# 700 MHz Clearance

# Planning Options

# Based on Existing Usage

**Study by Arqiva**

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Prepared for: Ofcom
by
Mark Jordan & Karina Beeke

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# 1. Summary

A preliminary investigation into the impact of clearing digital terrestrial television (DTT) services from the 700 MHz band has been carried out. As part of the work, three scenarios based on clearance plans which used existing 'Spectrum Rights' were considered; the three scenarios being

1. Reconstitute the three PSB layers using channels 21 to 48 but excluding the 600 MHz band, channels 31 to 38, which would remain as presently coordinated.
2. Reconstitute the three PSB layers as per scenario 1. Use any remaining spectrum, including the 600 MHz band, to recreate the three COM layers.
3. Reconstitute the three PSB and three COM layers (six layers total) using channels 21 to 48 but excluding the 600 MHz band, channels 31 to 38, which remain as presently coordinated – a total of nine layers.

The work carried out on these three scenarios has shown that, based on existing 'Spectrum Rights', it could be possible to reconstruct the three public service broadcast (PSB) layers (multiplexes) with coverage comparable to that of existing PSB services.

In addition to the PSB services, depending on how radical a solution is adopted, additional layers could be implemented. However, whilst more radical solutions, particularly those that use national SFNs, offer greater coverage or more layers or both, they become increasingly difficult to coordinate.

The success of any 700 MHz clearance plan will depend on agreement being reached by all administrations involved in the process. The key to success will be a plan that provides each administration with fair and equitable access to spectrum. With a reduction in the amount of spectrum available for DTT services, administrations may have to accept that, if planning is based on existing 'Spectrum Rights', a pro-rata reduction will be required on the number of layers sought. Applying this principle to the UK limits it to six layers, effectively eliminating the possibility of successfully coordinating scenario 3.

Consequently, basing a DTT clearance plan on existing 'Spectrum Rights' limits the UK to the first two scenarios. Scenario 1, the easier of the two to coordinate, would replicate the existing coverage of the three PSB layers and maintain the rights of the channels in the 600 MHz band. Scenario 2 should provide three layers with coverage matching that of existing PSB services as well as three COM layers with coverage comparable to existing coverage.

The investigation was originally carried out on the basis that DTT clearance of the 700 MHz band would occur some time after 2020 and at this time DVB-T2 would be the transmission standard used across Europe for the remaining broadcast spectrum. The decisions made at the recent World Radio

Conference in Geneva (WRC-12) may result in DTT clearance of the 700 MHz spectrum occurring earlier than 2020. Early DTT clearance of the 700 MHz spectrum would mean that many countries, including the UK, will not have fully migrated to DVB-T2. This will mean that any DTT clearance plan could need an option to use DVB-T which would significantly limit the planning options and would have some impact on coverage.

For the three scenarios considered,

- The PSB layers can use either DVB-T or DVB-T2.
- The 600 MHz or COM layers based on national SFNs can only operate using DVB-T2.
- The non PSB networks based on an MFN structure could use DVB-T instead of DVB-T2 albeit with some reduction in coverage.

This means that if clearance planning is based on the use of DVB-T then scenario 2 is the only viable option. Whereas this should maintain the coverage of the PSB services at existing levels, coverage of COM services will be reduced.

# 2. Introduction

Arqiva, on behalf of Ofcom, has carried out an initial investigation into the spectrum planning and coverage implications of clearing terrestrial broadcast services out of the 700 MHz band. The investigation assumed that planning for clearance could follow one of two paths.

1. A plan based on adoption of a 'Clean Sheet' approach across the whole of the planning region.
2. A plan based on existing 'Spectrum Rights' – present coordination agreements.

Both scenarios were based on channels 21 to 48 (28 channels) being available for terrestrial broadcasting, channels 49 and above being cleared of broadcast services. For both paths, the target coverage of the three public service broadcast (PSB) layers was to match the present coverage of 98.5% of UK households. The target coverage of the commercial layers (COM) is about 90% of UK households.

In the case that DTT clearance of the 700 MHz band would be based on existing 'Spectrum Rights' three scenarios were investigated.

1. Reconstitute the three PSB layers using channels 21 to 48 but excluding the 600 MHz band, channels 31 to 38, which would remain as presently coordinated.
2. Reconstitute the three PSB layers as per scenario 1. Use any remaining spectrum, including the 600 MHz band, to recreate the three COM layers.
3. Reconstitute the three PSB and three COM layers (six layers total) using channels 21 to 48 but excluding the 600 MHz band, channels 31 to 38, which remain as presently coordinated.

This report summarises the findings of the part of the investigation that dealt with DTT clearance based on existing 'Spectrum Rights'.

# 3. Background

The question facing all administrations is how to, or even whether to, reconstitute terrestrial broadcasting services moved out of the 700 MHz band.

The scale of this issue should not be underestimated. Following Geneva 06, terrestrial broadcasting had access to 48 channels; channels 21 to 69. After DTT clearance of the 800 MHz band, terrestrial broadcasting was reduced to 39 channels, channels 21 to 60.

Clearance of broadcast services from the 700 MHz band will further reduce the number of channels available for broadcasting to 28, channels 21 to 48.

The UK, because it had already planned for a digital dividend, managed to absorb the DTT clearance of the 800 MHz band without affecting coverage of the six main broadcast multiplexes. However, the loss of a further 11 channels means that unless there is a radical reappraisal of the design of terrestrial television networks, the number of planned layers will need to be reduced.

Apart from a possible reduction in the number of layers and hence services available on the terrestrial television platform, clearance of the 700 MHz band may also have a more direct impact on some viewers as their receive aerials may no longer be suitable.

Taking the UK's 800 MHz DTT clearance plan (version 6v015) as a starting point, almost half of UK stations will lose channels used by the six main multiplexes; these stations serving approximately half of the UK's population, Table 1.

| Channels Lost | Primary Sites | Households Affected | Relay Sites | Households Affected |
|---|---|---|---|---|
| 6 | 15 | 4,292,662 | 0 | 0 |
| 5 | 5 | 1,796,638 | 0 | 0 |
| 4 | 2 | 124,182 | 0 | 0 |
| 3 | 7 | 1,082,837 | 329 | 914,260 |
| 2 | 11 | 3,760,278 | 54 | 121,161 |
| 1 | 1 | 242,326 | 92 | 144,310 |
| 0 | 41 | 13,159,728 | 600 | 1,841,530 |

Table 1: Channel loss across UK network sites as a result of 700 MHz Clearance.

Clearance of the 700 MHz band may also have a more significant impact on viewers than DSO and 800 MHz clearance. Unlike DSO and 800 MHz clearance, where channel changes were kept within existing receive aerial groups to minimise impact to viewers, clearance of the 700 MHz band will mean that 18 primary stations and over 300 relays will go out of group. Viewers of these stations, up to 30% of the UK's population, may have to replace their existing receive aerials.

# 4. International Coordination

The key to successful clearance of the 700 MHz band is agreement across Europe to the changes required.

## *4.1. Overview*

The two paths considered for clearance, a 'Clean Sheet' plan and a plan based on existing 'Spectrum Rights' will require different approaches to planning and coordination.

A 'Clean Sheet' path, being a complete re-plan, would necessitate a common approach across the whole planning area and would involve one or more planning conferences to establish the planning method and a plan.

A plan based on existing 'Spectrum Rights', being an adjustment of the existing plan, could be developed on a local level in a manner similar to that adopted for the DTT clearance of the 800 MHz band.

Whichever path is adopted, the coordination and planning process will be protracted. The coordination processes associated with the planning for the Geneva 06 agreement and that for the subsequent DTT clearance of the 800 MHz band each lasted about 4 years. Clearance of the 700 MHz band, which might be viewed as more complicated than the two previous planning exercises, could take longer.

Of the two approaches to re-planning, the 'Clean Sheet' offers the best opportunity for an equitable, truly digital plan for terrestrial television that makes best use of the spectrum efficiencies offered by emerging technologies such as DVB-T2. However, it would require consensus across the whole planning area, and given the disparate requirements and goals of the administrations within the area, agreement for such an approach may be difficult. Even if agreement could be reached, the task of transitioning from the existing terrestrial network plan to the new plan is likely to be daunting.

Basing clearance on existing 'Spectrum Rights' should be simpler and will keep changes to a minimum, allowing some reuse of existing infrastructure and networks. It should be easier to agree a clearance plan as detailed agreement is only required locally and not across the whole planning area. Adjoining administrations would be able to agree clearance on a bilateral and/or multilateral level in a manner similar to the approach adopted for 800 MHz DTT clearance. Whilst this approach may be easier to implement than the 'Clean Sheet' it will still be a plan with its roots in the Stockholm '61 analogue plan and, as such, will not provide the potential efficiencies or equitable access to spectrum that a 'Clean Sheet' plan offers.

## *4.2. Access to Spectrum*

For any plan to succeed, the principles adopted for planning must be based on providing fair access to spectrum. This is often referred to as equitable

access although due to the different types of network configuration and deployment in each country, equitable access has previously proved difficult to define and agree.

Whilst basing planning on existing 'Spectrum Rights' would at first glance appear to be a reasonable approach for providing fair and equitable access to spectrum, variation in individual administration's rights means that some have much better access to channels 21 to 48 than others. France, for example, appears to have much better positions with respect to the existing allocation of channels below the 700 MHz band than do other administrations such as Germany and Belgium. Also there are administrations, such as the UK, who whilst having good access to channels 21 to 48 spread across the country, are short on channels below 700 MHz in particular areas where coordination is difficult; in the case of the UK in the south-east.

So though planning could be based on existing 'Spectrum Rights', administrations must recognise that, to maintain the principle of fair and equitable access, some concessions and alterations to existing plans must be made. Each administration's aspirations in terms of spectrum access and the number of layers they have available for terrestrial broadcasting will need to be moderated.

To meet the requirements of all, it is likely that a number of administrations will need to reduce the number of layers they seek and there may also have to be some aggregation of requirements. To improve the availability of channels, some requirements may need to be combined and more extensive use of larger single frequency networks will be required, particularly in areas where spectrum is in short supply.

If planning is to be based on existing 'Spectrum Rights' then, with a reduced number of channels available for terrestrial broadcasting, administrations will need to accept a pro-rata reduction in the number of layers. Of the countries directly affecting the UK, in the Geneva-06 agreement, Holland and Belgium had 7 layer plans based on portable reception whilst the UK, France and Ireland had 8 layer plans designed for fixed reception.

Following DTT clearance of the 800 MHz band, the Netherlands and Belgium reduced the number of layers they had to 6, the UK, France and Ireland maintained 8 layer plans, although in many cases the coverage levels have been eroded to some degree compared to the GE06 plan. Following clearance of the 700 MHz band, administrations will need to accept that planning based on existing 'Spectrum Rights' will result in a reduction in the number of layers. In this study, in the case of the Netherlands and Belgium, each country would potentially need to reduce their requirements by 2 layers compared to their Geneva-06 position, leaving them with 5 layers. On a similar basis, the UK, France and Ireland would also need to reduce their requirements by 2 layers leaving them with 6 layers.

An attempt by any administration to seek a greater number of layers could be viewed as unfair and not equitable. Such an action could be divisive in terms of the coordination process and could prolong or jeopardise agreement on a 700 MHz DTT clearance plan.

The need to seek access to a fair number of layers may preclude the UK seeking more than 6 layers as in the third planning option investigated.

### 4.2.1. United Kingdom

Access to spectrum for the UK, as a result of 700 MHz clearance, will be difficult at stations that lose four or more of the channels assigned to the main multiplexes. Of these stations, because of the differences in planning methods and existing spectrum rights, those in the south-east of England will be the most difficult to coordinate. It is anticipated that solutions for stations that interact with Ireland, will be easier to agree because Irish planning methods are comparable to the UK's and their access to spectrum post clearance will be similar to the UK's, i.e. we should be negotiating from a similar position.

In terms of the impact of 700 MHz clearance and coordination, the most difficult site in the UK to find alternative channels for, because of its position relative to the Continent, will be Dover. 700 MHz clearance at Dover will result in the site losing five of its six main multiplex channels, including the three channels used by PSB services. In addition to Dover, two other primary sites in the south-east will prove difficult to coordinate, Whitehawk Hill and Midhurst. 700 MHz clearance will result in both sites losing all six channels assigned to the main multiplexes.

There will be no easy solution for Dover with any solution likely to be controversial with France, Belgium and Holland. For 800 MHz DTT clearance, three channels had to be found for Dover, channels 33, 35 for layers 7 & 8 and channel 48 for the commercial multiplex COM6. None of these channels were ideal; because of large restrictions and high incoming levels of interference their coverage being lower than the channels they replaced.

Reconstituting the PSB services requires three new channels each with better coverage than that of the one remaining main multiplex channel at Dover, channel 48. UK regional requirements for PSB services, as well as interactions with the Continent, effectively rule out operating Dover as part of an SFN with another UK main station. If the UK can not source suitable channels from its existing 'Spectrum Rights' it will need to receive/exchange spectrum with neighbouring administrations, potentially a very controversial step. Based on spectrum usage in the area of the English Channel the best solution for Dover appears to be to use channels 39, 42 and 45 for the PSB services.

This would require negotiations with France (channels 42 and 45 are presently assigned to Dunkerque) and the Flemish Belgian community (channel 39 is currently assigned to the Oost Vlaanderen allotment).

For Whitehawk Hill it is proposed that, as with Dover, channels 39, 42 and 45 are adopted. At Midhurst it is proposed that channels 40, 43 and 46 are adopted. France will ask for protection for its stations, but in both cases these should be no more onerous than existing restrictions.

Compared with these three stations, changes required at other UK stations to reconstitute the three PSB layers are of lesser consequence.

### 4.2.2. France

Of all the countries in the area that affect the UK, France is in the best position to implement 700 MHz clearance within its existing 'Spectrum Rights'. Of the main stations that border Germany, Luxembourg, Belgium and those that interact with the UK, only three stations have fewer than six channels based on existing rights after 700 MHz clearance; Cherbourg (5), Abbeville (5) and Amiens (4). France should be able to, fairly easily, fill these deficiencies by reallocating rights from stations having more than six channels after clearance.

As France can readily satisfy a requirement for six layers, it will come under pressure from neighbouring administrations, including the UK, to release or share allocations to allow its neighbours to ease the spectrum deficiencies they have.

For any plan based on existing rights to succeed, France would have to cooperate with its neighbours and in some cases agree to redistribute some of its existing spectrum allocation rights.

For the purposes of assessing UK coverage in this study, France has been assumed to retain all existing rights including channels 42 and 45 at Dunkerque. To protect coverage of Dover on channels 42 and 45, the ERP of these channels at Dunkerque, towards the UK, has been reduced by 9 dB.

### 4.2.3. Belgium

Belgium is divided into three separate areas, French, Flemish and German communities, each with their own spectrum requirements.

Within each of the two main areas that comprise the Flemish Community, Oost Vlaanderen and the combined areas of Antwerpen, Vlaams Brabant and Limburg, it should be possible to reconstitute five layers plus have access to additional spectrum in Brussels.

The German community has exclusive access to three channels post 800 MHz DTT clearance; channels 22, 32 and 34. These channels will remain available post 700 MHz clearance.

The French community only has access to two channels in the western half of its territories and two channels in the eastern half. No satisfactory 6 layer solution was found for the French community as part of 800 MHz clearance; a solution for the area has been deferred until the existing DTT licences in

neighbouring countries expire in 2017. The situation would be considerably worse when considering 700 MHz clearance. In this study, no obvious solution presents itself to solving the spectrum shortage within the area of the French community.

The solution to a potential spectrum shortage in the French community lies primarily with all neighbouring countries particularly France and Germany. These countries would need to adapt their plans and aspirations to allow a solution in Belgium. Without their cooperation it is unlikely that Belgium will be able to achieve access to five layers and this may jeopardise agreement on clearance between all the countries that border the North Sea.

In this study, for the purposes of assessing UK coverage of the three scenarios based on clearance using 'Existing Rights' it has been assumed that the arrangement of allotments in Belgium and the channel assignments to stations in the allotments is rearranged as shown in Table 2

| Area | Channels |
|---|---|
| Oost Vlaanderen | 22, 34, 40, 43, 46 |
| Antwerpen, Vlaams Brabant, Limburg | 25, 39, 41, 44, 47 |
| Western French Community | 29, 33 |
| Eastern French Community | 28, 42 |
| German Community | 22, 32, 34 |

Table 2 : Channel assignments in Belgium assumed for planning study

### 4.2.4. Luxembourg

Subject to final agreement of 800 MHz clearance in the area around Luxembourg, for which a solution has been delayed until post 2017, Luxembourg could have 'Spectrum Rights' to five layers post 700 MHz clearance. If the 800 MHz clearance proposals are not ratified for a solution for post 2017, Luxembourg may be seeking one and possibly two channels to create five layers for the 700 MHz DTT clearance. As spectrum in this area is in very short supply, it is unclear if a solution for the extra channels in Luxembourg could be determined.

Luxembourg does not directly affect UK coordination and is not included in UK coverage calculations.

### 4.2.5. The Netherlands

With some rationalisation of allotment areas, it should be possible to reconstitute five layers in all areas of the Netherlands apart from the Brabant/Limburg region. Only three channels could be identified for use in this area.

Brabant/Limburg borders Germany, all three of Belgium's communities and is within a short distance of Luxembourg. This is an area of Europe where spectrum is scarce and there is no obvious source for the additional channels required by the Netherlands.

In this study, for the purposes of assessing UK coverage of the three scenarios based on clearance using 'Existing Rights', it has been assumed that the arrangement of allotments in the Netherlands and the channel assignments to stations in the allotments is re-arranged as shown in Table 3

| Area | Channels |
|---|---|
| Zeeland | 29, 32, 35, 36, 48 |
| Zuid & Noord Holland | 21,24,27,28,45 |
| Friesland & the Islands | 29,31,34,35,39 |
| Groningen/Drenthe | 25,30,33,40,46 |
| Overijssel/Gelderland | 23,26,36,42,47 |
| Brabant/Limburg | 27/30,31,33 |

Table3 : Channel assignments in the Netherlands assumed for planning study

### 4.2.6. Germany

Whereas Germany does not directly affect UK spectrum use, it does have a secondary effect. German spectrum usage dictates availability in eastern Belgium and Holland which ripples through to spectrum usage in the western part of those countries which in turn then affects the UK.

Whilst Germany has good access to spectrum because of its size, its position along the borders with the Netherlands, Belgium, Luxembourg and France means that spectrum is scarce. Post 700 MHz clearance, it will be left with between two and five layers for its stations along its western border. To reconstitute five layers will be difficult especially as each of the sixteen German Länder have their own spectrum requirements in a manner similar to that of the Belgian communities.

Finding spectrum in the areas adjoining Luxembourg, Belgium and the Dutch province of Limburg will be difficult especially as those countries also have spectrum shortages in the areas adjoining Germany.

As German stations do not directly affect UK coverage and creating a German plan for this study was beyond the scope of the investigation, for the purpose of assessing UK coverage German assignments have been excluded.

### 4.2.7. Ireland

The Irish terrestrial plan is very similar to that of the UK in the way channels are used. Consequently the impact of 700 MHz clearance on Irish stations is similar to that on UK stations. Ireland has two main stations and a major relay, that lose all the channels allocated to its first six layers, Truskmore, Clermont Carn and Monaghan. It also has a number of other primary stations that lose a number of channels allocated to its first six layers, Kippure, Three Rock and Spur Hill.

The Irish position is not dissimilar to that of the UK which loses all its channels for the six main layers at Winter Hill and Limavady and has several other

stations that lose channels allocated to the six main layers, Carmel, Huntshaw Cross and Llanddona.

Since both countries could have similar issues, it will probably be to their mutual benefit to adopt a similar approach to reconstituting missing layers.

For the purposes of assessing UK coverage, of the three scenarios based on clearance using 'Existing Rights' in this study, it has been assumed that the channels used at the main sites that lose their assignments for the first six layers as part of clearance are as shown in Table 4.

| Station | Channels |
|---|---|
| Clermont Carn | 35, 40, 43, 46, 48 |
| Truskmore | 35, 40, 43, 46, 48 |
| Monaghan | 39,42,45 |

Table 4: Channel assignments in this study for Irish stations losing the six main channels

At the remaining Irish sites it has been assumed that they retain existing channel allocations.

## *4.3. Coordination Summary*

Whilst it may be possible to reconstitute a sufficient number of layers in areas immediately adjacent to the UK to enable 700 MHz clearance based on existing 'Spectrum Rights', spectrum shortages in the border areas of Belgium, the Netherlands, Luxembourg and Germany may prevent agreement of an optimised plan.

For spectrum clearance based on existing 'Spectrum Rights' to succeed in Western Europe, it is essential that a workable solution is found to provide access to the prerequisite number of layers in this area.

# 5. Method

In this study the three scenarios based on existing 'Spectrum Rights' have been planned using the UK's 6v015 800 MHz DTT clearance plan as a starting point. To make the process of investigating coverage of the three scenarios manageable, planning has been limited to the 80 primary DTT stations.

As coverage of a network composed of just the 80 primary sites would be different to the full network, the coverage of the 80 primary sites in the 6v015 plan has been calculated to provide a baseline against which to assess coverage of each of the scenarios.

Coverage calculations have assumed that UK stations will use a DVB-T2 mode with similar C/N performance to that adopted by the UK for use by the existing HD terrestrial multiplex; the guard interval being chosen to suit the needs of any single frequency networks employed.

Irish and Continental interference was based on the interference files used for calculating the 6v015 plan modified by the assumptions outlined in section 4. German and Scandinavian stations, which have little impact on UK coverage, have been excluded from the calculations.

Antenna patterns used for the coverage calculations where a channel had not changed were based on existing patterns.

Where a PSB service has adopted a COM channel, the PSB service, where existing coordination permits, uses the same ERP as the channel it replaced.

In order to avoid overestimating coverage, new channels at sites where there is no existing coordination had the antenna patterns or the ERP restricted to a conservative level.

Coverage calculations of 600 MHz layers are based on the services operating at 10 dB below existing post-DSO PSB ERP levels. Patterns have been selected to meet agreed coordination restrictions.

Where 600 MHz channels have been used to reconstruct the COM layers, the services have been operated at powers similar to the existing COM layers, where antenna patterns and coordination permit.

# 6. Scenario 1 – 3PSB + 600 MHz

This scenario investigated the coverage that could be achieved if the 600 MHz spectrum remained as planned and coordinated and the remaining spectrum was used to recreate the three PSB services
The PSB channels have been planned using a systematic approach, with changes to the network kept to a minimum. The need to keep changes to a minimum means that, even with 20 channels assigned to the PSB services, the solution may be sub-optimal. Channels have been assigned as follows,

- Where PSB channels are unaffected by clearance, they remain in use (e.g. Crystal Palace).
- In cases where 700 MHz clearance dictates that PSB channels are lost but COM channels remain, the PSB services inherit the COM channels (e.g. Llanddona )
- Where a station loses more than three channels, it adopts COM services from a neighbouring station (e.g. Waltham)

There are exceptions; the main one being Winter Hill which, for internal coordination reasons, takes the channels used by the PSB services at Moel-y-Parc.

The main changes are listed below and are shown graphically in Figure 1.

**Winter Hill** adopts Moel-y-Parc PSB channels 39, 42 and 45 which means **Moel-y-Parc** moves on to channels 41, 44 and 47.
**Oxford** and **Salisbury** use channels 41, 44 and 47 (released by Hannington COMs) which means **Hemel Hempstead** has to move on to channel 40, 43 and 46.
**Waltham** uses channels 39, 42 and 45 (released by Sutton Coldfield and Tacolneston COMs) which means **Tacolneston** needs to use channels 40, 43 and 46.
**Huntshaw Cross** uses channels 21, 24 and 27 released by Caradon Hill COMs.
**Carmel** uses channels 39, 42 and 45 released by Presely and Wenvoe COMs.
**Limavady** uses channels 41, 44 and 47 which are shared with its relay at Londonderry. The two stations will need to work as part of an SFN.
**Selkirk** and **Angus** both use channels 41, 44 and 47 released by Black Hill COMs.
**Pontop Pike** uses channels 40, 43 and 46 released by Bilsdale COMs.
**Beacon Hill** uses two of its existing COM channels 42 and 45 and adopts channel 39, an unused GE-06 position moved from Redruth.
**Mendip** uses channels 40, 43 and 46. This is not an ideal situation from an internal UK point of view as it puts the station co-channel with Sutton Coldfield; however, it keeps changes within the network to a minimum and avoids a potential coordination difficulty with France.

**Midhurst** adopts channels 40, 43 and 46 which means that **Guildford** has to move to channels 41, 44 and 47 vacated by Hemel Hempstead.
**Whitehawk Hill** adopts channels 39, 42 and 45
**Dover** adopts channels 39, 42 and 45 redistributed from France and Belgium

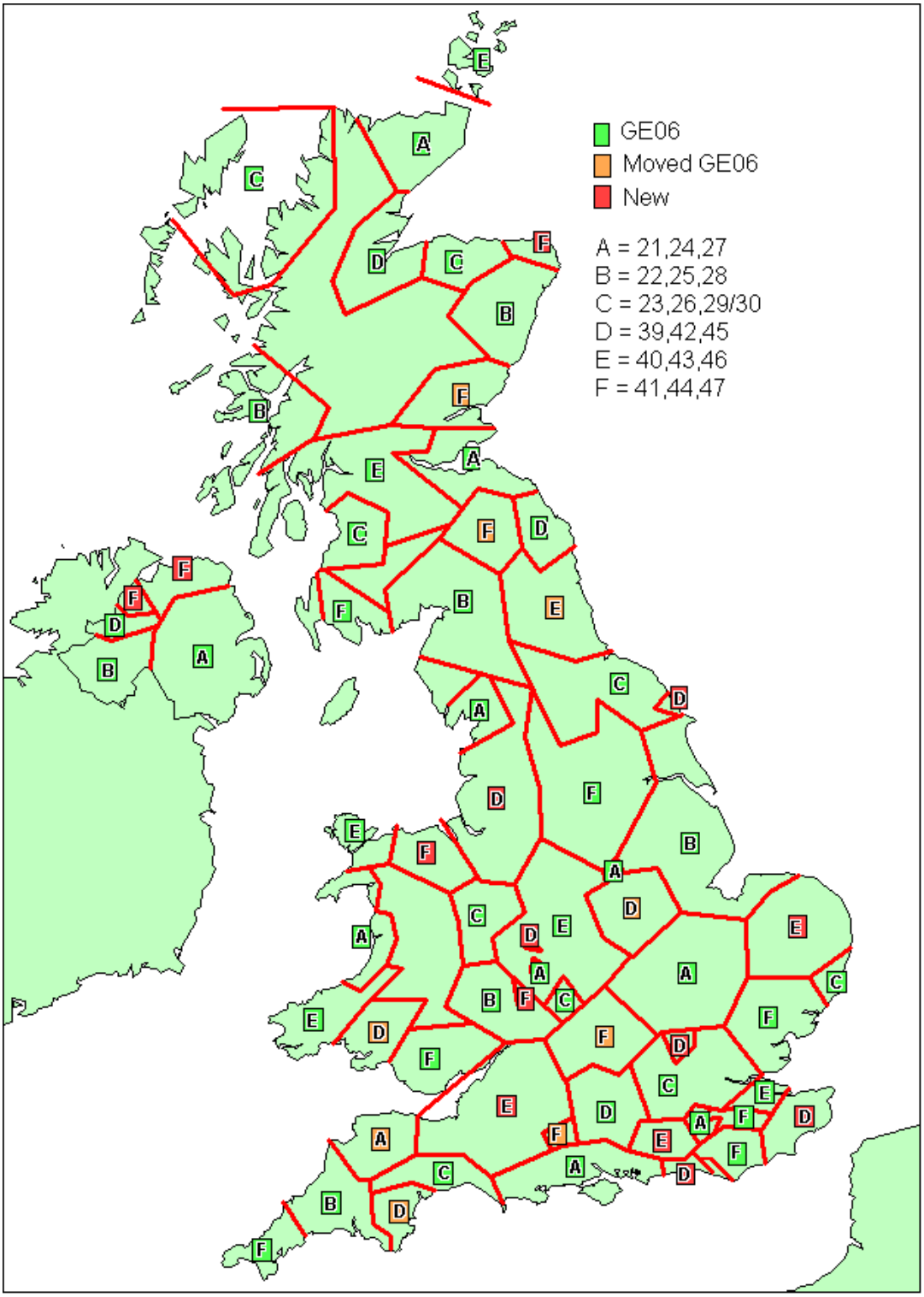


Figure 1: Scenario 1 channel redistribution to recreate the PSB layer following DTT clearance of the 700 MHz band.

It should be noted that the above map shows representative non overlapping service areas of the stations serving distinct areas. In some cases this includes stations that are not one of the 80 primary sites. Notable amongst these are the area around Peterhead in north-east Scotland, Londonderry and Strabane in Northern Ireland and Cambret Hill in south-west Scotland. Also for clarity some of the relay stations included within the primary 80 sites are not shown, e.g. Chesterfield, Idle, Keighley, Guildford etc.

## *6.1. Coordination*

The success of any UK 700 MHz clearance plan will completely depend on the ability to internationally coordinate a proposed solution with neighbouring countries.

### 6.1.1. PSB Layer coordination

Of the 80 primary stations, coordination of 71 should be straight forward. At these 71 stations either existing channels are used or the station has no direct impact on neighbouring administrations.

Of the remaining stations new channels at:

- Winter Hill, Limavady, Moel-y-Parc, Carmel and Huntshaw Cross will need to be negotiated with Ireland.
- Tacolneston and Dover will need to be coordinated with the Netherlands, Belgium and France.
- Whitehawk Hill and Midhurst will be need to be coordinated with France.

### 6.1.2. 600 MHz coordination

As there are no changes proposed to the UK's existing coordinated position for the channels in the 600 MHz band, coordination of these channels would simply be a case of protecting existing rights.

## *6.2. Coverage*

Coverage of the PSB layers following 700 MHz DTT clearance can be compared directly with the baseline numbers in order to draw any conclusions as to the efficacy of the proposed solution.

A similar comparison of the coverage of the 600 MHz layers cannot be made as at present there is no existing implemented coverage.

### 6.2.1. Baseline

The predicted coverage[1] of the 80 primary sites is shown in Table 5. Overall UK 3PSB coverage of the 80 sites is 94.6%, which should be compared with the 98.5% coverage figure achieved by a full network of over 1150 sites. The 6CORE coverage of 90.8% is slightly higher than normally achieved by the full network, as the coverage of the COM layers, which are only transmitted from the 80 primary sites, is not reduced by interference from the PSB relay network.

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| Nation | PSB_1 | PSB_2 | PSB_3 | COM_4 | COM_5 | COM_6 | | 3PSB | 6CORE | 3COM |
|---|---|---|---|---|---|---|---|---|---|---|
| Wales | 1,147,428 | 1,139,414 | 1,135,294 | 1,065,209 | 1,056,019 | 1,058,125 | | 1,127,401 | 1,032,261 | 1,044,514 |
| Scotland | 2,313,124 | 2,321,319 | 2,336,863 | 2,231,303 | 2,227,607 | 2,222,969 | | 2,305,218 | 2,209,233 | 2,213,155 |
| Northern Ireland | 619,464 | 614,327 | 613,200 | 533,999 | 532,572 | 532,524 | | 610,146 | 521,311 | 523,965 |
| England | 22,246,440 | 22,288,239 | 22,221,702 | 21,789,926 | 21,727,545 | 21,802,908 | | 22,037,915 | 21,284,431 | 21,448,983 |
| United Kingdom | 26,326,456 | 26,363,299 | 26,307,059 | 25,620,437 | 25,543,743 | 25,616,526 | | 26,080,680 | 25,047,236 | 25,230,617 |
| | 95.5% | 95.6% | 95.4% | 92.9% | 92.6% | 92.9% | | 94.6% | 90.8% | 91.5% |

Table 5 : Baseline coverage of a network of the 80 primary sites based on the version 6.015 of the UK 800 MHZ DTT clearance plan

### 6.2.2. Scenario 1

Calculated coverage of the PSB layers of the network proposed for Scenario 1 is shown in Table 6. Total UK coverage of the PSB layers is comparable to that of the PSB layers prior to DTT clearance of the 700 MHz band.

Coverage of the three 600 MHz layers based on the assumptions adopted are shown in table 6 in the columns marked Lay 7, Lay 8 and Lay 9. Lay 9 is a national SFN using channel 36. Lay 7 is composed of channels 31, 32 and 33. Lay 8 uses channels 34, 35 and 37.

**Scenario 1**

| Nation | PSB_1 | PSB_2 | PSB_3 | Lay_7 | Lay_8 | Lay_9 | | 3PSB | 6CORE | 3LAY |
|---|---|---|---|---|---|---|---|---|---|---|
| Wales | 1,147,376 | 1,140,747 | 1,133,900 | 950,154 | 884,091 | 1,054,920 | | 1,129,937 | 872,155 | 877,393 |
| Scotland | 2,347,453 | 2,345,091 | 2,341,610 | 2,181,830 | 2,150,265 | 2,222,100 | | 2,332,574 | 2,143,522 | 2,145,989 |
| Northern Ireland | 626,888 | 625,462 | 630,236 | 354,806 | 320,354 | 329,323 | | 623,422 | 256,260 | 256,260 |
| England | 22,172,339 | 22,261,488 | 22,121,956 | 19,664,367 | 19,227,307 | 21,381,305 | | 22,015,122 | 18,517,409 | 18,606,501 |
| United Kingdom | 26,294,056 | 26,372,788 | 26,227,702 | 23,151,157 | 22,582,017 | 24,987,648 | | 26,101,055 | 21,789,346 | 21,886,143 |
| | 99.9% | 100.0% | 99.7% | 90.4% | 88.4% | 97.5% | | 100.1% | 87.0% | 86.7% |

Table 6 : Scenario 1 coverage of a network of the 80 primary sites, three PSB layers plus three existing 600 MHz layers.

## *6.3. Discussion*

Based on the assumptions adopted for Scenario 1 it should be possible to maintain three PSB layers with coverage equal to that prior to 700 MHz band DTT clearance. The approach taken in scenario 1 was minimal change. This results in a non ideal distribution of channels and sub-optimal coverage. Coverage could probably be improved by adopting a plan that allowed a greater number of changes. The ideal solution would be a compromise between the amount of re-engineering accepted, difficulty of coordination and coverage achieved.

[1] Coverage numbers are based on 27,579,096 UK households.

The systematic approach adopted means that, as it is not part of any standard channel grouping, channel 48 is unused.

As the 600 MHz layers are clear of 700 MHz, services planned for these channels would be unaffected. In fact, coverage of the 600 MHz channels could be improved post 700 MHz clearance as, presently, services planned for these channels are limited by access to infrastructure.

Channel 38 remains available to PMSE.

# 7. Scenario 2 – 3PSB + 3COM

This scenario investigated the coverage that could be achieved if the three PSB layers were planned in the same manner as scenario 1 and the three COM layers were reconstructed from the 600 MHz channels plus unused or lightly used channels allocated to the PSB layers, channels 48, 29 and 30.

The first pass of the plan used the same channel allocations for PSB services as scenario 1. As this resulted in about a 1% fall in PSB coverage, due to use of channels 29 and 30 by the COM layers, the allocation of channels was iterated twice to improve coverage. This resulted in the changes to the scenario 1 channel allocation as listed below. The channel allocation is summarised graphically in Figure 2.

**Mendip** uses channels 39, 42 and 45 released by the COM services at Wenvoe. As a consequence **Hannington** PSB services have to move off channels 39, 42 and 45 on to channels 40, 43 and 46.
**Midhurst** uses channels 39, 42 and 45 released by the PSB services at Hannington.
With Mendip using channels 39, 42 and 45, **Beacon Hill** has to move on to channels 40, 43 and 46.
**Whitehawk Hill** uses channels 40, 43 and 46.
To release channel 30 for use by the COM services, the PSB layer on channel 30 at **The Wrekin** has been moved on to channel 29.

The first COM layer, COM6 has been constructed using channels 29, 30, 36 and 48, arranged as shown in Figure 3. The second two COM layers are composed of channels 31, 32 and 33 for COM5 and channels 34, 35 and 37 for COM6.

Whilst COM5 and COM6 use the same channels as 600 MHz Layers 7 & 8 in scenario 1, the ERP of the services has been increased – within coordination limits. As such, coverage of COM5 & 6 in scenario 2 is expected to be higher than coverage of Layers 7 & 8 in scenario 1.

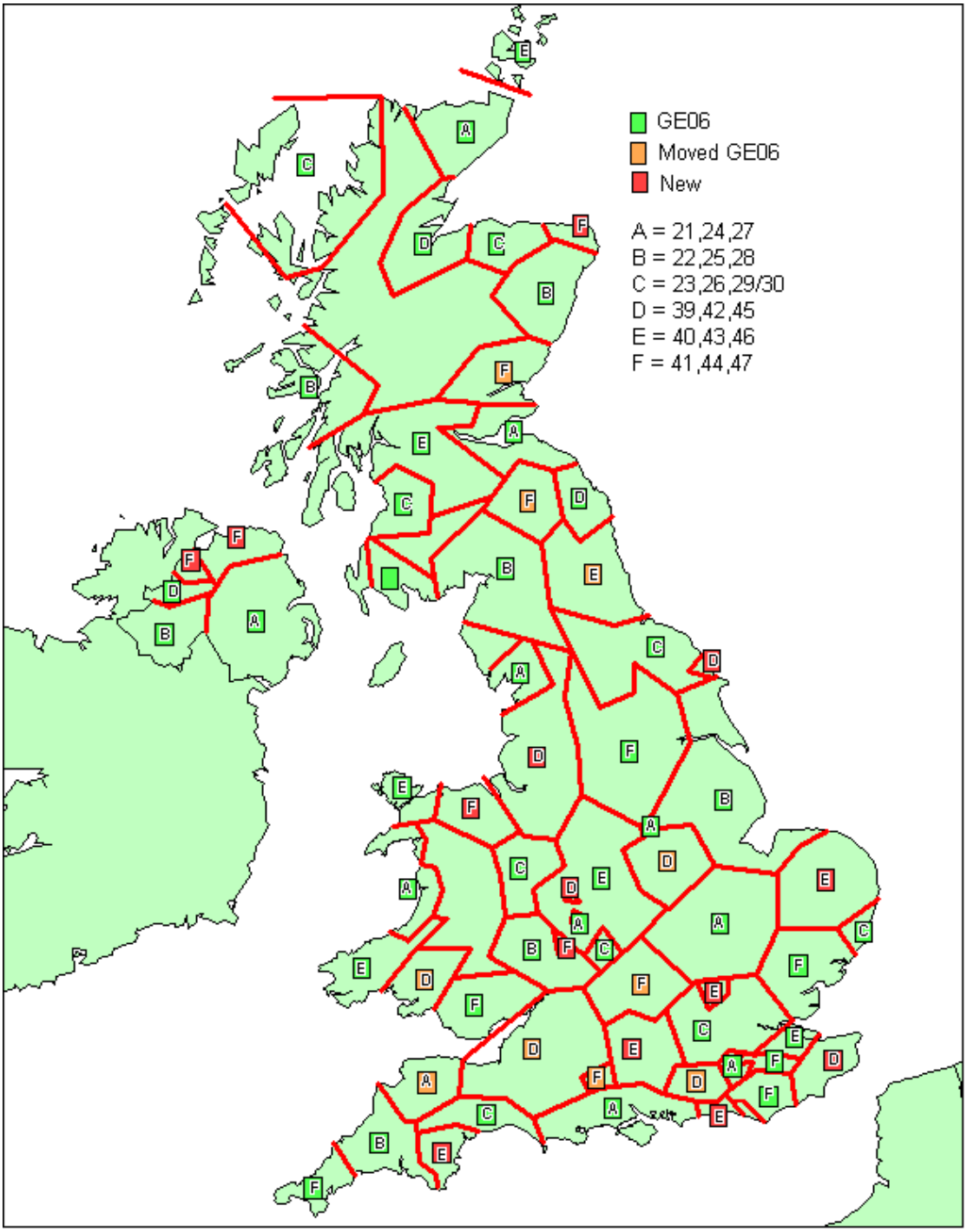


Figure 2: Scenario 2 channel redistribution to recreate the PSB layer following DTT clearance of the 700 MHz band.

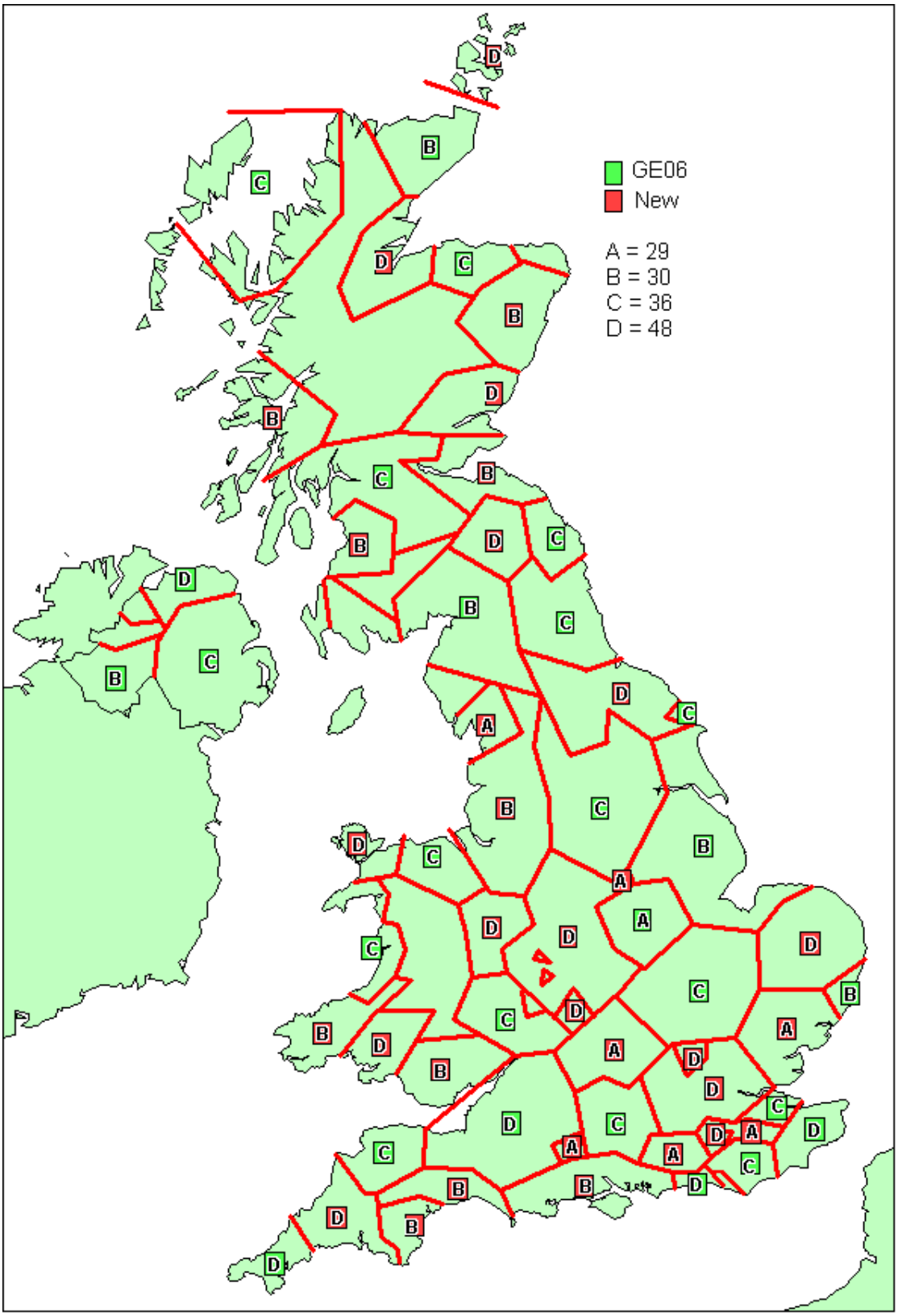


Figure 3: Scenario 2 channel allocation used to model the first COM layer, COM4.

## *7.1. Coordination*

For coordination of scenario 2, PSB layers will have similar issues to those of scenario 1, but with the differences listed below. These arise as a result of the different channel allocations at certain stations. COM layers 5 & 6 being based on existing 600 MHz coordination should have no issues. COM layer 4 will require coordination of the proposed channels at a number of stations.

### 7.1.1. PSB Layer coordination

The differences between scenario 1 and scenario 2 affect 6 stations. One station, The Wrekin, should not cause a problem with coordination. Of the other 5, only one, Mendip, requires coordination with both France and Ireland. The remaining four stations just affect France.

In scenario 1, Mendip took on board channels 40, 43 and 46 which put it co-channel with Sutton Coldfield. In scenario 2, Mendip uses channels 39, 42 and 45 taken from Wenvoe and Beacon Hill COMs and Hannington PSB. Midhurst would adopt channels 39, 42 and 45; Beacon Hill and Whitehawk Hill channels 40, 43 and 46. Coordination with France will be required as there are co-channel relationships with Abbeville, Brest, Caen, Le Havre, Neufchatel and Rennes.

### 7.1.2. COM Layer coordination

COM layers 5 and 6, being based on existing layers 7 & 8, should not require coordination. COM layer 4, being an amalgam of channels 29, 30, 36 and 48, would require coordination with Ireland at nine sites.

Use of channel 30 at Wenvoe, Presely, Winter Hill, Torosay and Darvel, channel 29 at Lancaster and channel 48 at Llanddona, Carmel and Caradon Hill would require co-ordination with Ireland due to co-channel relationships including Clermont Carn, Dungarvan, Kippure, Mount Leinster and Three Rock.

Coordination with France will also be required for the COMs for scenario 2 as there are co-channel relationships including Channel 29, 30 with Brest, Caen and Neufchatel.

None of the channels proposed for COM layer 4 should have any impact on Belgium channel allocations.

Towards The Netherlands, use of channel 29 at Sudbury and channel 48 at Tacolneston will require coordination with respect to the Dutch allotment in Zeeland. Tacolneston normally does not present any significant co-ordination issues with The Netherlands.

## 7.2. Coverage

The predicted coverage of the 80 primary sites based on scenario 2 is shown in Table 7. Coverage of the PSB services is the same as the baseline figure and less than 0.1% below the coverage predicted for scenario 1. The difference in coverage compared with scenario 1 can be attributed to the use of channels 29 and 30 by COM4. This increases interference to PSB stations using these channels, resulting in a slight reduction in coverage, though this has been offset to an extent by some optimisation of channel allocations.

Whilst coverage of individual COM multiplexes is within 5% of the baseline COM coverage, the 6CORE figure is 7% lower. Though a systematic approach has been adopted, the different structure of the COM layers leads to different sources of interference for the layers, and thus a different coverage for each layer at each station. The consequence of this is that the overlap in service areas where all services are available is smaller.

**Scenario 2**

| Nation | PSB_1 | PSB_2 | PSB_3 | COM_4 | COM_5 | COM_6 | | 3PSB | 6CORE | 3COM |
|---|---|---|---|---|---|---|---|---|---|---|
| Wales | 1150031 | 1143068 | 1133823 | 995251 | 1082386 | 1004164 | | 1131241 | 913752 | 925870 |
| Scotland | 2347453 | 2345091 | 2341015 | 2289042 | 2304915 | 2290165 | | 2332096 | 2216881 | 2220459 |
| Northern Ireland | 626888 | 625462 | 630236 | 549075 | 557932 | 532885 | | 623422 | 487267 | 487355 |
| England | 22214559 | 22257971 | 22092514 | 21145616 | 20952510 | 20710482 | | 21996808 | 19810997 | 19975919 |
| United Kingdom | 26338931 | 26371592 | 26197588 | 24978984 | 24897743 | 24537696 | | 26083567 | 23428897 | 23609603 |
| | 100.0% | 100.0% | 99.6% | 97.5% | 97.5% | 95.8% | | 100.0% | 93.5% | 93.6% |

Table 7 : Scenario 2 coverage of a network of the 80 primary sites, three PSB layers plus three COM layers based on the use of DVB-T2.

## 7.3. Discussion

Based on the assumptions adopted for Scenario 2, it should be possible to construct three PSB layers with coverage comparable to that of the PSB network prior to 700 MHz band DTT clearance. Along with the PSB layers, three COM layers can be created using a combination of the 600 MHz channels plus channels 29, 30 and 48. Coverage of these COM layers will be less than that of the existing COM services.

There is scope for further optimising the solution both to improve coverage and to ease some of the potential coordination problems. For example, as part of such an optimisation, use of channels 22 and 25 at Stockland Hill, for the layer 4 and 6 COM services, and channel 28 at Rowridge for the COM4 service should improve both COM coverage from these two stations as well as PSB coverage at Crystal Palace. These changes would not introduce any new sources of interference to the PSB network as they are existing channels at these stations. Further gains could be made by optimising coverage in the Midlands, possibly by more extensive use of SFNs for the COM services to avoid the interaction between The Wrekin PSB and Waltham COM services on channel 29. Use of channels 22, 25 and 28 is an extension of the policy of using lightly used PSB channels. This channel group, whilst used extensively by COM multiplexes in the South in the existing plan (Stockland Hill, Rowridge and Crystal Palace) is only used by PSB services at Caradon Hill, see Annex 1.

Further coverage could be also recovered by using a more robust mode, albeit at the expense of reduced bit rate; though a more robust DVB-T2 service would still offer a higher data rate than present DVB-T services.

Coordination of scenario 2 will be more difficult than scenario 1, in particular coordination of the COM4 layer. Though a conservative approach has been adopted, changes resulting from coordination may result in reduced coverage of layer COM4.

As the COM layers are organised as MFNs, albeit with some use of SFN, they could operate using DVB-T though with some reduction in coverage.

# 8. Scenario 3 – 3PSB + 3COM + 600 MHz

Scenario 3 investigated the possibility of keeping 600 MHz spectrum and creating the 3PSB and 3COM multiplexes in the remaining channels. Under scenarios 1 and 2, the UK effectively is abandoning rights, particularly at Band IV stations. Scenario 3 aims to make maximum use of UK rights.

To try and maintain the target coverage of 98.5%, the three PSB layers have been constructed in a similar manner to that adopted for scenario 1. However, to clear spectrum for the COM multiplexes, PSB services on channels 22, 25 and 28 have been moved. To accommodate this move at a number of stations such as Caradon Hill, Durris, Brougher Mountain, it has been necessary to operate the stations as part of an SFN with adjacent stations. At Belmont it has been necessary to split the service into a north firing service that operates as part of an SFN with Bilsdale and a south firing service that operates as part of an SFN with Sandy Heath. The channel structure adopted for the PSB channels is summarised in Figure 4.

The COM layers are reconstituted as three national SFNs using channels 22, 25 and 28. The prime reason for adopting these channels for a national SFN is the UK's existing coordinated position.

With channels 22, 25 and 28 coordinated for use at Caradon Hill, Stockland Hill, Rowridge and Crystal Palace, the UK has a good coordination position with respect to France. Also, at all these stations other than Caradon Hill, the channels are used by COM services and are not reassigned to PSB services as part of clearance, i.e. under scenario 1 these are effectively abandoned. With respect to Ireland, the existing UK positions at Caradon Hill, Blaenplwyf, Caldbeck and Brougher Mountain mean that Ireland has largely avoided use of these channels in areas that interact with the UK.

Whilst the UK has good rights on channels 22, 25 and 28, use of these channels in the east of England will be restricted. Modelling of this scenario has recognised the need to protect existing French and Belgium rights on these channels by using restricted antenna patterns and restriction of the ERP where required. For example, use of these channels at Dover would be difficult because of French positions at Abbeville (channels 22, 25 and 28)

and use of channel 22 by Belgium in Oost Vlaanderen. As a consequence, the ERP at Dover has been restricted to 5 kW, 13 dB below the coordinated level of existing channels, and a restricted pattern has been used. Likewise the ERP of Heathfield has been restricted to 5 kW, 9 dB below the coordinated level of existing channels

600 MHz spectrum remains as coordinated.

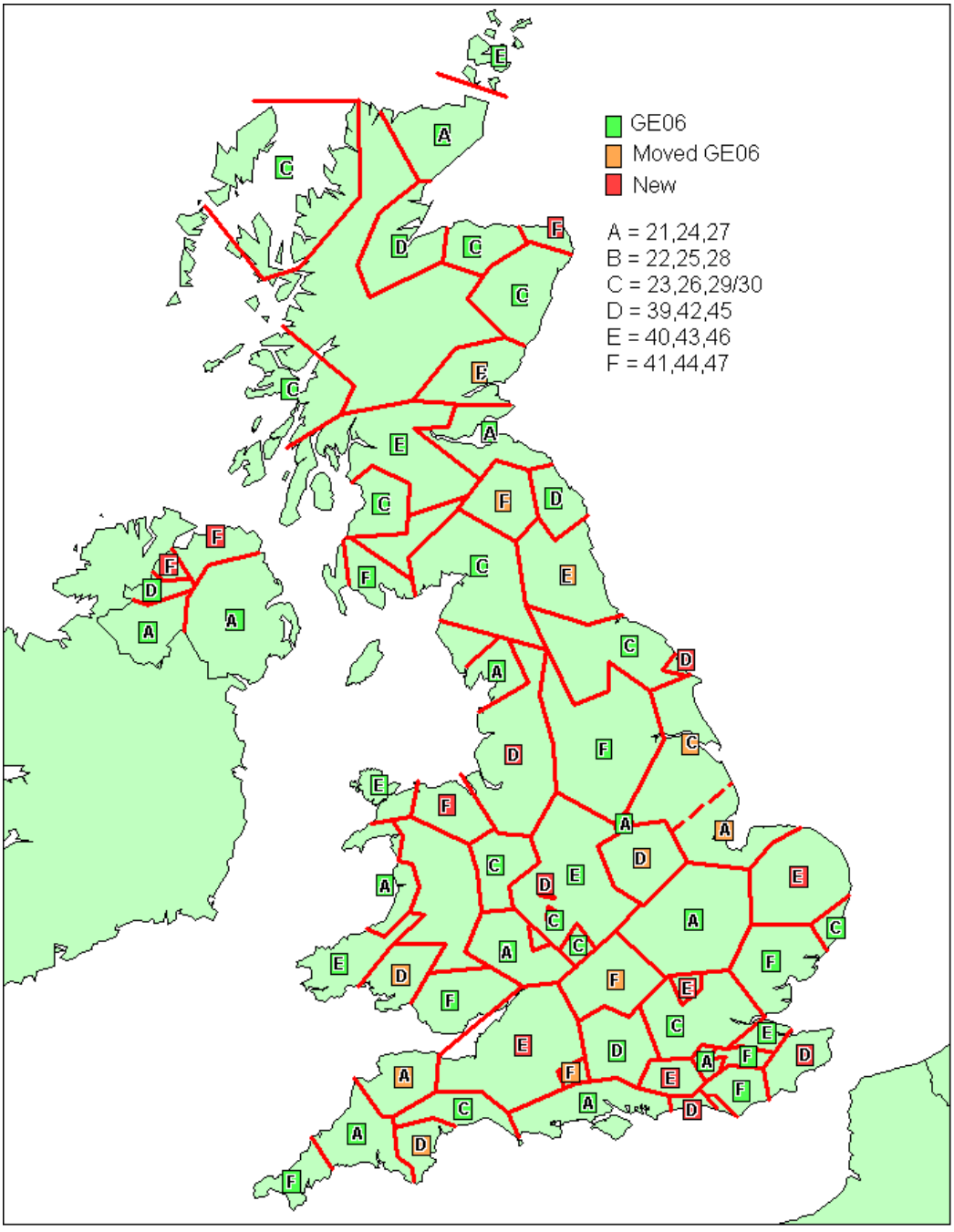


Figure 4: Scenario 3 channel redistribution to recreate the PSB layer following DTT clearance of the 700 MHz band.

## *8.1. Coordination*

The main obstacle to coordination of scenario 3 will be the number of layers being sought by the UK. Whilst it can be argued that the scenario plan is efficient in its use of spectrum, having made extensive use of SFNs, and it is largely based on existing rights, it will be viewed as not equitable. This will mean that getting neighbouring administrations to agree to the necessary redistribution of channels required for Dover PSB services will be very difficult.

Issues regarding the number of layers will be pivotal to agreeing scenario 3. Leaving these aside however, coordination of scenario 3 PSB layers will have similar issues to those of scenario 1, but with the differences listed below. 600 MHz coordination should have no issues. Coordination of the COM layers will be difficult, particularly at stations in the east and south-east of England. It is likely that coordination of these layers may result in some compromises that reduce coverage below that predicted.

### 8.1.1. PSB Layer coordination

Where channels 22, 25 and 28 have been reassigned to the COM SFNs, the PSB services adopt existing COM channels. The exception to this is Belmont but this is sufficiently distant from the Continent not to cause any significant coordination issues. In scenario 1, the COM channels at Caradon Hill were assigned to Huntshaw Cross. Within scenario 3, both Huntshaw Cross and Caradon Hill use the same channels, Caradon Hill's existing COM channels. This change would need to be negotiated with Ireland but should not present any major co-ordination issue.

### 8.1.2. 600 MHz coordination

As there are no changes proposed to the UK's existing coordinated position for the channels in the 600 MHz band, coordination of these channels would simply be a case of protecting existing rights.

### 8.1.3. COM layer coordination

Coordination of the COM layers will be complicated. Whilst the basis of the layers is in existing 'Spectrum Rights', to obtain national coverage, use of the channels will need to be extended. Use of the channels at Dover and Heathfield will be difficult to coordinate with France with respect to Abbeville. In a similar manner, coordination of channel 22 for use at Dover and Sudbury will be difficult with Belgium; though this could be mitigated by using channel 48 instead of channel 22 at these two stations.

With respect to Ireland, alternative channels or antenna restrictions may be needed for the COM layers at Limavady to protect the Holywell Hill coverage area. Some restriction may also be required at Llanddona and Presely to protect use of channels 22 and 25 at Kippure.

## 8.2. Coverage

The predicted coverage of the 80 primary sites based on scenario 3 is shown in Table 8. Coverage of the PSB services is comparable to the baseline figure and is less than 0.1% below the coverage predicted for scenario 1.

Coverage of individual COM multiplexes is within 1% of the baseline COM coverage, the 6CORE figure is less than 2% lower.

**Scenario 3**

| Nation | PSB_1 | PSB_2 | PSB_3 | COM_4 | COM_5 | COM_6 | 3PSB | 6CORE | 3COM |
|---|---|---|---|---|---|---|---|---|---|
| Wales | 1,146,623 | 1,140,992 | 1,134,711 | 1,129,494 | 1,116,877 | 1,121,047 | 1,129,566 | 1,082,116 | 1,109,712 |
| Scotland | 2,319,855 | 2,318,660 | 2,311,945 | 2,305,900 | 2,299,946 | 2,324,680 | 2,306,109 | 2,269,994 | 2,291,489 |
| Northern Ireland | 630,534 | 630,773 | 632,924 | 549,366 | 500,821 | 551,689 | 628,712 | 497,958 | 499,026 |
| England | 22,154,053 | 22,242,646 | 22,121,401 | 21,397,176 | 21,483,380 | 21,182,499 | 22,016,279 | 20,742,333 | 21,058,182 |
| United Kingdom | 26,251,065 | 26,333,071 | 26,200,981 | 25,381,936 | 25,401,024 | 25,179,915 | 26,080,666 | 24,592,401 | 24,958,409 |
| | 99.7% | 99.9% | 99.6% | 99.1% | 99.4% | 98.3% | 100.0% | 98.2% | 98.9% |

Table 8 : Scenario 3 coverage of a network of the 80 primary sites, three PSB layers plus three COM layers.

Coverage of the 600 MHz channels under scenario 3 is the same as that of scenario 1, see Table 6.

## 8.3. Discussion

In principle it appears as if 700 MHz clearance based on scenario 3 offers the possibility of achieving PSB and COM coverage that is comparable to existing coverage, whilst retaining access to the 600 MHz channels. However, though such a plan is based on existing UK rights, it is likely to be viewed as disproportionate in terms of the number of layers sought, and, as such, could prove very difficult to coordinate.

# 9. Conclusion

Based on existing 'Spectrum Rights', with each of the three scenarios investigated, it is possible that, post DTT clearance of the 700 MHz band, three PSB layers could be reconstructed with coverage similar to that of the existing services.

Scenarios 1 and 2 have demonstrated that, in addition to the PSB layers, three additional layers are possible. The simplest option is that presented in scenario 1, basing the three additional layers on existing 600 MHz coordination. Coverage of the layers is below that of the existing COM services, though this is in part due to the conservative assumptions made as part of this study regarding operating conditions.

The alternative presented in scenario 2 will be more difficult to coordinate because of the greater number of changes. The higher powers assumed for the 600 MHz channels, though still within agreed coordination, demonstrated that coverage close to that of the existing COM services could be achieved.

Both scenarios 1 and 2, whilst creating six layers, see the UK not using a number of its existing spectrum rights, particularly at Band IV stations. As part

of the optimisation of scenario 2, the number of such unused channels should be reduced.

The third scenario used a more radical approach to planning to see whether the existing six layers plus the 600 MHz services could be reconstructed post DTT clearance of the 700 MHz band. This investigation has shown that, by adopting the use of SFNs for the COM layers, this could be possible. However, though such a solution is based on existing 'Spectrum Rights', it would be at odds with the number of layers that our neighbours may seek. In addition, the PSB layers at Dover would require spectrum from France and Belgium to be redistributed to the UK; as such it is very unlikely that such a plan could be coordinated.

The results of the study provide an indication of what could be achieved. Optimisation of the plans should provide some gains in coverage, though these gains may be offset by additional restrictions resulting from coordination beyond those included as part of this exercise.

It must be recognised that, to maximise the coverage of the layers, DVB-T2 should be used. The layers created as national SFNs, scenario 1 layer 9 and scenario 3 the COM layers will only work if DVB-T2 is used. The other COM or 600 MHz layers, because of the limited spectrum available, have been created as MFNs using just 3 channels per layer. Though these layers are primarily arranged as an MFN, they employ a number of large SFNs and, for these to provide the required levels of coverage, DVB-T2 should be used. Use of DVB-T for these layers will result in some reduction in coverage.

The PSB layers being designed as an MFN using 6 channels per layer could operate using either DVB-T or DVB-T2.

# Annex 1 : Network Coverage based on DVB-T

The decisions made at WRC-12 may result in an earlier DTT clearance of the 700 MHz band than originally expected. This means that the assumption used for the investigation that DTT clearance would occur sometime after 2020 and would be based on the use of DVB-T2 may be incorrect. Early DTT clearance would mean that many countries, including the UK, will not have fully migrated to DVB-T2 and any clearance plan could need an option to use DVB-T.

The use of DVB-T significantly reduces the options available to planners particularly with respect to the use of large, regional or national, SFNs. This in turn impacts the possibility of reconstituting the coverage of the COM networks in scenarios 2 and 3.

In scenario 1 the PSB networks, being based on the use of six channels per layer and each layer being arranged as an MFN, will achieve the target coverage whether DVB-T or DVB-T2 is used. All planning for the 600 MHz layers has always assumed the use of DVB-T2. However, Layers 7 & 8, being based on an MFN structure with some SFNs could operate using DVB-T albeit with reduced coverage. Layer 9, the ch36 national SFN, is only viable if operated using DVB-T2.

As with scenario 1, the coverage of the PSB networks in scenario 2 is similar, and will achieve the target coverage, whether the networks are based on DVB-T or DVB-T2. The COM networks in scenario 2, will have reduced coverage if they are required to operate using DVB-T. Table 9 shows the coverage of scenario 2 with all networks operating using the existing DVB-T mode C2E.

**Scenario 2.1 using DVB-T C2E**

| Nation | PSB_1 | PSB_2 | PSB_3 | COM_4 | COM_5 | COM_6 | | 3PSB | 6CORE | 3COM |
|---|---|---|---|---|---|---|---|---|---|---|
| Wales | 1134192 | 1128097 | 1119073 | 1044098 | 1011030 | 988341 | | 1115739 | 915872 | 926651 |
| Scotland | 2336786 | 2331600 | 2328141 | 2268750 | 2300692 | 2287546 | | 2320235 | 2206553 | 2211862 |
| Northern Ireland | 624961 | 623462 | 628046 | 548464 | 557458 | 533436 | | 621448 | 488542 | 488622 |
| England | 22186661 | 22227937 | 22107840 | 20757769 | 19797301 | 19530199 | | 22013087 | 18504818 | 18644699 |
| United Kingdom | 26282600 | 26311096 | 26183100 | 24619081 | 23666481 | 23339522 | | 26070509 | 22115785 | 22271834 |
| | 99.8% | 99.8% | 99.5% | 96.1% | 92.7% | 91.1% | | 100.0% | 88.3% | 88.3% |

Table 9 : Coverage of scenario 2 with initial optimisation based on the use of DVB-T

The network modelled has been subject to some initial optimisation compared to that presented in section 7 of the main body of the report. To provide a like for like comparison with the coverage of this network using DVB-T2, coverage of the network with initial optimisation using DVB-T2 is shown in Table 10.

**Scenario 2.1 using DVB-T2**

| Nation | PSB_1 | PSB_2 | PSB_3 | COM_4 | COM_5 | COM_6 | | 3PSB | 6CORE | 3COM |
|---|---|---|---|---|---|---|---|---|---|---|
| Wales | 1176970 | 1169834 | 1160652 | 1094006 | 1108858 | 1081852 | | 1157244 | 1010901 | 1022234 |
| Scotland | 2411100 | 2408730 | 2404688 | 2351331 | 2380111 | 2364771 | | 2395173 | 2286789 | 2292374 |
| Northern Ireland | 729086 | 726829 | 733130 | 635640 | 649986 | 619678 | | 724724 | 564108 | 564231 |
| England | 22735510 | 22782801 | 22658768 | 21774773 | 21445468 | 21257583 | | 22558408 | 20453125 | 20601424 |
| United Kingdom | 27052666 | 27088194 | 26957238 | 25855750 | 25584423 | 25323884 | | 26835549 | 24314923 | 24480263 |
| | 102.8% | 102.7% | 102.5% | 100.9% | 100.2% | 98.9% | | 102.9% | 97.1% | 97.0% |

Table 10 : Coverage of scenario 2 with initial optimisation based on the use of DVB-T2

With scenario 3, coverage of the PSB services is effectively independent of whether DVB-T or DVB-T2 is used. However, coverage of the COM layers which are based on national SFNs is significantly reduced, Table 11.

**Scenario 3 all layers operating DVB-T C2E**

| Nation | PSB_1 | PSB_2 | PSB_3 | COM_4 | COM_5 | COM_6 | 3PSB | 6CORE | 3COM |
|---|---|---|---|---|---|---|---|---|---|
| Wales | 1,130,702 | 1,125,422 | 1,118,680 | 583,690 | 564,477 | 564,816 | 1,113,698 | 548,546 | 552,963 |
| Scotland | 2,305,273 | 2,303,455 | 2,296,726 | 1,747,088 | 1,745,357 | 1,753,992 | 2,290,788 | 1,726,623 | 1,732,217 |
| Northern Ireland | 618,773 | 618,328 | 620,078 | 497,084 | 451,445 | 485,647 | 615,860 | 448,692 | 448,882 |
| England | 22,000,320 | 22,101,754 | 22,032,544 | 13,581,507 | 13,634,372 | 13,650,456 | 21,861,345 | 13,209,663 | 13,309,870 |
| United Kingdom | 26,055,068 | 26,148,959 | 26,068,028 | 16,409,369 | 16,395,651 | 16,454,911 | 25,881,691 | 15,933,524 | 16,043,932 |
| | 99.0% | 99.2% | 99.1% | 64.0% | 64.2% | 64.2% | 99.2% | 63.6% | 63.6% |

Table 11 : Coverage of scenario 3 based on the use of DVB-T

# Annex 2 : Glossary of abbreviations

| | |
|---|---|
| 3COM | Coverage of the area where all three commercial multiplexes are available |
| 3PSB | Coverage of the area where all three PSB multiplexes are available |
| 6Core | Coverage of the area where all six main multiplexes are available |
| 600 MHz Band | UK released spectrum consisting of channels 31, 32, 33, 34, 35, 36 and 37 |
| 800 MHz Band | Released spectrum consisting of channels 61, 62, 63, 64, 65, 66, 67, 68 and 69 |
| C/N | Carrier to Noise ratio |
| CEPT | European Conference of Postal and Telecommunication Administrations |
| COM | Commercial multiplex |
| DMOL | Digital television Multiplex Operators Limited |
| DSO | Digital switchover |
| DTT | Digital Terrestrial Television |
| DVB-T | Digital Video Broadcasting – Terrestrial; the original system standard |
| DVB-T2 | Digital Video Broadcasting – Terrestrial; the new version of DVB-T |
| ERP | Effective Radiated Power |
| EPG | Electronic Programme Guide |
| FEC | Forward Error Correction |
| GE06 | GE06 agreement, Geneva 2006 |
| GI | Geographically Interleaved |
| ITC | Independent Television Commission (now part of Ofcom) |
| ITU | International Telecommunication Union |
| JPP | Joint Planning Project |
| Mbit/s | Megabits per second |
| MFN | Multi-frequency Network |
| MHz | Megahertz |
| PMSE | Programme Making and Special Events |
| PSB | Public-service broadcasting |
| QAM | Quadrature Amplitude Modulation |

| | |
|---|---|
| RPC1 | Fixed roof level reception |
| RRC-06 | Radio Regional Conference 2006 |
| SFN | Single-frequency Network |
| SI | Service Insertion |
| SIP | Service Insertion Point |
| UHF | Ultra High Frequency |
| WRC | World Radio Conference |