of the 23 areas that are either full or have very limited capacity available).

5.12 Ofcom's position on licensing additional Local multiplexes was last set out in our Statement on licensing small-scale DAB[5] in April 2019. In that Statement we noted the interaction between the demands made by small-scale DAB and additional Local multiplexes on a limited pool of spectrum. Ofcom therefore confirmed that it would proceed to give priority to advertising small-scale radio multiplex licences but will consider advertising further Local radio multiplex licences, where there is evidence of demand and spectrum availability permits.

5.13 As we complete successive rounds of small-scale DAB licensing, Ofcom will review the level of demand from potential applicants and consider whether it is appropriate to advertise any additional Local radio multiplex licences in areas where there would be sufficient spectrum to enable us to do so. However, it should be noted that licensing additional Local DAB multiplexes would have additional transmission costs and would consume additional electricity that would not be the case if existing multiplexes converted to DAB+.

[4] Ofcom intends to use frequency blocks 7D, 8A, 8B, 9A, 9B & 9C for small-scale DAB but may need to use some blocks in VHF channels 10, 11 and 12 in areas of high frequency congestion.
[5] https://www.ofcom.org.uk/__data/assets/pdf_file/0027/193662/statement-licensing-small-scale-dab.pdf

6. Band II and MW Spectrum

6.1 As part of this review, Ofcom investigated potential alternative (non-broadcast uses) for the spectrum currently used by AM broadcasting in the Medium Wave band (530-1603 kHz) and FM broadcasting in Band II (87.5-108 MHz).

6.2 There has been no evidence of demand or requests from stakeholders for access to Band II or MW spectrum for non-broadcasting use. We therefore reviewed market trends and manufacturer developments to consider which technologies use similar spectrum and might potentially make use of Band II or MW spectrum if it were to become available for non-broadcasting use. We also looked at developments worldwide, particularly in countries that have embarked on switching off analogue radio services or have announced plans to do so.

Potential uses

6.3 Band II and MW have very different wavelengths and propagation characteristics. In our study we concentrated on uses for Band II spectrum for a number of reasons:

a) There is a greater bandwidth available In Band II than in the Medium Wave band;

b) Band II propagation is less variable than for Medium Wave;

c) Wavelengths for Band II frequencies are more manageable allowing efficient antennas of a reasonable size to be used;

d) Band II is less susceptible to man-made noise.

6.4 The total bandwidth that would be available if the whole of Band II were to be made available is just over 20MHz. The amount of bandwidth available to any individual device using that band would most likely be significantly less, or be time-shared in some way, to manage interference between users and therefore place a limit on the data throughput capability.

6.5 In the absence of any international moves to standardise alternative technologies in Band II, potential candidates for alternative technologies that could be considered to use a modest bandwidth either planned or on an opportunistic basis include the Internet of Things Devices, White Space Devices and remote telemetry, for example by utility companies.

6.6 The Internet of Things (IoT) is the interconnection via the internet of computing devices embedded in everyday objects, enabling them to send and receive data. The popularity of IoT, and the various solutions this technology provides has resulted in increased development and a rise of use in business applications. As a result, there may be demand for Band II spectrum for IoT applications if that capacity ever becomes available. As the spectrum remains in use for broadcasting in most countries in the world, the market for such devices is small and there is no known demand at present.

6.7 White space devices (WSD) were originally considered in the UK for use amongst the TV and wireless microphone use of UHF spectrum (470-862MHz). The 800MHz and 700MHz clearance programmes have reduced the amount of spectrum available to WSDs once the DTT services had been re-allocated to a smaller portion of that band (470-694 MHz).

6.8 Potential use for WSDs included infrastructure monitoring and commercial wireless broadband applications but the concept of these devices and the demand for these applications is currently low within the marketplace which would suggest little or no demand at present for use of Band II or MW spectrum.

6.9 The possible use of this spectrum for remote telemetry by utility companies is a possibility. Development within the utilities sector of smart meters and infrastructure sensors continues, but with no current demand for access to additional spectrum. If monitoring or the transfer data requirements grow a demand for spectrum could develop.

6.10 Ofcom's studies did not conclude a clear or emerging picture of how AM and FM spectrum could be used if vacated by broadcasting.

6.11 Although several different technologies and applications were reviewed, there was no evidence of development, demand or compatible equipment that could be used if these frequency bands were vacated.

6.12 It is likely to be some time before any potential clearance of these bands takes place, so it would be appropriate to review demand closer to this point.

International activities

6.13 Ofcom also reviewed developments in countries that have switched off analogue broadcasting, or are in the process of doing so, to investigate what options these countries have identified for using the spectrum that could be released.

6.14 Norway, Italy and Switzerland are countries Ofcom identified where a total or partial switch-off is planned or has already happened.

6.15 Norway became the first country in Europe to switch off National broadcasting of its FM radio network with the preference to switch over to DAB broadcasting and provide better quality services. The transition resulted in the number of national radio stations increasing from five to thirty-one.

6.16 The Norwegian regulator decided the use of FM radio stations that serve smaller geographical areas would continue to operate until 2022. We have not been able to ascertain whether Norway intends re-allocating Band II spectrum to non-broadcasting uses, although we note that bordering countries have not announced any plans to follow Norway.

6.17 Italy has been promoting (with a view to mandating) DAB capability in receivers and (as a trial) had already switched off FM services in the South Tyrol area. Italy is not at present pursuing a national FM switch-off and has no plans for reallocating that spectrum.

6.18 Switzerland has officially announced a phased FM switch off which is expected to complete in 2023. Although the timescale for the switch-off is clear, there does not appear to be a clear indication of how the spectrum might be used in the future.

6.19 Switzerland is a relatively small land-locked country with extensive cross-border overspill reception of radio services from surrounding nations. The options for re-deployment of the FM band spectrum will most likely be limited until a wider switch-off of FM transmitters in Switzerland's neighbouring countries occurs. At present there are no signs that other countries will follow.

6.20 International comparisons do not therefore provide any clear indicators for either alternative uses or likely future demand for Band II or MW spectrum, should those bands cease to be used by broadcasters. Although candidate uses and evidence of demand may emerge if a country such as the UK were to announce a plan and timescale for switching off analogue radio, the level of interest would depend on the market size if devices are able to be used in a single-country market only.

7. Conclusions

7.1 Ofcom's contribution to the DCMS Digital Radio and Audio review followed the scope of work as detailed within this report.

7.2 The primary deliverable task was to technically analyse the National DAB and Local DAB networks and compare the coverage results against their comparative FM networks.

7.3 The results were assessed to identify coverage shortfalls in DAB services where FM coverage was otherwise available.

7.4 The data was reviewed by spectrum planners from Ofcom, the BBC and Arqiva to identify solution options which could potentially improve each coverage shortfall.

7.5 The resulting information as presented in this report was shared with the Distribution and Coverage Group to support parallel workstreams and feed directly into transmitter pricing and other costing exercises which cut across several linked topics.

7.6 The analysis produced by Ofcom was required to determine and compare the current FM and DAB networks and to identify coverage shortfalls in National DAB and Local DAB services. This allowed the broadcasting organisations to work together to produce a comprehensive report of solution options.

7.7 The work carried out by Ofcom and the options set out in this report provide an input to the DCMS Review and are not recommendations or proposals for future development to the radio broadcasting networks. The results have been provided strictly as a technical review collated in a format that could be applied to the costing exercises within the workstreams of the Distribution and Coverage Group: this was the core use of Ofcom's results to determine the costs and benefits of various options for delivering digital radio coverage.

7.8 Separately, Ofcom's review of DAB multiplex occupancy levels across the UK recognised that while multiplex capacity is constrained in some locations, adoption of DAB+ is a technically relatively straightforward option for dealing with current constraints and likely future demand for DAB capacity from programme services in the future.

7.9 Ofcom notes that making spectrum available for licensing additional Local multiplexes could only provide a solution to around one-third of the locations where Local multiplex capacity is either full or is very nearly so. Ofcom's priority in the short to medium term is to give priority to advertising small-scale radio multiplex licences but will consider advertising further Local radio multiplex licences, where there is evidence of demand and spectrum availability permits.

7.10 Finally, Ofcom's investigation of Band II and MW spectrum indicated that while there are some potential alternative uses for FM or MW spectrum if broadcasting was to ever cease using these bands, Ofcom are not aware of any significant demand from stakeholders, nor is there any evidence from other countries of demand nor plans for non-broadcast uses at present.

Caveats

a) The FM and DAB network coverage analysis was produced by Ofcom using software tools and modelling settings that align with Ofcom's working methodologies for radio broadcasting predictions and were accepted by the Broadcast Radio Coverage Group (BRCG).

b) The coverage results were based on prediction modelling and are trusted to be as accurate as possible to the real-life implemented networks, although modelling does not guarantee to provide reliable coverage on the ground in every location.

c) It should be noted that in the case of FM calculations, noise-limited coverage predictions were used. These can tend to over-predict FM coverage due to the fact that they do not consider the mutual interference between transmitter coverage areas which can sometimes occur.

d) In some cases, deficiencies identified may not in reality exist and, in some cases, deficiencies identified may be more severe than predicted but the coverage results were reviewed by BRCG members and accepted as meaningful prediction results.

e) The solution options recorded against any identified deficiency were not the result of a detailed technical planning exercise to provide precise coverage solutions.

f) The solution options were based on network knowledge which provided a best engineering estimate to generally improve the coverage shortfall(s).

g) The output of this technical work was provided to the Distribution and Coverage Group to apply the potential solution options to their costing workstream exercises.

h) The coverage percentage figures resulting from this technical review were not being produced to replace the current network figures already in the public domain. The overall aim was to compare network coverage differences not the coverage percentage figures directly.

i) Ofcom therefore considers that the resulting coverage percentage figures should not be included in this report in order avoid any inconsistency with the current published information that was produced using different prediction software tools and modelling.

A1. Technical Parameters and Settings applied to HTZ Communication Planning Software

The information below provides the technical settings applied to produce Ofcom's DAB coverage calculations.

Ofcom's Technical Policy Guidance Note for DAB licensees defines DAB coverage by field strength and percentage locations served.

The field strengths we used in our calculations mirror those in the Guidance Note and are reproduced in the table below:

Table A1: DAB coverage definitions

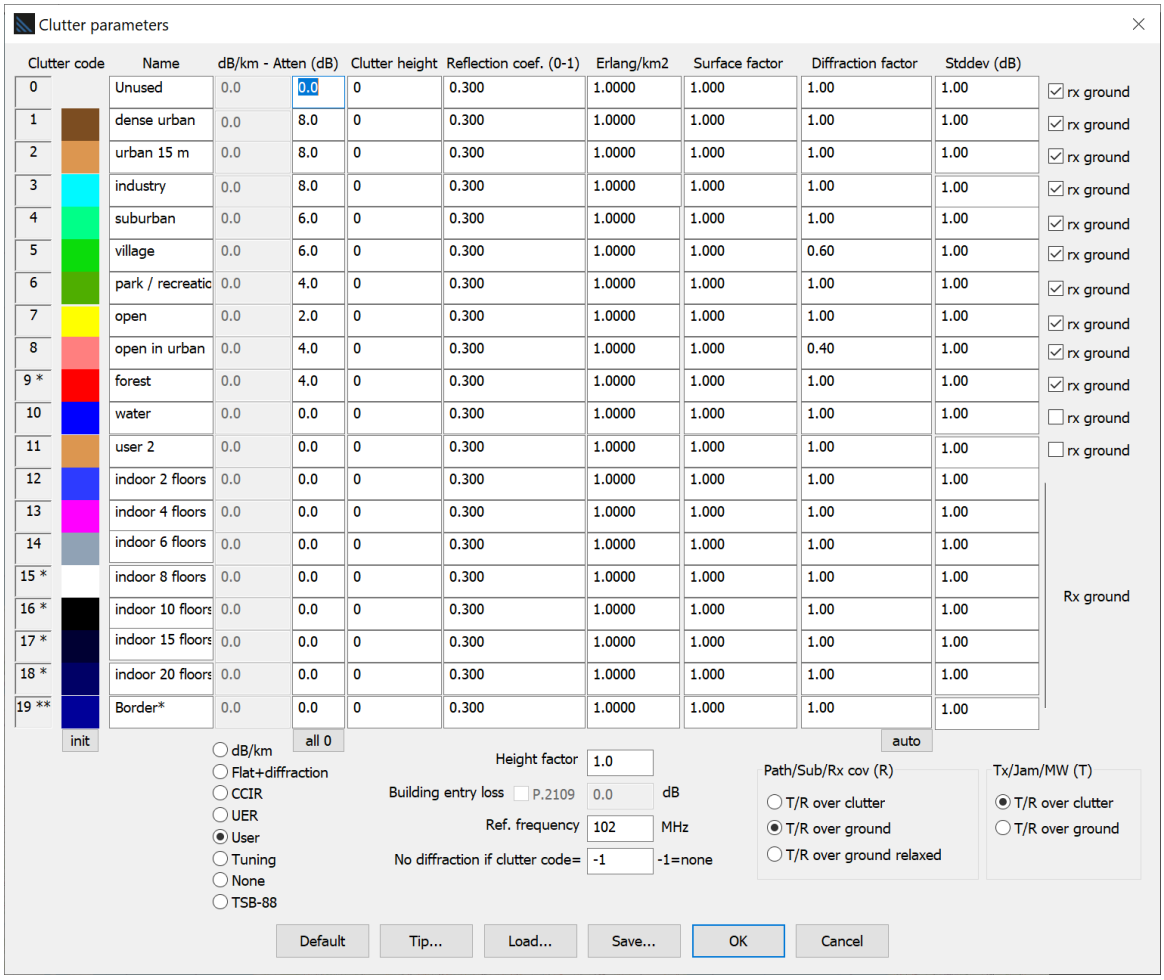
Type of coverage	Location availability	Minimum median field strength
Indoor population – robust	95%	68 dBµV/m
Indoor population – useable	80%	63 dBµV/m
Outdoor/roads	99%	54 dBµV/m

Prediction Settings

The DAB assessment reviews required prediction calculations for both wanted and interfering coverage levels. The following parameters and datasets were applied:

- Transmitter site parameters were imported from the technical parameter datasets (see section 3.10 onwards of main report) which included antenna patterns where present;
- The terrain data applied was Ordnance Survey 50m resolution;
- Infoterra clutter data was applied as shown below:

Figure A1: Infoterra clutter data screenshot



Prediction Settings – Wanted Coverage:

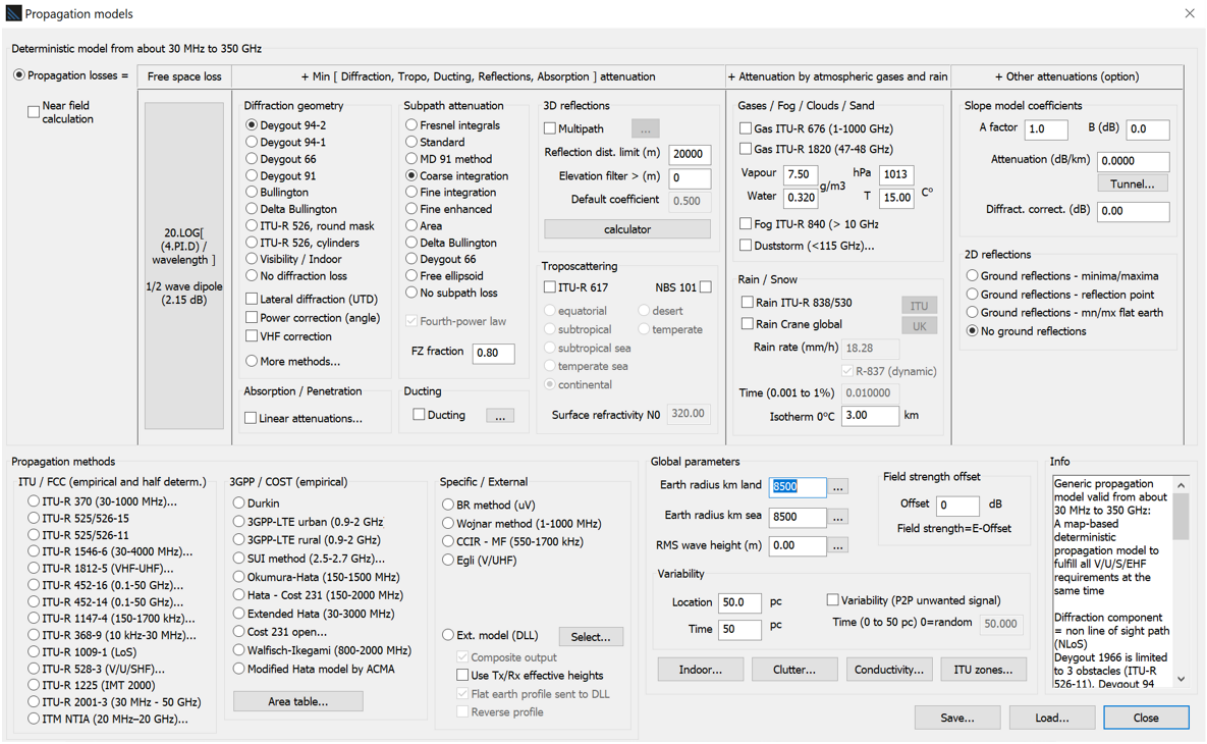
Wanted coverages predictions were carried out using a 'one and a third - 8,500km' Earth radius value and the Fresnel / Deygout model.

Coverage of the wanted sites were predicted to a radius of:

- 100km for transmitter powers up to and including 1kW;
- 150km for transmitter powers greater than 1kW.

These model settings are shown in the screen shot below:

Figure A2: Prediction model settings screenshot – Wanted coverage



Prediction Settings – Interference Coverage:

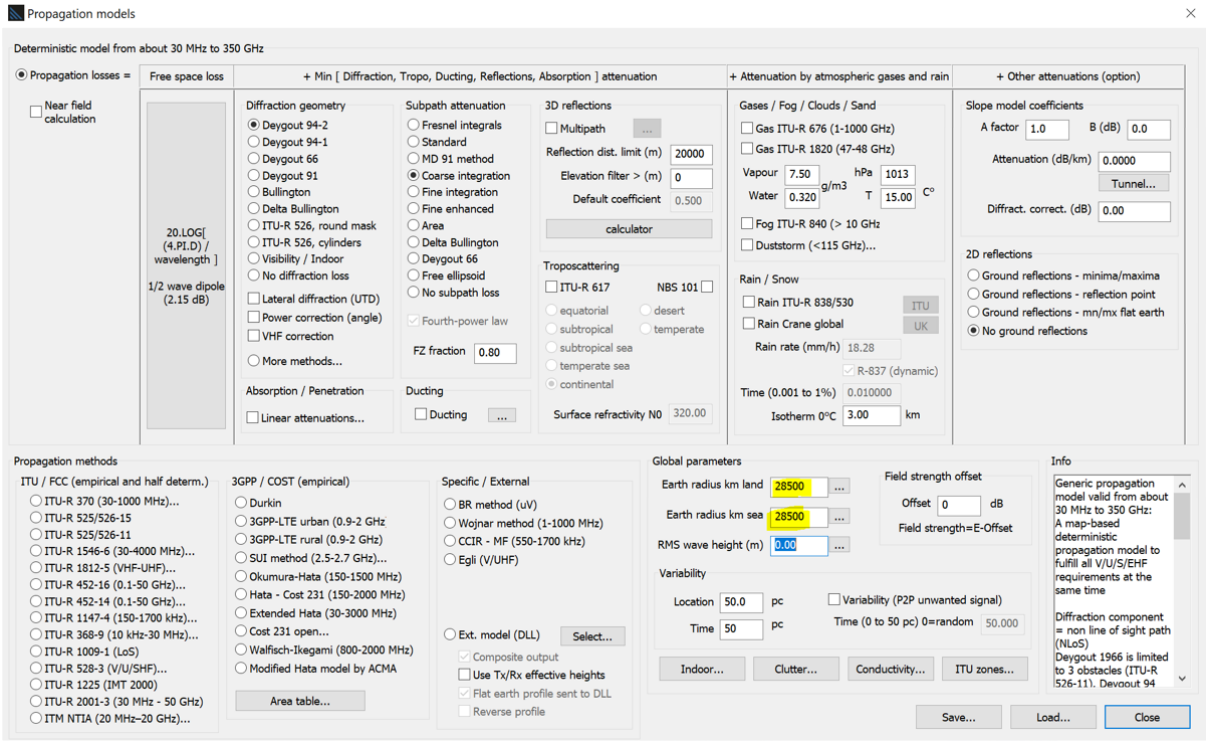
Interference coverages predictions were carried out using a ‘four and a half - 28,500km’ Earth radius value and the Fresnel / Deygout model.

Coverage of the interference sites were predicted to a radius of:

- 250km for transmitter powers up to and including 1kW;
- 350km for transmitter powers greater than 1kW.

These model settings are shown in the screen shot below:

Figure A3: Prediction model settings screenshot – Interference coverage



SFN Settings and Parameters:

The settings detailed in the list and screen shots below show the SFN settings used for the National network coverage predictions:

- The default signal parameters within HTZ Communication for DAB Mode 1 were used
- Progressive destructive and constructive field strength were included in the calculations
- The Rx. gain is set to '-2.9dBi for outdoor' (roads) and '-8.1dBi for indoor' coverage
- The KTBF setting used the default level of '-106 dBm' for the assessed frequency band
- The Margin was set to 6dB (which is linked to the Wanted threshold listed below)
- The Median C/N+I level was set to 13dB to represent the noise in a Rayleigh Channel
- The standard deviation level was set at 4dB for outdoor (roads) and 6dB for indoor coverage
- The LP (location probability) Target was set to 100% to ensure the maximum percentage locations were calculated for every pixel
- The Wanted threshold was set to 45dBµV/m for outdoor (roads) and 58dBµV/m for indoor
- Ensure the SFN = Same NetID function was selected to activate all transmitters with the same network identification parameter within the SFN to be calculated
- The Check conflicts setting was not used
- The default EBU formulas setting to ensure the SFN summation formulas defined by the EBU was applied (see EBU document BPN066 for full details)
- The Coverage from CFDw/CFDu was selected for wanted (calculated at 50%-time) and unwanted (calculated at 1%-time) prediction coverages respectfully
- The k-lnm setting for SFN summation was applied with a 'k value of 0.5' for indoor coverage and a 'k value of 0.7' for outdoor (roads) coverage

- The Synchronisation vs Pointing settings were left on the default 'first server option'
- The Rx. antenna discrimination option was set to 'none' as we assume no antenna discrimination for DAB receivers

Figure A4: HTZ SFN settings used for National Outdoor (road) DAB coverage assessments

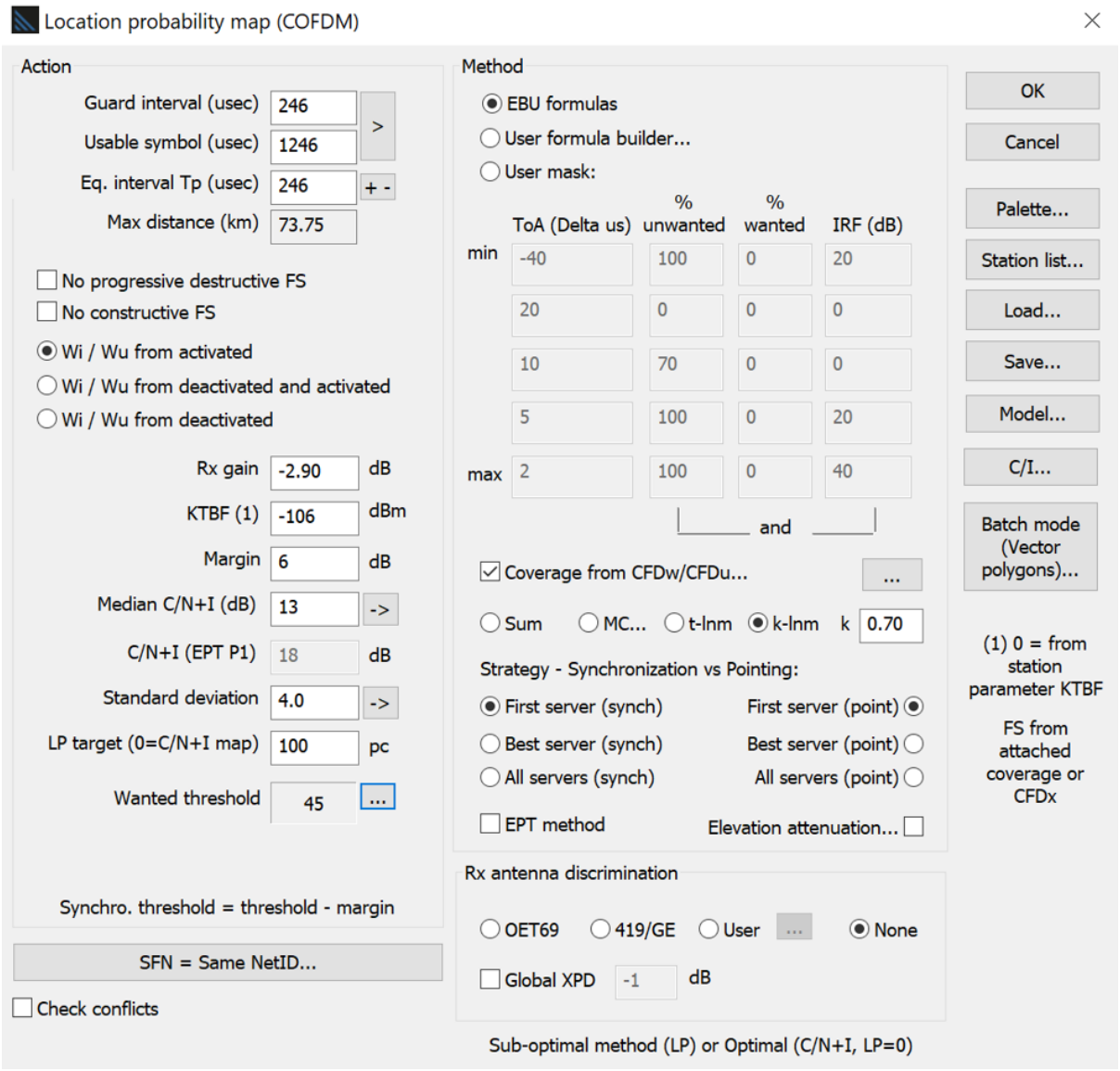
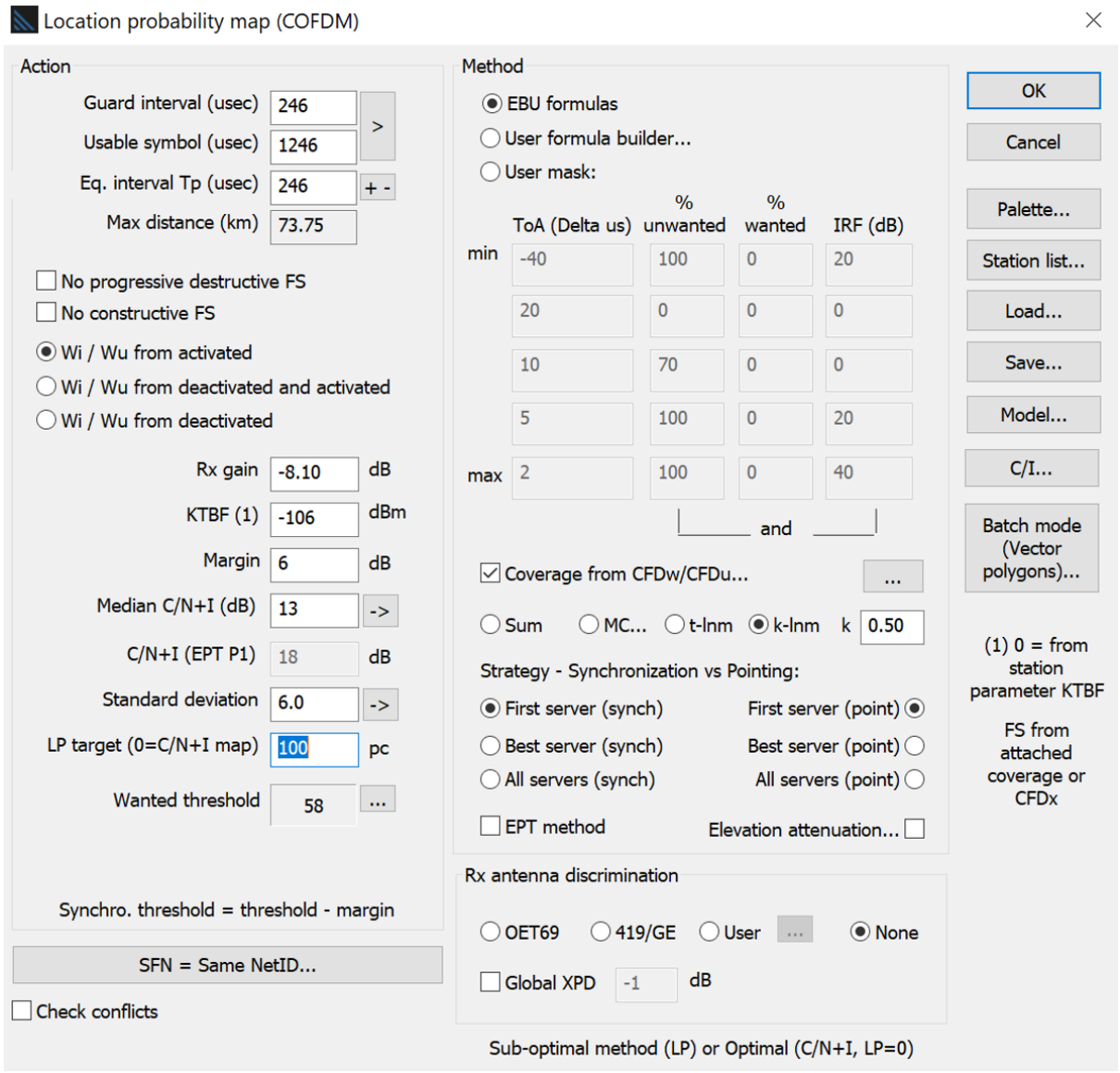


Figure A5: HTZ SFN settings used for National Indoor DAB coverage assessments



A2. Deficiency Solution Option Results: Local DAB services

This annex has been published separately on the Ofcom website

A3. Deficiency Solution Option Results: National DAB services

This annex has been published separately on the Ofcom website