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Final report for the Commerce and Employment Department of the States of Guernsey Government

4G spectrum allocation review in the Channel Islands

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1 Executive summary

This is the final report of a study conducted by Analysys Mason Limited (Analysys Mason) on behalf of the Commerce and Employment Department of the States of Guernsey Government. The report provides an assessment of the spectrum requirements for fourth-generation (4G) services in the Channel Islands. The assessment has been conducted in conjunction with the Economic Development Department of the Jersey Government and the Channel Islands Competition and Regulatory Authorities (CICRA).

The overall objectives of this study have been to determine the amount of spectrum required to deliver fixed and mobile broadband services through 4G wireless technologies in the Channel Islands, and to advise on the appropriate framework for 4G spectrum award. The insights gained from this study will be used by the Governments of Guernsey and Jersey, and CICRA, to define a 4G spectrum management strategy for the Channel Islands that supports their competition and growth objectives.

The study also highlights issues for discussion with the UK regulator, the Office of Communications (Ofcom), in relation to the issue of 4G spectrum licences, noting Ofcom's responsibility for authorising civil use of radio spectrum in the Channel Islands.

1.1 Approach to 4G spectrum demand estimation modelling

We have developed a model of spectrum requirements to meet wireless broadband traffic, both for mobile and fixed broadband, in the Channel Islands until 2026. Our model evaluates both mobile and fixed wireless access (FWA) spectrum demand in four geotypes: split by Bailiwick and by urban/rural areas. Therefore, the model includes appropriate input and analysis segmented by geotype to support network assumptions.

Our modelling approach is illustrated below in Figure 1.1.

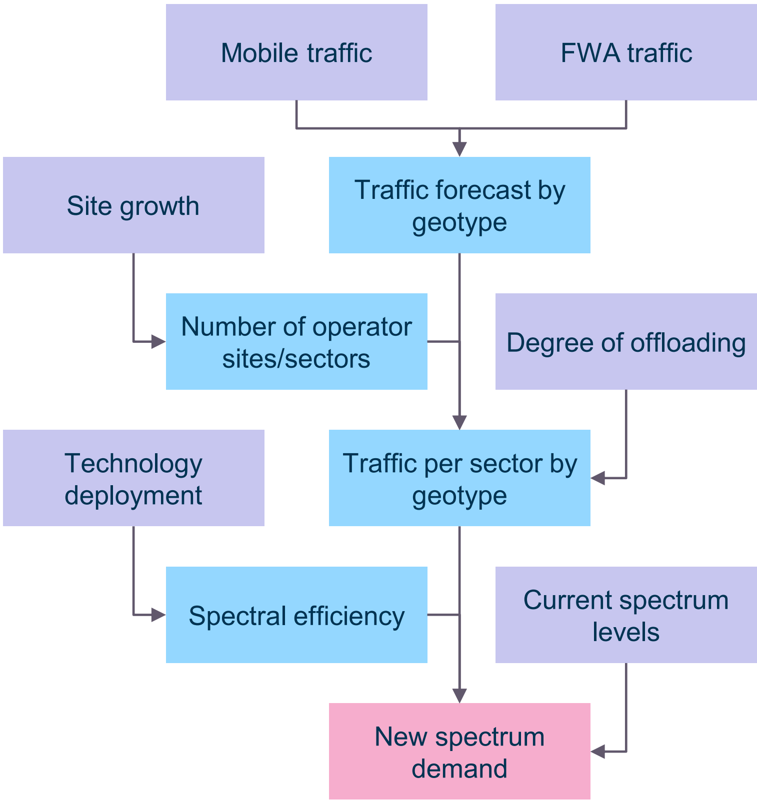


Figure 1.1: High-level modelling approach [Source: Analysys Mason, 2013]

1.2 Key assumptions

There are several key assumptions that affect the demand estimation modelling. These are summarised below:

- traffic forecasts per subscriber (for both fixed and mobile)
- long-term subscriber market shares (for both fixed and mobile)
- increases in the number of base station sites ('site growth') across both Jersey and Guernsey
- network utilisation and accepted site congestion
- LTE-Advanced (LTE-A) spectral efficiency uplift beyond LTE
- technology deployment timings.

As part of this project, we consulted with the three existing mobile operators in Jersey and Guernsey on our choice of modelling assumptions. We would like to extend our thanks to each operator for the inputs they have provided.

Although we have consulted with each of the three operators, it should be noted that assumptions used within the demand model are those of Analysys Mason. The information received from both the operators and CICRA allowed us to check each of the model parameters discussed later, and make sure all assumptions were appropriate for the Channel Islands' mobile market. The data received was assumed in good faith to be accurate, and where parameters were only supplied by a few operators, rather than each operator, we assumed that the market average would be roughly consistent. As such, we believe that our assumptions/parameters used in the modelling give a fair portrayal of the Channel Islands' market and its likely development.

One issue, which we were unable to confirm consistently with operators, was the likely timing of network technology evolution on the Channel Islands. Specifically, operators gave a range of answers for timings associated with shutdown (and refarming of spectrum) of the legacy 2G and 3G networks, including many stating that it would be highly dependent upon how international markets (and especially international roaming) developed in the future.

As such, we have assumed that the Channel Islands are likely to match our current best views of the rest of Europe (and specifically the UK) with 4G services being deployed as soon as possible, 2G shutdown occurring around 2020, and 3G shutdown occurring slightly later in 2022.

1.3 Scenarios modelled

We have calculated the spectrum and additional sector requirements using scenarios to test the impacts of possible changes in the Channel Islands' markets by modifying several of the key assumptions detailed above. The four key areas that have been tested in our scenarios are:

- The distribution of mobile spectrum within the market, including consideration of equal awards of new spectrum,[1] redistribution of existing assignments in the 1800MHz band for LTE use, or if a new entrant were to emerge, spectrum caps on sub-1GHz spectrum.
- A market with four (as compared to the current three) mobile operators in the long term, where it is assumed that a new entrant joins both Jersey and Guernsey's markets in 2013.
- The impact of higher levels of fixed broadband substitution by mobile operators within the Channel Islands' markets.
- The impact of site growth being limited on the islands, and hence a limit on the maximum possible number of base station sectors.

In addition to our scenarios to test these areas, we sensitivity tested the impact of changing various parameters including:

- LTE-A spectral efficiencies
- mobile offloading assumptions
- data traffic forecasts
- long-term operator market share
- various site growth assumptions, including the differential site growth between Bailiwicks.

1.4 Results of the spectrum demand modelling

Below we show the results for our base case scenario which assumes immediate release of the full 800MHz, 1800MHz and 2.6GHz bands spectrum.

1 New spectrum refers to 800MHz and 2.6GHz bands, and the unassigned portions of the 1800MHz band.

Figure 1.2: Spectrum analysis for ***Airtel-Vodafone*** *under our base case (Scenario 2) [Source: Analysys Mason, 2013]*

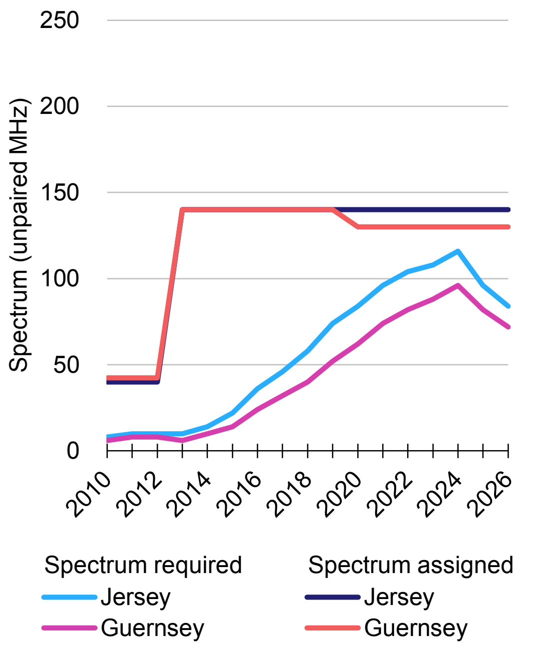


Figure 1.3: Spectrum analysis for ***Jersey Telecom*** *under our base case (Scenario 2) [Source: Analysys Mason, 2013]*

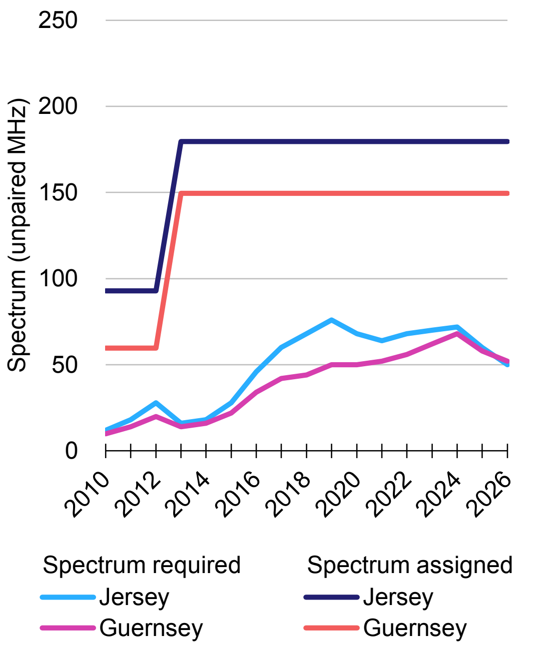
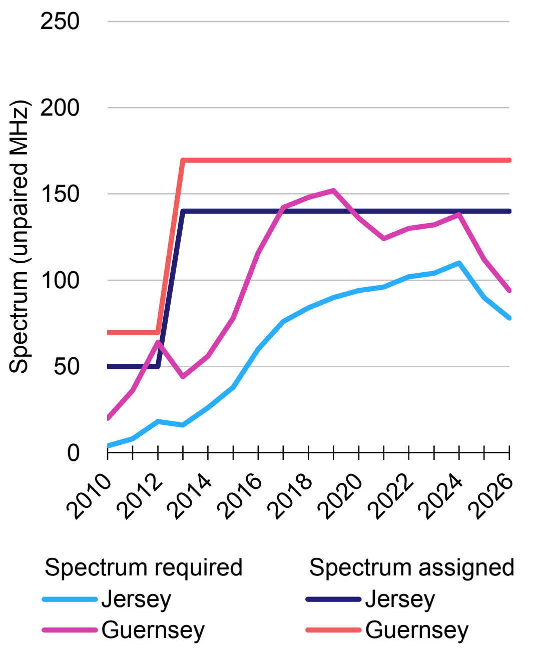


Figure 1.4: Spectrum analysis for ***Sure (C&W)*** *under our base case (Scenario 2) [Source: Analysys Mason, 2013]*



As can been seen in Figure 1.2, Figure 1.3 and Figure 1.4, our modelling shows that demand for spectrum does not exceed current and planned assignment, for any of the existing operators, under our base case assumptions. However, the margin between the spectrum demand and availability is sufficiently small that only a slightly larger demand is needed before some operators exceed their current and planned spectrum availability in the later years of our modelling.[2] As such, we conclude that while dramatic additional spectrum changes are not necessary, the Governments of Guernsey and Jersey, and CICRA, should make efforts to ensure that smaller improvements in assignment efficiency (such as realignment of the 1800MHz band, which is included in our base case) can be achieved.

Results from varying the key assumptions, as described above, are summarised below.

Relative spectrum holdings

The modelling shows that, overall, Jersey Telecom will have sufficient spectrum to account for its traffic under even the highest traffic forecasts, due in part to the higher site-to-traffic ratio seen on Jersey. Conversely, Sure frequently becomes spectrum-constrained in Guernsey under our higher traffic scenarios, due to the limited number of sites and its significant share of the Bailiwick's traffic. Airtel-Vodafone tends to become equally constrained across both islands at a slightly higher level of traffic per subscriber than was needed for Sure, but needing similar levels of new sites to Sure, due to the constraints in new site availability occurring on both islands.

Redistribution of spectrum

The modelling showed that redistributing the 1800MHz spectrum increases the overall spectrum efficiency by removing issues with non-contiguous spectrum (a situation which exists for both Airtel-Vodafone and Sure). The new award, as in the base case (Scenario 2), increases the usable spectrum available for all operators.

We note that a redistribution of the 1800MHz band along with the award of the remaining 1800MHz spectrum would result in a net gain of spectrum by each operator, even in the case where part of the new spectrum was required for a new entrant.

Increase in the number of base station sites (site growth)

One of the key factors influencing the overall spectrum demand (and which is partially controllable by the Bailiwick governments) is the potential for an increase in the number of sites over the modelled time period. A larger number of sites will increase capacity without increasing the need for spectrum; conversely, growth in demand for services without an increase in the number of sites requires additional spectrum to be deployed. The potential for growth in the number of sites is especially important in Guernsey, given the island's current high level of subscribers per site. In our base case modelling, we assume a lower level of site growth in Guernsey than Jersey, due in part to the more restrictive planning conditions required. However, if this difference is removed, the margin between spectrum demand and spectrum availability increases, reducing the risk that demand will exceed availability in Guernsey.

2 Planned spectrum refers to award of new 800MHz, 1800MHz and 2.6GHz spectrum to each operator, for 4G services. Our assumptions on distribution of this new spectrum are set out in Section 6.

New entrant

Our modelling shows that there is sufficient spectrum to support a new entrant, although this increases the risk of spectrum shortages for both Sure and Airtel-Vodafone. One area which would require attention in the case of a new entrant would be to ensure that this does not limit the potential for an increase in the number of sites for the other operators, as discussed above.

One possible way of doing this could be to ensure that an additional portion of new sites were allowed for the new entrant on each Bailiwick, which would then increase the possible options for the other operators in terms of site sharing, at the same time as reducing the entry risk for the new operator.

1.5 Benefits of releasing new spectrum to enable 4G services and consequences of not releasing new spectrum

Potential benefits of releasing spectrum to enable 4G services

A considerable amount of literature has been written on the potential benefits accrued through the deployment of next-generation mobile/LTE networks.[3] Likewise, there have been extensive studies undertaken into the benefits of Internet and next-generation broadband access to homes and businesses, both via fibre networks and via wireless broadband.[4] It is noted that 4G technologies, including LTE and WiMAX, can be used to provide both broadband connection wirelessly to mobile devices on the move, as well as to provide broadband services wirelessly to receivers at fixed locations ('fixed wireless access').[5]

Consumer benefits from mobile/wireless broadband services will be created through access to much higher speeds for mobile data transmission, and reduced network congestion, compared to the services that are currently available. This change in speed and efficiency will help to support a wider availability of new mobile services and generate an improved user experience compared to earlier generations of mobile telecommunications. For this reason, we note that consumers are beginning to expect LTE support on high-end devices, with the Global Suppliers Association (GSA) device database currently listing 221 models of LTE-compatible handsets, with LTE devices being provided by 25 different manufacturers including all the 'top tier' brands.

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3 For example: 'The benefits of using LTE in digital dividend spectrum', 4G Americas, 2011; 'Getting the most out of the Digital Dividend', Spectrum Value Partners, 2008; 'Mobile Broadband and the UK Economy', Capital Economics, 2012; 'Estimating the cost to UK businesses of slow mobile broadband' Open Digital Policy Organisation, 2011.

4 For example, see http://www.gfirstbroadband.co.uk/Portals/11/Broadband%20Files/Useful%20Documents/EconomicImpactofNGABroadbandinHerefordshireGlos.pdf and http://www.irg.eu/streaming/ERG_(09)_17_Report_on_NGA_Economic_Analysis_and_Regulatory_Principles.pdf?contentId=546059&field=ATTACHED_FILE.

5 Although we consider WiMAX is most likely to be used for FWA rather than mobile broadband in the Channel Islands, given the mobile operators' natural evolutionary paths to LTE and the dominance of LTE within Europe. See http://www.analysysmason.com/Research/Content/Comments/RDMM0_WiMAX_threat_to_DSL_Mar2008/

The efficiency of the 4G services, including the reduced costs of transmitting large amounts of traffic wirelessly, also offers consumers a more feasible alternative method of accessing broadband services in the home via 4G, which may benefit areas where fibre broadband is not available and might improve the competitiveness of the broadband market. We consider this especially important given the relatively high fixed broadband prices faced by consumers across the Channel Islands.

Direct and indirect benefits to the economies in Guernsey and Jersey will arise as a result of the increased productivity enabled by faster mobile technologies and the required capital investments being made in mobile/wireless broadband infrastructure by existing, and possible new, operators. In addition, a move to 4G by the Channel Islands also helps demonstrate the region's commitment to modern infrastructure, including increasing mobile services, which will help to improve the work environment for other key business sectors such as banking, manufacturing and tourism.

Releasing 4G spectrum in the 800MHz, 1800MHz and 2.6GHz bands also has significant benefits of international coordination with operators across Europe. This allows the Channel Islands operators to benefit from the strong equipment ecosystems (including consumer devices) in each of these bands, as well as significantly simplifying coordination issues with other countries, i.e. France and the UK. The use of these key 4G bands will also have future advantages in terms of LTE-A and new facilities such as carrier aggregation, for which equipment will undoubtedly be developed first for the main 3GPP defined bands.

Possible consequences of not releasing new spectrum

In considering the counterfactual case where no new spectrum is released to operators, there would likely be two main consequences: a limit to the deployment of 4G services and the benefits it can provide; and the removal of one of the key methods for operators to accommodate future traffic demand across the Channel Islands.

By not releasing spectrum in the 800MHz, 1800MHz or 2.6GHz bands, the Channel Islands would have severely limited the potential for its operators to deploy 4G networks and services across the islands. With operators having no access (or limited access in the case of 1800MHz) to the most popular 4G spectrum bands globally, covering each of the strongest device and equipment 4G ecosystems, it is likely that operators would be forced to retain the majority of their traffic on the existing 3G networks. While operators would likely deploy the newest HSPA+ releases to gain a close (but inferior) equivalent to LTE and LTE-A, the limited efficiency (and hence increased cost) with which traffic could be carried and the lack of speeds seen by the end user, would lose a sizeable fraction of the 4G benefits as discussed.

In addition to limiting 4G services, a lack of available spectrum would mean that operators need to find other ways to deal with future traffic demand. While we note that some traffic demand would be naturally reduced by a lack of services offering sufficient speeds (for example FWA services are unlikely to be as popular), the level of traffic is still likely to significantly outgrow the level of spectrum currently available. To deal with this excess traffic, operators would require significant additional site growth across the islands, particularly in urban areas, and if this site growth is restricted for environmental/planning reasons, then operators would need to limit mobile traffic. This could be achieved in several ways, but would likely include increasing prices to reduce demand and making offered data packages less capable (i.e. lower speeds and reduced data limits).

1.6 Framework for assigning spectrum

Our analysis suggests that it will be beneficial to operators and consumers if spectrum used for 4G services in the Channel Islands is aligned with that of the UK and France. This suggests awarding new 4G licences to use spectrum in the 800MHz, 1800MHz and 2.6GHz bands, as well as considering possible redistribution of existing 900MHz and 1800MHz 2G assignments to make them suitable for liberalisation to 4G.

Mitigating interference issues

LTE use in the 800MHz band needs to be coordinated with digital terrestrial television (DTT) and deployment in the 2.6GHz band needs to be coordinated with air traffic control (ATC) radar. In the UK (for the avoidance of doubt, excluding Guernsey and Jersey), an interference mitigation company (originally referred to as the UK 'MitCo', and now renamed as Digital Mobile Spectrum Limited) has been set up between the mobile operators to implement suitable mitigation measures to overcome LTE interference to DTT. This required Ofcom to conduct detailed studies to assess the number of DTT households likely to be affected by interference, in order to estimate the funding requirements of Digital Mobile Spectrum Limited (DMSL).[6] DMSL is being funded by fees paid in instalments by the UK mobile operators.

With regard to the assignment of spectrum in the 800MHz band in the Channel Islands, we have noted that modelling of the potential for LTE to interfere with DTT is potentially required (similar to the studies conducted in the UK) in order to confirm possible interference mitigation costs, and to determine a suitable approach to implementing interference mitigation on DTT installations (and within LTE networks, as required). Ofcom has indicated that this would be a matter for the Governments of Guernsey and Jersey, with CICRA, to resolve. It may be possible to estimate costs by extrapolating the UK results to reflect the number of DTT households in the Channel Islands, however a more accurate approach would be to model the potential for interference using a radio planning tool.

We understand that replacement of currently deployed radars in the S-Band (adjacent to the 2.6GHz band) in the Channel Islands is being planned and that the radar in Jersey Airport has recently been replaced.[7] Guernsey Airport is following a similar process at present. Confirmation will be needed from both airports that the new systems have sufficient immunity from the effects of mobile services using the adjacent 2.6GHz band. Based on the UK coordination process, it is

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6 See http://at800.tv/.

7 We understand that this new radar may not yet be fitted with the filter needed to protect it from 2.6GHz LTE transmissions, but that such a filter could be fitted if required.

noted that some coordination at affected installations will still be required even after the UK radars have been upgraded. Ofcom has therefore proposed different protection thresholds before and after radars are modified (with thresholds after modification being less restrictive).[8] The Governments of Guernsey and Jersey should therefore confirm with each airport, and potentially the manufacturer of the radars used in Guernsey and Jersey, if the post-modification threshold proposed in the UK is required in the Channel Islands, and if it is sufficient to avoid interference.

The other interference issue affecting 4G spectrum is possible co-channel interference arising from the use of similar frequencies in the UK and in France. This cross-border interference is typically managed through the development of a 'Memorandum of Understanding' (MoU), which imposes field strength limits that constrain base station deployment, such that base stations close to national borders need to be coordinated via the relevant national regulators with the operators in neighbouring countries. Until recently, separate MoUs were negotiated between the UK and France applying to each individual mobile frequency band in use for 2G and 3G services (i.e. 900MHz, 1800MHz and 2.1GHz). We understand from discussions with Ofcom, however, that a process is now underway to consolidate all existing MoUs into a single agreement. This would mean that for both the UK and France, and separately for the Channel Islands, all previous MoUs for mobile bands between 800MHz and 2.6GHz will be consolidated. Coordination methods and thresholds will also be standardised, taking account of the propagation differences between bands. This should not change the actual coordination levels or selection of preferential or non-preferential channels for current GSM use, but will extend the scope of the coordination to the potential use of LTE in all bands. We note that coordination of bands used for LTE does not involve division of bands into preferred and non-preferred channels but is based on field strength limits applying across each band (which is further described below). We understand from Ofcom that the Governments of Guernsey and Jersey, and CICRA, will be notified when this process is completed.

Ofcom has indicated to us, as part of this study, that the consolidated MoUs will be based as far as possible on pan-European coordination recommendations established by the European Communications Committee (ECC) of the Conference of Postal and Telecommunications Administrations (CEPT).

Mechanism for efficient assignment of 4G spectrum

As noted above, our conclusion is that the Governments of Guernsey and Jersey should use similar spectrum for 4G services to that of the UK and France, which comprises the 800MHz, 900MHz, 1800MHz and 2.6GHz bands. However, the 900MHz band can only be used for 4G once existing 2G usage has been migrated, and once existing 2G assignments have been re-planned into contiguous blocks suitable for 4G.

Our demand analysis suggests that the available 4G spectrum should be sufficient to meet spectrum demand for either three or four mobile operators under the majority of scenarios. This

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8 See annexes to Ofcom's 4G IM for details.

provides scope for the Governments of Guernsey and Jersey, and CICRA, to assign 4G spectrum to a new market entrant if this emerges. It also suggests that assignment of 4G spectrum via an auction may not be required if demand does not exceed supply (since auctions are most commonly used where excess demand exists), and a simpler process, either by direct award or using a beauty contest (e.g. if spectrum is to be awarded to a new entrant), could be adopted.

However, one area where demand could possibly exceed supply relates to the use of the available spectrum below 1GHz. The total bandwidth available in the 800MHz band is 2×30MHz and in the 900MHz band it is 2×35MHz. The entire 900MHz band is currently assigned for 2G use in Guernsey. There is an uneven distribution of 900MHz spectrum between Airtel-Vodafone, Jersey Telecom and Sure, with Airtel-Vodafone having less spectrum overall which is also assigned as non-contiguous blocks in Guernsey (GSM does not need contiguous blocks, but UMTS and LTE benefit significantly).

If three 4G operators are to be licensed in Guernsey and Jersey, there is sufficient new spectrum in the 800MHz band for each operator to be awarded an equal 2×10MHz block. Assigning the 800MHz band in 2×10MHz blocks is the most common outcome of European 4G award processes, and a 2×10MHz assignment per operator enables each operator to deploy an LTE service. However, if four operators are to be licensed (i.e. the three existing operators and a new entrant), there will be insufficient spectrum available in the 800MHz band for each operator to be awarded a 2×10MHz block. In this case, the options would be to divide the band into unequal packages (e.g. two blocks of 2×10MHz and two blocks of 2×5MHz), or to link access to 800MHz spectrum to spectrum currently assigned in the 900MHz band, which would avoid any one existing operator gaining a dominant share of spectrum below 1GHz. For example, a number of regulators in Europe have implemented sub-1GHz spectrum caps to avoid any one operator gaining a large share of spectrum in both the 800MHz and 900MHz bands.

A suitable cap might be 2×20MHz, which would mean that existing operators with 900MHz spectrum cannot acquire new 800MHz spectrum unless the total holding in both bands does not exceed 2×20MHz. The effect of this may be to encourage existing operators with larger 900MHz assignments to consider relinquishing some 900MHz spectrum if they want to acquire new 800MHz spectrum. The relinquished 900MHz spectrum could then be used either to even out the distribution of 900MHz spectrum between existing operators (i.e. to provide Airtel-Vodafone with more bandwidth), or alternatively could be assigned to a new entrant.

Based on advice from Ofcom, it is noted that, without spectrum trading, it is not possible to transfer amounts of spectrum directly between operators. Therefore, any re-planning of the 900MHz and/or 1800MHz band would potentially need to be consulted on by the Governments of Guernsey and Jersey, and CICRA. Once agreed with all stakeholders, Ofcom can be notified of the amendments to be made.

A possible two-stage process could be as follows:

- Firstly, the Governments of Guernsey and Jersey, along with CICRA, invite existing operators to meet to discuss voluntary re-alignment of existing 900MHz and 1800MHz assignments. The purpose of this should be to design a method by which current assignments of spectrum can be moved to form contiguous blocks of spectrum, ideally aligned for each operator between Guernsey and Jersey, with suitable space left for the allocation of additional 1800MHz spectrum in the next phase. If agreement cannot be reached between operators, we suggest that the Governments of Guernsey and Jersey, along with CICRA, intervene to propose a solution upon existing operators. This might involve enforcing a sub-1GHz spectrum cap on existing operators (preventing operators with large 900MHz assignments from being assigned 800MHz spectrum unless some 900MHz spectrum is relinquished), as well as proposing a re-alignment of 1800MHz spectrum into contiguous 2×5MHz blocks across each island (likely to require each operator to move some existing GSM channels to other parts of the band). However, it is noted that it would be highly desirable for a voluntary agreement to be negotiated with the existing operators, since the operators themselves are best placed to advise on what re-alignment is possible and what is not, based upon current 2G spectrum usage.

- Once a potential method to re-align existing assignments has been agreed, the second stage would be a consultation document, describing the proposed re-alignment of existing spectrum and inviting expressions of interest to acquire further 4G spectrum (in the 800MHz, 1800MHz and 2.6GHz bands). If demand for 4G spectrum in any band exceeds the available bandwidth, a process of comparative selection (e.g. a beauty contest) may then be required.

Use of the 2.3GHz and 3.4GHz bands

As part of this study, we were asked to comment on the suitability of 2.3GHz spectrum to provide wireless broadband connectivity between the Channel Islands, and the UK/France.

The UK Frequency Allocation Table (FAT) designates the 2.3GHz band in the UK as being managed by Ministry of Defence (MOD). This covers the UK mainland and coastal waters. Therefore, any use of the 2.3GHz band either in the Channel Islands or between Channel Islands and the UK would require the Channel Islands Governments/CICRA to liaise with the UK MOD in the first instance regarding the use of the spectrum to provide a link to the UK. We understand a similar process would need to be followed in France, since the 2.3GHz band is used by the French military.

The UK MOD is currently considering release of part of the 2.3GHz band from defence use in the UK, for commercial use. This has been prompted by reform to the way that public-sector spectrum is managed in the UK, and also because the 2.3GHz band is being standardised for LTE use

Work is underway in Europe within CEPT to develop a harmonised decision on mobile use of the 2.3GHz band. Therefore, whilst providing wireless connectivity between the Channel Islands and the UK/France is a possible use of the 2.3GHz band, it may be that a preferred use of this band is for mobile broadband services, using LTE, once a European decision is in place. Remaining aligned with neighbouring countries has substantial benefits. The 2.3GHz band could be considered as a band to meet possible future 4G spectrum demand (noting that our demand modelling suggests scope for demand to exceed the current and planned spectrum from around 2020 under certain more aggressive assumptions).

Similarly, the 3.4–3.6GHz band has been identified internationally for use by 4G systems and work is also underway within CEPT to update an earlier ECC Decision regarding harmonised use of this band for LTE. We recommend that the Governments of Guernsey and Jersey, and CICRA, consider this when assessing possible future use of the 3.4GHz band, since mobile operators may identify possible uses of this band for 'small cell' LTE deployments.

Our recommendation regarding the use of available spectrum in both the 2.3GHz and the 3.4GHz bands is that the Governments of Guernsey and Jersey, and CICRA, should wait to assign new spectrum in these bands until usage has been confirmed in the UK and France. This is likely to happen once the current European harmonisation discussions on both bands are finalised.

1.7 Summary of conclusions and recommendations

A summary of the conclusions and recommendations from our study in response to each of the questions posed in the scope of work is provided below.

Whether the availability of existing and proposed spectrum will meet demand in Jersey and Guernsey over the medium to long term

Our modelling suggests that there will likely be sufficient spectrum availability to meet the level of spectrum demand in both a three- and four-player market (although noting this in itself does not mean that a four-operator market is economically viable) under our base case assumptions, assuming existing 900MHz and 1800MHz spectrum licences remain in place, and with the 800MHz, 1800MHz and 2.6GHz bands being made available for mobile use in Jersey and Guernsey. We note, however, that under even marginally more aggressive spectrum demand forecasts, for example increased levels of FWA traffic or reduced levels of site growth, certain operators' spectrum demand begins to exceed their individual spectrum availability.

Recommendations:

We recommend that the Governments of Guernsey and Jersey, and CICRA, should proceed with the design of a process to award new 4G spectrum in the 800MHz, 1800MHz and 2.6GHz bands, and to consider options for redistributing 900MHz and 1800MHz spectrum as soon as practical. The award process should be designed to determine the spectrum assignment to each existing operator. Given that a possible new entrant has already been identified through the earlier expression of interest on 2.6GHz spectrum issued in Jersey, the process should also allow for a possible fourth operator.

Opportunities for reorganising existing 900MHz and 1800MHz spectrum (including options for ensuring spectrum holdings are not under-used)

Our conclusion is that there is merit in reorganising 1800MHz spectrum in the short term, such that operators have contiguous blocks and also have access to the same blocks in Guernsey and Jersey. We believe the 900MHz band may be harder to reorganise in the short term as a result of the more limited bandwidth available in that band, the fact that the available bandwidth is fully assigned to the existing operators (with markedly different assignments for Sure and Jersey Telecom in their 'home' markets), and as a result of coordination constraints with the UK and France. These constraints arise due to the need to maintain existing 2G frequency coordination agreements until such time that 2G services are replaced by 3G/4G, where the same constraints will not apply, since 3G/4G frequency coordination is not based upon the division of frequencies into preferred and non-preferred channels, which is a factor affecting the current 900MHz spectrum distribution between operators in the Channel Islands.

Reorganisation will benefit operators in potentially being able to gain efficiencies through harmonising assignments between Guernsey and Jersey, and the mobile market by enabling all operators to refarm existing 2G assignments for 3G/4G use.

Recommendations:

We recommend that the Governments of Guernsey and Jersey, with CICRA, should review opportunities to reorganise existing 900MHz and 1800MHz assignments in conjunction with the existing operators (to establish what options are feasible). A voluntary agreement to redistribute spectrum between operators may be possible with the agreement of all operators. If operators fail to agree on redistribution, there is an option open to the Governments of Guernsey and Jersey, with CICRA, to link the liberalisation of 2G frequency rights in the 900MHz and 1800MHz bands (for 3G/4G use) to the assignment of new 4G spectrum – for example by imposing a sub-1GHz spectrum cap upon all operators in the market (e.g. such that no operator can hold more than 2×20MHz of spectrum below 1GHz). This would prevent existing operators with larger 900MHz holdings from gaining spectrum in the 800MHz band unless they relinquish an equivalent amount of spectrum in the 900MHz band and would also act as an incentive to ensure that existing 900MHz spectrum is being used efficiently (or if it is not, is relinquished and made available for re-award).

Potential to use

The 2.3GHz band is managed by the Ministry of Defence (MOD) in the UK

2.3GHz for wireless broadband connectivity between the Channel Islands and the UK/France

and we understand a similar situation applies in France. The UK MOD has announced that it intends to release some spectrum in the 2.3GHz band for commercial use (noting that the 2.3GHz band is standardised for LTE and LTE-A use in the relevant 4G equipment specifications).

Any move to use the 2.3GHz band in the Channel Islands would therefore need to be coordinated with both the UK and French defence agencies. This is likely to be time-consuming and may not be practical until both countries have determined future use of the band. It is noted that studies are currently on going to implement a European harmonisation decision covering the 2.3GHz band.

Recommendations:

Although it is technically possible that the 2.3GHz band could be used to provide broadband connectivity between the Channel Islands and the UK/France (France being more likely due to line-of-sight considerations), our recommendation regarding the use of available spectrum in the 2.3GHz (and 3.4GHz) band is that the Governments of Guernsey and Jersey, and CICRA, should wait to assign new spectrum in these bands until usage has been confirmed in the UK and France, noting that both bands are suitable for use by 4G mobile services in the longer term. Confirmation of usage is likely to happen once the current European harmonisation discussions on both bands are finalised.

Assess the economic and commercial effects of introducing better wireless connectivity within each island (including the potential to develop 4G wireless Internet to homes and 4G Internet for mobile devices), and ensure that small and innovative firms have access to new spectrum

Consumer benefits from mobile/wireless broadband services will be created through access to much higher speeds for mobile data transmission than is currently available, which will support wider availability of new mobile services and generate an improved user experience compared to earlier generations of mobile telecommunications. This could also offer consumers an alternative method of accessing broadband services in the home via 4G, which may benefit areas where fibre broadband is not available, and might improve the competitiveness of the broadband market.

Direct and indirect benefits to the economies in Guernsey and Jersey will arise as a result of the capital investments being made in mobile/wireless broadband infrastructure by existing, and possible new, operators.

While access to benefits of 4G services will lead to a significantly increased level of spectrum demand, our modelling suggests there will likely be sufficient spectrum availability to meet the level of spectrum demand in both a three and four player market (i.e. a possible new entrant, which may be a smaller, innovative firm) under our base case assumptions, with 800MHz, 1800MHz and 2.6GHz bands being made available for mobile use in Jersey and Guernsey.[9]

Recommendations:

As noted above, we recommend that the Governments of Guernsey and Jersey and CICRA should proceed with the design of a process to award new 4G spectrum in the 800MHz, 1800MHz and 2.6GHz bands, and to consider options for redistributing 900MHz and 1800MHz spectrum as soon as practical.

Review options for delivering 4G and other high-capacity services ahead of the UK, and in bands other than 800MHz and 2.6GHz, and the risks of deviating from the way in which spectrum is used in the UK and Europe

As noted above, operators and consumers in the Channel Islands will benefit from the Governments of Guernsey and Jersey assigning similar spectrum for 4G services to that of the UK and France – which is the 800MHz, 900MHz, 1800MHz and 2.6GHz bands.[10]

The main risks identified from deviating from the UK and Europe are a lack of economies of scale for equipment, leading to increased cost of network roll-out and a reduction in availability of suitable 4G Internet devices (such as smartphones and tablets). There is also a greater risk of reduced spectrum efficiency as a result of cross-border interference problems between the Channel Islands and the UK/France.

Recommendations:

We recommend that the Governments of Guernsey and Jersey and CICRA should proceed with the design of a process to award new 4G spectrum in the 800MHz, 1800MHz and 2.6GHz bands, and to consider options for redistributing 900MHz and 1800MHz spectrum as soon as practical, as noted above.

We also recommend that the Governments of Guernsey and Jersey, and CICRA, should await decisions in the UK and France regarding the use of the 2.3GHz (and 3.4GHz) bands before determining the best use of those bands. We note that the 3.4GHz band in particular has had a heavy emphasis on use by FWA services and, given the highlighted benefits for competition in the fixed market, the Channel Islands should consider quickly assigning this spectrum once the UK and France have made their intentions clear.

9 Under more aggressive spectrum demand forecasts, for example increased levels of fixed wireless access traffic or reduced levels of site growth, certain operators' spectrum demand begins to exceed their individual spectrum availability.

10 Noting that the 900MHz band can only be used for 4G once existing 2G usage has been migrated and also once existing 2G assignments have been re-planned into contiguous blocks suitable for 4G.

The right mechanism for an efficient award of 4G spectrum, including options for setting fees

Given that our analysis suggests there is potentially sufficient 4G spectrum available to support four operators (although noting this in itself does not mean that a four-operator market is economically viable), and given the small size of the Channel Islands' markets, our conclusion is that a simple direct award or a beauty contest-based process (if one or more new entrant operators are envisaged after initial consultation on award options) could be used, rather than an auction.

Fees for 4G spectrum (both liberalised 900MHz and 1800MHz spectrum, and new assignments in the 800MHz, 1800MHz and 2.6GHz bands) could be set in one of two ways: either by adopting the new UK 900/1800/2100MHz annual licence fees once these are determined by Ofcom, adjusted by head of population as per the current methodology applied to 2G spectrum, or by devising a new approach based upon revenue per operator, which could be implemented by using telecoms legislation in the Channel Islands, since this approach is not possible via the Wireless Telegraphy Act (WTA). To reduce complexity in this case, it may be worth considering that WTA fees are reduced to zero at the same time (or covered by CICRA) so that operators only pay a single fee to a single entity.

Recommendations:

To establish requirements for new spectrum to be awarded, we recommend that a consultation document is issued to establish demand for 4G spectrum in general, including new entrant(s).

If results of the consultation suggest that the only interest in 4G spectrum is from the existing mobile operators, then it could be appropriate to proceed with a direct assignment of spectrum to each operator. This could be done on the basis of assigning equal amounts of spectrum to each existing operator in each of the available 4G bands (i.e. 800MHz, 1800MHz and 2.6GHz). If one or multiple new players were to emerge as a result of the consultation process, then a process of comparative selection (e.g. a beauty contest) may be the most appropriate way to assign spectrum to existing and new players.

2 Introduction

This document has been prepared by Analysys Mason Limited (Analysys Mason) on behalf of the Commerce and Employment Department of the States of Guernsey Government, in conjunction with the Economic Development Department of the Jersey Government, and the Channel Islands Competition and Regulatory Authorities (CICRA). This document is the final report of a study into 4G spectrum requirements in the Channel Islands.

Mobile operators in the Channel Islands currently use spectrum in the 900MHz and 1800MHz bands to provide second-generation (2G) services using GSM technology, and in the 2.1GHz range to provide third-generation (3G) services using UMTS/HSPA technology.

In line with many other governments worldwide, the Governments of Guernsey and Jersey intend to assign spectrum for the launch of fourth-generation (4G) services. 4G networks will be provided by operators potentially using long-term evolution (LTE) technology. The Governments of Guernsey and Jersey, along with CICRA, are responsible for determining the policy and framework for award of 4G licences. Licences for use of radio spectrum will be assigned to operators by the UK Office of Communications (Ofcom) based on the recommendations made by the Governments of Guernsey and Jersey, since Ofcom has responsibility for civil spectrum management in the Channel Islands.

Although a consultation document has previously been issued by CICRA in relation to the award of 800MHz and 2.6GHz spectrum, which are both frequency bands that are ideally suited to providing 4G services, final decisions have not been taken regarding the most efficient assignment of 4G spectrum. Furthermore, the most efficient assignment of 4G spectrum may require consideration of current 2G/3G assignments with a view to ensuring that all market players have sufficient spectrum to meet longer term demand. It is noted that CICRA has already carried out an exercise to re-organise 3G spectrum amongst existing players. A similar exercise might be envisaged for 2G spectrum, however the 2G re-organisation raises a number of complex issues as a result of the current uneven distribution of spectrum between different market players, as well as differences in assignments between the same operators in Guernsey and Jersey.

It is likely that 4G spectrum in the Channel Islands will be released in frequency bands that are broadly consistent with the approach used across the UK. However, the Governments of Guernsey and Jersey, and CICRA, have an opportunity to define and communicate their spectrum requirements so as to influence and optimise the assignment of 4G spectrum to meet the Channel Islands' objectives. Of particular note in this regard is the digital strategy being developed by the States of Guernsey Government, and similar objectives being considered in Jersey.

The Commerce and Employment Department has therefore commissioned this study with a view to establishing spectrum requirements for 4G services in the Channel Islands, and to develop a 4G spectrum assignment strategy. This will be used to inform subsequent decisions regarding award of licences and possible redistribution of 2G spectrum and will also serve as a basis for discussion with Ofcom, in relation to the process leading towards the issue of 4G licences.

2.1 Objectives

The key objectives of the study are to establish the demand for 4G spectrum in the Channel Islands, and to recommend a strategy for 4G spectrum assignment that will support the States of Jersey and Guernsey, and CICRA in developing their future spectrum management strategy for the Channel Islands. It is envisaged that 4G networks will be used in the Channel Islands both to provide next-generation mobile broadband services as well as, potentially, wireless broadband connectivity into homes.

It is likely that in order to ensure that all market players have sufficient spectrum for delivery of future mobile services, opportunities for reorganising existing 2G assignments may need to be assessed. The study has therefore considered this, along with the likely availability of 4G spectrum in different frequency bands, in order to ensure that existing and new players have access to suitable spectrum. Finally, the study has considered the scope to use wireless broadband connectivity, such as using wireless links deployed in the 2.3GHz band, to provide connectivity between the Channel Islands and the UK/France, which may increase competition in international connectivity routes.

Key issues we have considered within the study are:

- what spectrum might be suitable for 4G services
- what demand exists for 4G spectrum in the Channel Islands, and whether existing and planned spectrum will meet this demand
- what opportunities exist to re-organise existing 2G assignments with a view to harmonising assignments between Jersey and Guernsey and to enable 2G spectrum to be refarmed for 3G/4G use
- what the possible constraints on use of spectrum within certain 4G bands are, such as cross-border coordination and/or interference and co-existence issues with adjacent spectrum users
- what mechanism(s) should be used to assign 4G spectrum, including possible spectrum fees.

As part of the study, we have consulted with each of the three existing mobile operators in the Channel Islands (Jersey Telecom, Sure and Airtel-Vodafone) concerning assumptions to be used within the spectrum demand model we have developed, which models demand from the current time up to 2026. We have also obtained certain modelling input assumptions from CICRA and Ofcom. We would like to thank each operator and both of the regulators for their inputs to the study.

2.2 Scope

The full scope of the study as set out in Analysys Mason's proposal to the Commerce and Employment Department of the States of Guernsey Government is as follows:

- Review of commercial and public-sector demand for radio spectrum in the Channel Islands, including:
  - review of existing and proposed spectrum for 2G/3G/4G services, and whether proposed allocations will meet anticipated demand over the medium to long term
  - opportunities to reorganise spectrum, if required, to make sufficient bandwidth available for new 4G and other high-capacity wireless broadband services
  - potential to use 2.3GHz spectrum (subject to Ofcom confirmation on availability) to provide wireless broadband connectivity between the Channel Islands and UK/France
  - economic and commercial effects of introducing wireless connectivity within each island, as an alternative to existing fixed infrastructure.

- Assessment of potential variations to spectrum usage, including:
  - options for delivering 4G and other high-capacity services ahead of the UK, using bands other than 800MHz and 2.6GHz
  - potential to develop wireless 4G broadband Internet for homes and for mobile devices
  - risks of varying spectrum usage in the Channel Islands from the way it is used in the UK and in the European Union (including risk of interference, such as with DTT and aeronautical/maritime radar, or with French military radar).

- Review options and incentives available for ensuring that spectrum is used efficiently.

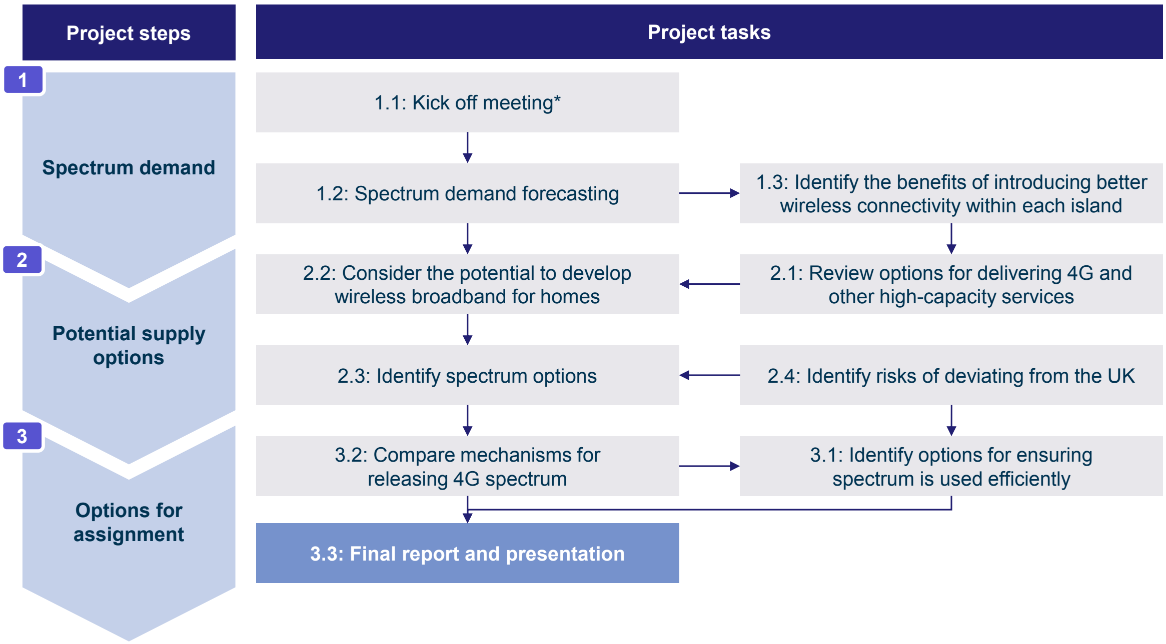
- Review mechanisms for efficient assignment of spectrum, such as auctions and comparative selection processes, and their applicability in the Channel Islands.

- Consider options for raising revenues via ‘top slicing’ of licence fees.

2.3 Approach to the study

Our overall approach to the study is summarised in Figure 2.1.

Figure 2.1: Approach to the study [Source: Analysys Mason, 2013]



A brief description of our approach to each task is provided below.

Spectrum demand forecasting

Within this task, our objective has been to calculate the amount of spectrum required in order to carry the volume of traffic we have forecast for each year of the modelling period, across our two geotypes (urban and rural). To achieve this we have developed a 4G spectrum demand model, applying from the current time until 2026. To validate certain input assumptions to our model, we have obtained input from CICRA and from Ofcom, and have also contacted the three main mobile operators on Jersey and Guernsey and gathered information from them on current and forecast mobile voice and data usage, and existing network characteristics.

The approach and results from the modelling are described in Sections 6 and 7.

Benefits of introducing better wireless connectivity within each island

Considerable literature has been written on the potential benefits accrued through the deployment of next-generation mobile/LTE networks especially in relation to use of the 'digital dividend' spectrum.[11] The purpose of this task was to consider some of the likely benefits from LTE roll-out for the Channels Islands, including both the benefits gained by consumers and by each island. This is summarised in Section 8.

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11 For example: 'The benefits of using LTE in digital dividend spectrum', 4G Americas, 2011; 'Getting the most out of the Digital Dividend', Spectrum Value Partners, 2008; 'Mobile Broadband and the UK Economy', Capital Economics, 2012; 'Estimating the cost to UK businesses of slow mobile broadband' Open Digital Policy Organisation, 2011.

Review options for delivering 4G and other high-capacity wireless services

The aim of this task was to identify frequency bands that might be considered as options to accommodate 4G spectrum requirements in the Channel Islands. In order to do this, we have reviewed the frequency bands that have been standardised for 4G use within the relevant equipment standards, the bands that are currently harmonised for this purpose in Europe, and the proposed assignment of 4G spectrum in the UK, as announced by the UK regulator, Ofcom. Frequency bands for 4G use and their characteristics are discussed in Section 4.

Consider the potential to develop wireless broadband to homes

The purpose of this task was to consider competition and pricing in the supply of fixed broadband services within each island, and pricing of connectivity between Guernsey/Jersey and the UK/France. From this, we have considered the extent to which the wider availability of new wireless broadband connectivity might improve the availability, choice and cost of broadband connectivity for homes and businesses in the Channel Islands. This is summarised in Section 8 and Annex B.

Identify spectrum options

We have assessed the scope for different spectrum combinations to accommodate the forecast 4G demand within the Channel Islands. This has involved analysis of the technical characteristics of different 4G bands (e.g. coverage/capacity capabilities and bandwidth available per band) and consideration of a range of other factors influencing suitability, including timing of availability, equipment and device availability and any constraints on use (including those due to interference with adjacent users and cross-border coordination with the UK and Ireland). As part of this task, we have also considered options to reorganise existing 2G spectrum assignments, if necessary, to meet 4G demand. This is summarised in Sections 4, 7 and 12.

Identify risks of deviating from the UK

This task identifies the key benefits of aligning the Channel Islands' 4G spectrum strategy with that of the UK and the European Union (EU), and the possible risks and issues from not doing so. This is summarised in Section 12.

Identify options for using spectrum efficiently

The objective of this task has been to review options available within the 4G licensing process to ensure that spectrum is used efficiently, such as spectrum caps, coverage obligations and reservation of minimum spectrum for certain players in the market. This is summarised in Sections 9 and 10.

Compare mechanisms for releasing 4G spectrum

We have undertaken research to contrast the methods used to release 4G spectrum in the UK and selected EU countries, to provide guidance on a suitable framework for award of spectrum in the Channel Islands. This is summarised in Sections 9 and 10.

Based on the analysis described above, we have developed a 4G spectrum strategy for the Channel Islands and describe it in this report. In addition to this final report, a presentation will be given to the Governments of Guernsey and Jersey, and CICRA, providing a summary of key findings.

2.4 Structure of report

The remainder of this report is laid out as follows:

- Section 3 gives some background on the latest evolving mobile technologies, specifically focusing on HSPA and LTE technologies and their developments
- Section 4 considers the key 4G spectrum bands in Europe and details the characteristics of each of these bands
- Section 5 gives a brief summary of the Channel Islands' mobile and fixed markets
- Section 6 details our approach to spectrum demand modelling for the Channel Islands
- Section 7 describes the results of the spectrum demand modelling, including our parameter sensitivity testing
- Section 8 discusses the potential economic benefits of LTE deployment in the Channel Islands
- Section 9 gives an assessment of alternative approaches to 4G spectrum release
- Section 10 explores the possible approaches to setting licence fees for mobile spectrum
- Section 11 considers the possible frequency coordination and interference issues which may affect the Channel Islands
- Section 12 provides our conclusions and recommendations.

The report includes a number of annexes containing supplementary material:

- Annex A provides a glossary of abbreviations and terms used in the report
- Annex B provides a benchmark of the cost of fixed broadband services to consumers in the Channel Islands versus other European countries
- Annex C provides a benchmark of selected spectrum fee calculation approaches
- Annex D details some of the confidential spectrum demand modelling inputs
- Annex E presents the spectral efficiencies chosen for the modelling
- Annex F details the operator-specific results for the spectrum demand sensitivity tests run during our modelling
- Annex G describes some of the approaches to 4G spectrum release within selected EU countries.

3 Background to evolving mobile technologies

In this section, we briefly describe the evolution of 3G mobile technologies to 4G, covering enhanced 3G (HSPA+), pre-4G (LTE) and 4G (LTE-Advanced), and considering the spectral efficiencies of different technologies i.e. capacity per base station per unit spectrum, a key parameter used in our demand modelling.

3.1 Evolved 3G technology

3G technology has continued to evolve since its initial deployment nearly a decade ago. 3G networks – also referred to as universal mobile telecommunications system (UMTS) – use wideband CDMA (WCDMA) technology, which has evolved to high-speed packet access (HSPA) and subsequently HSPA+. These enhancements allow increased capacity within existing 3G spectrum bands, prior to, or alongside, deployment of 4G (LTE and LTE-Advanced) in existing and new spectrum.

Operators are taking various approaches to deploying HSPA+ and LTE. Most operators are deploying LTE once new spectrum is available (see next section), but many are also deploying HSPA+ in the meantime in order to benefit from the higher speeds that HSPA+ provides compared to previous versions of the 3G standard.

Both 3G and 4G technologies are standardised by the 3rd Generation Partnership Project (3GPP), which periodically releases new standards. Release 8 of the 3GPP standard is the first to incorporate LTE functionality, although LTE-Advanced or LTE-A ('true' 4G to some observers) will not be available until Release 10 of the standard, which is expected to be introduced in equipment during 2013.

Whereas LTE requires operators to invest in a new radio architecture and technology, HSPA and HSPA+ are often just software upgrades to existing, modern, 3G equipment. The exception is if Multiple In, Multiple Out (MIMO) technology is used. MIMO requires hardware upgrades to existing base station sites, including site visits to install new antennas. It is therefore more costly to deploy than a pure software upgrade.

Figure 3.1: Evolution of 3G technology [Source: Analysys Mason, 2013]

Technology	Bandwidth	Downlink data rate (peak) (Mbit/s)	Downlink data rate (average) (Mbit/s)	Version of 3GPP standard
HSPA	5MHz	14.4	2.75	3GPP Release 5
HSPA+ with 64QAM[12]	5MHz	21.6	3.7	3GPP Release 7
HSPA+ with 2×2 MIMO	5MHz	28.8	5.5	3GPP Release 7
HSPA+ with 64 QAM and 2×2 MIMO	5MHz	42	7.4	3GPP Release 8
HSPA+ with 64 QAM and dual carriers	10MHz	42	7.4	3GPP Release 8
HSPA+ with 64 QAM, 2×2 MIMO and dual carriers	10MHz	84	14.8	3GPP Release 9
LTE	10MHz	73	16	3GPP Release 8 / 9

A number of mobile operators in Europe have chosen to deploy HSPA+ networks in existing 2G (e.g. 900MHz) or 3G (2.1GHz) spectrum, either ahead of deploying LTE, or alongside LTE.

This is summarised below in Figure 3.2.

Figure 3.2: HSPA+ deployments in Western Europe [Source: Analysys Mason, 2013]

Country	Operational	In deployment [Planned]
Austria	A1 Telekom (DC-HSPA+) 3 (DC-HSPA+) Orange (DC-HSPA+) T-Mobile (HSPA+)	[Orange (84Mbit/s DC-HSPA+ with MIMO & 64 QAM)] [T-Mobile (DC-HSPA+)]
Belgium	Mobistar (DC-HSPA+)	Proximus (DC-HSPA+) Base (HSPA+)
Cyprus	MTN (HSPA+)	
Denmark	TDC (DC-HSPA+) 3 (HSPA+) TeleNor (HSPA+)	[3 (84Mbit/s DC-HSPA+ with MIMO & 64 QAM)]
Faroe Islands	Faroese Telecom (HSPA+)	
Finland	DNA (DC-HSPA+) Elisa (DC-HSPA+)	
France	Bouygues Telecomm (DC-HSPA+) Free Mobile (Iliad) (DC-HSPA+) Orange (DC-HSPA+) SFR (DC-HSPA+)	
Germany	Deutsche Telekom (DC-HSPA+) T-Mobile (DC-HSPA+) E-Plus Mobilfunk (HSPA+) O2 (HSPA+)	

12 Quadrature Amplitude Modulation, an enhanced modulation scheme that provides faster speeds over shorter distances.

Country	Operational	In deployment [Planned]
Greece	Cosmote (DC-HSPA+) Vodafone - Panafon (DC-HSPA+) Wind Hellas (DC-HSPA+)	
Guernsey	JT (DC-HSPA+)	
Ireland	Vodafone (DC-HSPA+) Hutchison 3G (HSPA+) Meteor (HSPA+) O2 (HSPA+)	[3 (DC-HSPA+)]
Italy	3 (DC-HSPA+) Vodafone Omnitel (DC-HSPA+) TIM (HSPA+)	Wind (DC-HSPA+) [TIM (DC-HSPA+)]
Jersey	JT (DC-HSPA+)	
Luxembourg	Orange (HSPA+)	
Malta	Go Mobile (DC-HSPA+) Vodafone (DC-HSPA+)	
Netherlands	Vodafone (HSPA+)	KPN (HSPA+) T-Mobile (HSPA+)
Norway	NetCom (HSPA+) Telenor (HSPA+)	
Portugal	Vodafone (DC-HSPA+) Optimus/Sonaecom (HSPA+) TMN (HSPA+)	Optimus/Sonaecom (DC-HSPA+) TMN (DC-HSPA+)
Spain	Telefonica Movistar (DC-HSPA+) Vodafone (DC-HSPA+) Yoigo (HSPA+)	Orange (DC-HSPA+)
Sweden	3 (DC-HSPA+) TeleNor (DC-HSPA+) Tele2 (HSPA+) TeliaSonera (HSPA+)	[3 (84Mbit/s DC-HSPA+ with MIMO & 64 QAM)]
Switzerland	Orange (DC-HSPA+) Swisscom (DC-HSPA+) Sunrise (HSPA+)	[Sunrise (84MBps DC-HSPA+ (with MIMO & 64 QAM))]
UK	3 (DC-HSPA+) O2 (HSPA+) Vodafone (HSPA+)	O2 (DC-HSPA+) Orange (DC-HSPA+) T-Mobile (DC-HSPA+)

The main frequency band used for HSPA and HSPA+ in Europe is the 3G spectrum from 1920–1980/2110–2170MHz (‘the 2.1GHz band’). However, many European operators are also opting to deploy HSPA/HSPA+ in 2G spectrum in the 900MHz band, by refarming legacy 2G networks in order to deploy 3G in parts or all of the 900MHz band. It is also theoretically possible to deploy HSPA/HSPA+ in 2G spectrum in the 1800MHz band. However European operators have tended to refarm 1800MHz spectrum directly to LTE, rather than to HSPA/HSPA+. As described later in this report, this has affected the device eco-system for HSPA+ and LTE devices operating in 2G-spectrum, with HSPA+ devices currently more widely available for operation in

900MHz and 2.1GHz spectrum, and LTE devices more widely available for operation in 1800MHz and 2.6GHz spectrum.

While technical advances to HSPA (such as HSPA+ and dual-carrier HSPA) are defined in 3GPP releases 7 to 9, as noted above, the HSPA standard is likely to continue to evolve despite the increasing focus on LTE from Release 8 onwards. Further enhancements to HSPA+ are expected to be included in the 3GPP Release 11 specification and in subsequent releases. At the forefront of these developments are vendors like Qualcomm, which refer to 'HSPA+ Advanced' to provide maximum HSPA performance in the 5MHz carriers that 3G/HSPA networks typically use.[13] Some of the advancements being considered include heterogeneous networks in HSPA (i.e. hierarchical networks including 'small cells'), and various technical features to improve efficiency in use of a 5MHz HSPA carrier.

3.2 Long-Term Evolution

LTE is a term used to describe the latest generation (Release 8, Release 9 and beyond) of mobile standards from 3GPP. LTE offers significant performance improvements compared with UMTS and HSPA (described above) by adopting a new radio access technology (orthogonal frequency division multiple access, or OFDMA), and different modulation techniques in the air interface. Although the 4G radio interface is different to 3G, 4G technology can be deployed at existing 3G (or 2G) sites, by adding 4G base station equipment to existing cabinets and adapting antennas if required (depending on the frequencies used to transmit 4G services).

A key difference between LTE and 3G (including UMTS and HSPA/HSPA+) networks is that, with LTE, both the core and access networks operate entirely on Internet protocol (IP) communications. LTE is often referred to as 4G, and the majority of operators worldwide have begun rolling it out, or plan to roll it out soon. However, Release 8 and 9 of the 3GPP standard are sometimes considered as 'pre-4G' technology, with 'real' 4G (in accordance with the ITU's definition of 4G) being Release 10 of the standard (which is to be issued in 2013), referred to as LTE-Advanced. This is an issue where operator marketing differs from the views of the purists.

We note that in addition to LTE, other 4G standards exist, including WiMAX. However, in this report we focus on LTE, given its popularity as the key technology with which to provide 4G services. This popularity, compared to other technologies, is primarily due to mobile operators having a natural path of evolution towards LTE.

The maximum throughput of LTE depends on the amount of spectrum (or bandwidth) that an operator is assigned, the spectrum configuration (e.g. whether channels are contiguous, or not), the antenna configuration of the base station, the capabilities of the user device, and the modulation and coding configuration of the LTE signal.[14] LTE is theoretically capable of achieving data download rates of up to 156Mbit/s, but speed tests from early LTE deployments have typically

13 http://www.qualcomm.com/media/documents/hspa-advanced-taking-hspa-next-level.

14 Link adaptation is a core part of the LTE standard, which involves the variation of modulation and coding schemes to maximise throughput by the base station (e-NodeB, or eNB)

shown real downstream speeds of between 5Mbit/s and 30Mbit/s. In addition, the coverage achieved at different download data rates also depends on the frequency of the spectrum, since lower frequencies propagate further and, therefore, enable larger areas to be covered with fewer base stations.

LTE networks are able to operate using spectrum at various frequencies. Regulators must therefore decide which spectrum bands are to be used for this particular use, and while there is a degree of harmonisation in certain regions, there is considerable variation in the availability of spectrum for LTE around the world. This is reflected in the 3GPP standards. The LTE standard has two modes of operation – frequency division duplex (FDD) operating in paired spectrum, and time division duplex (TDD) operating in unpaired spectrum. To date, FDD deployments have been more widespread, particularly within Europe.

The main frequency bands that have been (or will be) used in Europe for LTE for FDD operation are:

- 800MHz
- 900MHz
- 1800MHz
- 2100MHz
- 2600MHz.

Other bands that are included in the 3GPP specifications for LTE (specifically for the TD-LTE mode) are 2.3GHz and 3.4GHz.

Whilst all of the above bands are likely to be used in Europe for LTE in the future, there are constraints in terms of the availability of devices that are capable of operating in some of bands (as discussed in more detail in Section 4.2).

The typical amount of spectrum allocated to a mobile operator for 4G deployment per frequency band within the countries in Europe that have already licensed 4G services varies between 2×5MHz and 2×20MHz. It is typically the case that wider bandwidths per operator (e.g. 2×20MHz) can be more easily accommodated in higher frequency bands (e.g. 1.8GHz or 2.6GHz). Bands below 1GHz have less bandwidth available overall, such that the assignment per operator is usually 2×10MHz, rather than 2×20MHz. This impacts the peak capacity and peak downlink data speed achievable using a lower frequency network layer. However, operators are typically deploying multi-frequency networks for LTE, incorporating lower and higher frequency layers, which means that higher speeds can be accommodated in areas covered by the higher frequency overlay. If the base stations are widely spaced, this may mean that network performance perceived by the end user is variable, depending on proximity to the base station.

Each of the bands noted above for LTE use in Europe are supported by European harmonisation decisions, published either by the European Commission (EC) and/or the European Communications Committee (ECC) of the Conference of Postal and Telecommunications Administrations (CEPT). These harmonisation measures are described in Section 4.

3.3 LTE-Advanced

Current LTE commercial networks are using either Release 8 or 9 of the 3GPP standards. Release 10 and beyond is referred to as LTE-Advanced (LTE-A). Release 10 was finalised in March 2011 and is expected to be implemented in commercial networks from late 2013 onwards. Release 11 of the standard, which will standardise further enhancements to LTE-A, is expected to be completed during 2013.

LTE-A brings together a number of significant enhancements beyond the capabilities of LTE.

These developments bring advances in both capacity and spectral efficiency, with LTE-A able to deliver theoretical download speeds in excess of 1Gbit/s given sufficient spectrum, and with a (vendor stated) performance improvement of 30–70% seen compared to LTE networks with equivalent spectrum (as shown in Section 3.4). Importantly, LTE-A is backwards-compatible, allowing earlier LTE devices to use the LTE-A network, though they do not gain the advantages of LTE-A.

The capacity and spectral efficiency improvements provided by LTE-A are achieved through use of enhanced-uplink, multiple-access mechanisms and enhanced multiple-antenna transmission. The principal enhancements in Release 10 that allow LTE-A to achieve higher data rates are:

- Carrier aggregation (CA) – the ability to combine several radio frequency carriers, in the uplink or downlink (or both) directions, to give total bandwidth per carrier of up to 2×100MHz (versus 2×20MHz for LTE). Carrier aggregation can take place either within a frequency band (intra-band CA), or between frequency bands (inter-band CA). [15]

- Higher order 'multiple-input, multiple-output' (MIMO) techniques – a technology that allows greater throughput to be achieved in each cell through the use of spatial multiplexing. The major change in LTE-A compared to earlier standards is the possible use of higher-order MIMO: 8×8 MIMO on the downlink and 4×4 MIMO on the uplink is being discussed, for example. Higher order MIMO requires many more antennas on the base station and in devices.[16]

- Relay nodes – these are low-power base stations that can provide enhanced coverage and capacity within a cell, either at a cell edge or to extend coverage indoors.

The performance improvements offered by LTE-A depend in particular on the specific MIMO technique used. However, the market is not yet sufficiently developed for us to have real world data on the preferred operator set-up for a 'standard' LTE-A deployment, and as such we need to use estimates of the final speeds which may be seen in practice.

Release 10 of the 3GPP standard supports 43 different frequency bands in order to accommodate the requirements of different world regions, of which eleven are TDD and the remainder are FDD.

15 Only certain bands are currently supported for this feature.

16 It is noted that MIMO can only provide significant improvement in data rates in environments where signal-to-noise ratio is high – see http://www.3gpp.org/IMG/pdf/lte_advanced_v2.pdf.

Of these, only three bands currently support intra-band carrier aggregation, which are the 2.1GHz, 2.3GHz and 2.6GHz bands.

Two bands (2.1GHz and 850MHz, the latter of which is not used in Europe) support inter-band carrier aggregation in Release 11 of the standard, though compatibility with more bands is expected to be added in later releases, as detailed in Figure 3.3.

Figure 3.3: Predicted development of inter- and intra-band carrier aggregation amongst LTE-A releases (generated from current 3GPP working groups) [Source: Analysys Mason, 2013]

3GPP bands	Band 3 (1800MHz)	Band 7 (2.6GHz)	Band 8 (900MHz)	Band 20 (800MHz)	Band 38 (2.6GHz, TDD)	Band 40 (3.4GHz, TDD)
Band 3	Release 12	Release 11	Release 11	Release 11	N/A	N/A
Band 7	Release 11	Release 11	N/A	Release 11	N/A	N/A
Band 8	Release 11	N/A	N/A	Release 11	N/A	N/A
Band 20	Release 11	Release 11	Release 11	N/A	N/A	N/A
Band 38	N/A	N/A	N/A	N/A	Release 11	N/A
Band 40	N/A	N/A	N/A	N/A	N/A	Release 10

Future enhancements are also being studied within subsequent LTE-A releases, including coordinated multipoint transmission and reception (CoMP), designed to improve cell edge performance, which will increase the overall capacity of a cell. Provided that sufficient spectrum is available, LTE-A is theoretically designed to deliver downlink (i.e. network to user) speeds in excess of 1Gbit/s, and 200Mbit/s on the uplink.

3.4 Spectral efficiencies of various mobile technologies

It is important for our demand modelling, as discussed in Section 6, to consider the spectral efficiency of all three technologies discussed above (HSPA+, LTE and LTE-A), as well as other currently existing technologies that will be used in legacy networks for many years to come.

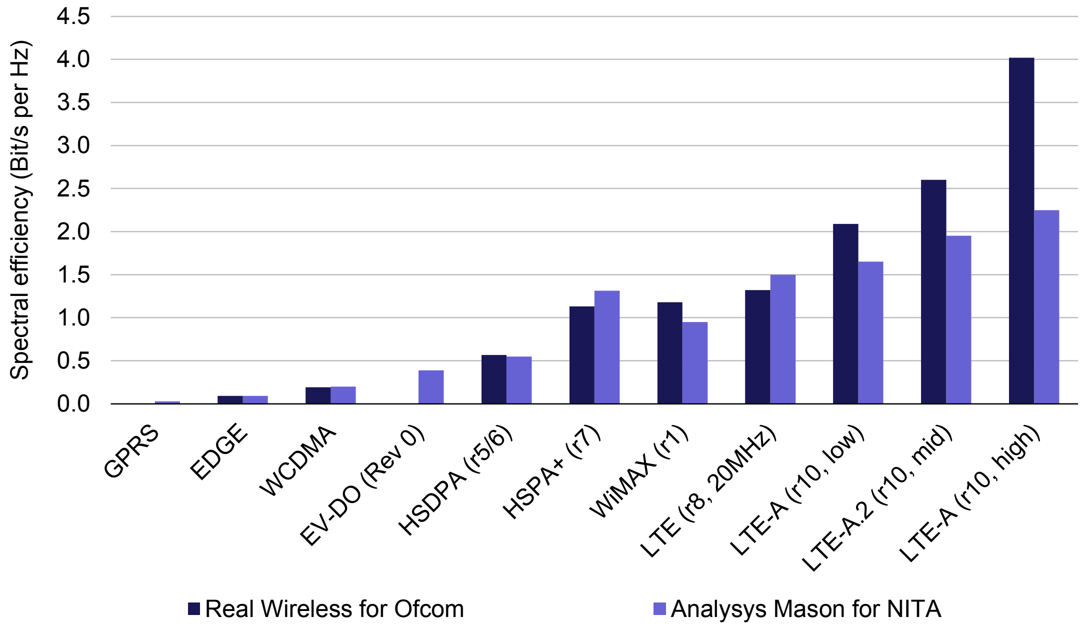
An issue in any comparison of various transmission technologies is the assumptions that underlie any estimates of spectral efficiency, including factors such as the cell loading or signal-to-noise ratios, both of which significantly affect the level of spectral efficiency seen in practice. To address this, we have based our modelled efficiencies on established benchmark studies taken across regulators and industry, focusing on the technical variant of each technology that is most commonly deployed in practice by mobile operators.

The main study we have used in developing the benchmark of spectral efficiency is Real Wireless's report for Ofcom on '*4G Capacity Gains, 2011*'.[17] These figures have also been compared against our previous work on spectrum demand efficiency in Denmark where a detailed

[17] http://stakeholders.ofcom.org.uk/binaries/research/technology-research/2011/4g/4GCapacityGainsFinalReport.pdf

literature review was undertaken.[18] We have compared spectral efficiency estimates for technology values between these studies, as shown in Figure 3.4, and have found little variation except in the case of LTE-A, as discussed below.

Figure 3.4: Benchmark of spectral efficiency by technology [Source: Real Wireless for Ofcom,[19] Analysys Mason, 2011]



The main difference between the two studies is the assumed level of future market adoption of higher order MIMO, especially in future LTE-A technologies. As demonstrated in Figure 3.3, MIMO is a key variant in the spectral efficiency of newer technologies. However, as MIMO solutions require multiple antennas to be built into devices with at least a minimum level of antenna isolation (which in practice requires separation), the exact feasibility of this in all but the largest tablet or laptop devices is unidentified. This issue is compounded by the increasing complexity of antenna design required in devices due to the large number of bands that LTE operates across. The Danish study tended to take more conservative spectral efficiencies for HSPA+, LTE and WiMAX assuming minimal levels of MIMO compatibility, whereas the UK Real Wireless study is considerably more aggressive particularly towards its LTE-A 'high-end' deployment profile.

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18 Source: The future need for broadband frequencies in Denmark, Analysys Mason, 2011. The following papers were reviewed: FCC's report on 'Mobile Broadband: The Benefits of Additional Spectrum', 3G Americas' report on 'HSPA to LTE Advanced, 2009', 3GPP's report on '3GPP, ITU-R WP5 3rd Workshop on IMT-Advanced, Mobile World Congress, 2009', Telus's report on 'Next Generation RAN Architecture, 2009'.

19 'Typical expected roll-out' values have been used in each case, except for HSPA+ (r7) where the 'high-end' value is considered.

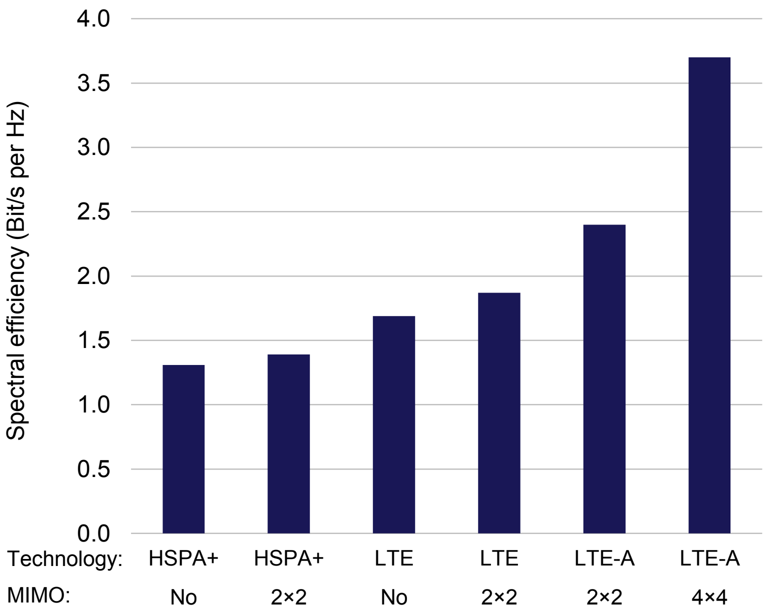

Figure 3.5: Demonstration of the difference in spectral efficiency due to various MIMO types [Source: Agilent, 3G Americas, Telus, 3GPP]

We note that in order to limit the size of the set of results, we have restricted our results to one variant per technology, despite the large number of small incremental upgrades within each technological step. Where there is uncertainty as to the exact forecast spectral efficiency of LTE-A, including the timing of implementation of features, we have modelled three steps relating to the Real Wireless 'low-end', 'typical expected roll-out' and 'high-end' cases.

The largest increase in LTE-A's efficiency comes from use of MIMO, which, as discussed above, is currently limited – especially in smartphones – but is likely to develop over time. As such, we believe that modelling this capability as a series of efficiency steps developing over time is appropriate, though we have tested this in our sensitivity analysis in Section 7.2.

Given the significant growth in spectral efficiencies modelled, the fact that later growth is mostly MIMO-related, and the difficulties at extending the number of antennas in devices beyond a certain level, it is assumed that any mobile or FWA technology deployed between now and 2026, for example, a future release of WiMAX, will be equivalently as spectrally efficient as our highest LTE-A case. Given this, and the current lack of information on further future technological innovations, we do not consider possible technologies beyond LTE-A.

We do not consider FWA technologies independently, given the strong convergence of wireless technologies used for both fixed and mobile services, although we note that spectrum (especially in the higher frequency bands) can be used for both FWA and mobile services. One of the key differences between these technologies is the use of an external antenna attached to the outside of a house in most FWA technologies, which results in better reception, especially when operating at high frequencies in rural areas. This can allow for slightly increased spectral efficiencies, but is balanced, however, by consumer preference for technologies such as mobile broadband (i.e. dongles) that can be used both at home (as a substitute for FWA) and while on the move.

4 4G spectrum in Europe and the characteristics of different bands

4.1 Introduction

In this section, we summarise the various frequency bands that European regulators are typically assigning for 4G use, based upon European harmonisation decisions and international spectrum allocations.

It is noted that, because 3GPP standards for LTE and LTE-A support operation in existing mobile spectrum (i.e. bands previously used for 2G and 3G mobile services), as well as in new bands, regulators across Europe have typically considered the need for both existing and new bands to support the 4G market. This therefore involves consideration of existing spectrum distribution within 2G/3G bands, and whether the amount of spectrum available in existing bands, and its configuration, is a suitable basis upon which to move forward with 4G licensing.

In the UK, for example, Ofcom is proposing to meet future demand for spectrum for mobile broadband or 4G services through two related policies:

- Award of new mobile spectrum licences to use spectrum between 790–862MHz (‘the 800MHz band’) and 2500–2690MHz (‘the 2.6GHz band’) in early 2013.
- Liberalisation of 2G spectrum (in the 900MHz and 1800MHz bands) to enable existing 2G operators to refarm spectrum for 3G/4G use.

Therefore, when considering the options for meeting 4G spectrum demand, it is appropriate for the Governments of Guernsey and Jersey to consider not just new spectrum bands (e.g. 800MHz and 2.6GHz) but also the existing bands used for 2G/3G mobile services (e.g. 900MHz, 1800MHz and 2.1GHz), which can be refarmed for 4G use. For example, it is noted that not all the available 2G spectrum in the 1800MHz band has previously been assigned for 2G use in the Channel Islands and so there is a possibility of the remaining spectrum in that band being assigned directly for 4G use.

It is also noted that the current configuration, and distribution, of 2G spectrum in the 900MHz and 1800MHz bands, in particular in Guernsey and Jersey, may need to be considered in the context of seeking to obtain an equitable distribution of spectrum between existing and potential new operators for 4G.

This is illustrated by the table below, which indicates the maximum spectrum available in each frequency band potentially suitable for 4G services, the typical assignment per operator in each band that would be most suitable for deploying LTE (based upon an equitable division of each band into blocks suitable to support 4G) and the currently assigned spectrum in the Channel Islands.

Figure 4.1: Spectrum availability of the relevant bands [Source: Analysys Mason, 2012]

Frequency band	Maximum spectrum	Typical assignment per operator for LTE	Current assignment per operator in Jersey	Current assignment per operator in Guernsey
800MHz	2×30MHz	2×10MHz	Not yet assigned	Not yet assigned
900MHz	2×35MHz	2×10MHz or 2×15MHz	2×24.8MHz Jersey Telecom, 2×5MHz Sure and 2×5MHz Airtel-Vodafone	2×19.8MHz Sure, 2×9.8MHz Jersey Telecom and 2×5MHz Airtel-Vodafone[20]
1800MHz	2×75MHz	2×25MHz	2×11.6MHz Jersey Telecom, 2×10MHz Sure[21] and 2×5MHz Airtel-Vodafone[22]	2×5MHz Sure, 2×10MHz Jersey telecom and 2×6.2MHz Airtel-Vodafone[23]
2.1GHz	2×60MHz	2×20MHz	2×10MHz each for Jersey Telecom, Sure and Airtel-Vodafone	2×10MHz each for Jersey Telecom, Sure and Airtel-Vodafone
2.3GHz	100MHz (unpaired)	Undetermined[24]	Not yet assigned	Not yet assigned
2.6GHz	2×70MHz	2×20MHz or 2×30MHz	Not yet assigned[25]	Not yet assigned
3.4-3.6GHz	200MHz (unpaired)	Undetermined[26]	2×20MHz Newtel	2×20MHz Newtel

As can be seen from this table, the current 2G spectrum distribution in the 900MHz and 1800MHz bands in both Guernsey and Jersey is not suitable for 4G deployment, because some of the existing assignments are in blocks of less than 2×5MHz (the practical minimum for 4G deployment).[27] Assignments in the 900MHz band are also heavily weighted towards two operators at present, Jersey Telecom in Jersey and Sure in Guernsey.

In the following section, we have grouped our consideration of frequencies suitable for 4G deployment into bands below 1GHz and bands above 1GHz. This is because the frequency of a radio wave has a significant impact on its physical propagation and penetration characteristics,

20 However, the spectrum assigned to Airtel-Vodafone is in non-contiguous channels of 2×2.6MHz and 2×2.4MHz.

21 However, the spectrum assigned to Sure is in non-contiguous channels of 2×8.2MHz and 2×1.8MHz.

22 However, the spectrum assigned to Airtel-Vodafone is in non-contiguous channels of 2×2MHz and 2×3MHz.

23 However, the spectrum assigned to Airtel-Vodafone is in non-contiguous channels of 2×5MHz and 2×1.2MHz.

24 Not yet assigned for LTE use in Europe.

25 An earlier consultation exercise has resulted in 2×20MHz of 2.6GHz spectrum being reserved for Clear Mobitel Jersey but a WTA licence is yet to be issued by Ofcom, pending review of the licensing decision.

26 Not yet assigned for LTE use in Europe.

27 While the 3GPP specifications support a minimum bandwidth of 2×1.4MHz for LTE in the 900MHz and 1800MHz band, we consider 2×5MHz to be the practical minimum given the reduced spectral efficiency for operators below this level, and a lack of 4G equipment operating with channel widths of less than 5MHz.

affecting the coverage that can be provided using different frequencies as well as the ability of base stations to penetrate buildings.[28]

4.2 Characteristics of different spectrum bands used for 4G in other parts of Europe

Below we consider the characteristics of different 4G spectrum bands, including, for each band:

- the current global device ecosystem
- the theoretical radii that would be seen in deployment of LTE cells using the band
- the amount of spectrum available in the band
- the current state of European harmonisation seen in each band
- any other issues that may affect the band, such as interference or historical assignment.

One of the key characteristics of the different spectrum bands is the difference in cell radius due to different radio propagation characteristics. In general, lower frequencies propagate more readily than higher frequencies. This reduces the theoretical number of cells required by a single operator to cover the island, and thus reduces a significant part of the operator's capital and operational network costs.

To more accurately compare between cell sizes at different frequencies, we have calculated below the theoretical cell radius using an LTE link budget model, with a service providing a 75% probability[29] that a single user at the cell edge (of an unloaded cell) will be able to achieve a specified throughput for either indoor or outdoor measurement. This is consistent with the assumptions typically used by network operators in their radio planning exercises. However, in practice, the average cell radii will also vary depending on additional geographic and terrain factors, including hilliness and lack of perfect tessellation, and thus this data is given just for comparison.

As well as there being differences in propagation conditions between different frequency bands for LTE, there are also differences in equipment economies of scale, and in device availability. For each band, we have commented on the current device ecosystem seen, and how this may develop into the future. Information on the number of devices in each band is taken from the Global Suppliers Association (GSA) '*GSA Analyzer for Mobile Broadband Devices*' (GAMBoD).

The GAMBoD database currently lists 221 models of LTE-compatible handsets,[30] with LTE devices being provided by 25 different manufacturers. However, this is still significantly behind the 3G/HPSA ecosystem, with GAMBoD listing 1677 handsets, from 86 different manufacturers, being available for HSPA. According to Wireless Intelligence, global HSPA connections are estimated to reach 998.7 million in Q3 2012 compared to 43.5 million connections for LTE. The two frequency bands most commonly used for HSPA/HSPA+ are the 900MHz and 2.1GHz bands.

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28 In general, the lower the frequency, the further the radio wave propagates through the air and the deeper it penetrates inside buildings. This means that to achieve a similar user experience, fewer sites need to be built at lower frequencies, and so the capital expenditure required can be reduced.

29 The 75% cell edge probability relates to a cell area probability of approximately 90%.

30 However, we note that many HSPA and LTE handsets are repeats of the same phone design, but with small adaptations for specific geographical markets.

4.2.1 The 700MHz band

In relation to availability of sub-1GHz LTE spectrum in the long term, we note that Ofcom has consulted on proposals for spectrum in the 700MHz band, adjacent to the 800MHz band, to be released from DTT use. This follows provisional identification of the 700MHz band for International Mobile Telecommunications (IMT) use at the ITU World Radio Conference in 2012 (WRC-12) – a decision which is to be ratified at WRC-15. In addition, the Conference of Postal and Telecommunications Administrations (CEPT) is currently looking at developing harmonised technical conditions for the 700MHz band (694–790MHz) in the EU for the provision of mobile broadband services.

Ofcom's consultation paper, '*Securing long term benefits from scarce spectrum resources: A strategy for UHF Bands IV and V*' was published in March 2012, and considers options to re-plan spectrum in the UHF band to make bandwidth available for mobile services in the 700MHz band. However, the consultation suggests that spectrum in the 700MHz band would not be available for mobile broadband use in the UK until after 2018 at the earliest, as a result of the need to re-plan existing DTT services in order to release 700MHz spectrum for mobile use.

In addition, the Channel Islands need to consider France's use of the 700MHz band. Currently, the French regulator (ARCEP) is thought to be considering possible redistribution of UHF spectrum in order for the 700MHz band to be used to provide mobile services. However, as of yet no formal plans have been announced. We note that in February 2013, the French media regulator (CSA) published a report detailing its intent to move all DTT services to DVB-T2 before 2020 and to use this upgrade as an opportunity to move existing channels to HD. The move would therefore allow for the release of only a limited amount of spectrum, if any at all.[31]

Given the timeframes suggested by Ofcom and ARCEP, we do not consider that use of 700MHz spectrum is a suitable option for LTE deployment in the short term in the Channel Islands, and depending on France's decisions regarding the future of DTT, the 700MHz band may not be a possible option for the long term either. As such, this band is not considered further in this report.

31 http://www.csa.fr/Etudes-et-publications/Les-autres-rapports/Rapport-sur-l-avenir-de-la-plateforme-TNT

4.2.2 The 800MHz band

Frequency characteristics

Figure 4.2: Summary of the 800MHz band's LTE characteristics, contrasted with selected other bands [Source: Analysys Mason, Global Suppliers Association, 2013]

	800MHz	1800MHz	2.1GHz	2.6GHz
Number of LTE devices				
- handsets/tablets:	**36**	49	44	43
- dongles/routers:	**76**	78	39	110
% of all global LTE devices compatible with band	**21%**	23%	16%	27%
Est. cell radii (km)				
- urban:	**0.7–1.1**	0.4–0.6	0.3–0.5	0.3–0.5
- suburban:	**1.3–1.8**	0.9–1.2	0.8–1.1	0.7–1
- rural:	**5.1–6**	3.7–4.4	3.4–4	3.1–3.6
Spectrum available in band	**2×30MHz**	2×75MHz	2×60MHz	2×70MHz

800MHz spectrum is generally considered to be one of the more popular bands for 4G deployment in Europe. This is because of its superior propagation characteristics compared to higher frequency bands, as well as the economies of scale that are developing in relation to the supply of LTE network equipment and devices to use the 800MHz band.

Mobile operators prefer sub-1GHz spectrum such as the 800MHz (and 900MHz) band not just because it provides better coverage of hard-to-reach and indoor locations, but also because the use of lower frequencies enables operators to provide a more consistent service across wider cell areas and across all environments (i.e. urban, suburban and rural). This improvement in service consistency results in an improved customer experience of mobile broadband services (e.g. consistent speeds and better connection potential), which is valuable to mobile operators and to consumers alike.

The beneficial effect of deploying 4G base stations using frequencies below 1GHz is shown in Figure 4.2, where we demonstrate typical radii for LTE at different frequencies, developed using an LTE link budget model. As can be seen, the range (or cell area) of a base station operating at 800MHz (or 900MHz) is almost four times the range of a base station operating at 2.6GHz especially in an urban environment.

In addition to its good propagation characteristics, the 800MHz band is emerging as one of the more popular bands in terms of LTE device availability, driven by the number of European mobile operators to be awarded 800MHz licences. The 800MHz band supports a reasonably large level of dongle and router device availability, which is likely due to the band's popularity in rural deployments. In practice 800MHz can often provide a fixed wireless access (FWA) broadband service in rural wire-line broadband 'not-spots'. Some European Union (EU) regulators have imposed rural coverage obligations on the 800MHz band, ensuring its availability.

One issue with this band is the limited amount of spectrum available (2×30MHz). This splits into three 2×10MHz blocks, so in four player markets, it is frequent for an operator to miss out on the spectrum, which could potentially lead to difficulties for the operator in gaining market traction in the future. This concern would be particularly marked if they were already weak for some reason (e.g. a recent market entrant).

Harmonisation background

The 800MHz band has been released for LTE in Europe as a result of the replacement of analogue TV broadcasting by digital terrestrial television (DTT), creating a 'digital dividend' of spectrum released from analogue broadcasting use, which has now been re-allocated to mobile.

Until 2007, spectrum across UHF Bands IV and V[32] was allocated internationally to digital TV services. In Europe, this spectrum was being planned in line with the International Telecommunications Union (ITU-R) Geneva-06 (GE-06) agreement for DTT.

However, in 2007, the ITU World Radio Conference (WRC-07) allocated the 790–862MHz band (or parts of it in some countries) on a primary basis to mobile services in selected countries in ITU Region 1, comprising Europe, including all European Union countries, Africa and the Middle East. This is in accordance with footnote number 5.316A of the ITU Radio Regulations.

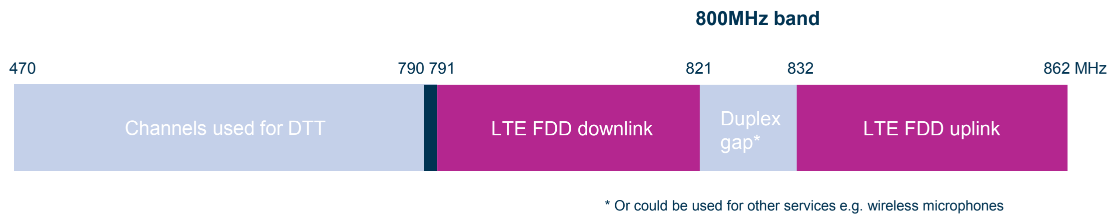
The 800MHz band, 790–862MHz, comprises the top eight channels of the UHF band.

The EC subsequently put forward Decision 2010/267/EC to harmonise the use of the 790–862MHz band for electronic communications systems such as mobile broadband services.[33]

Consequently, many European countries have now re-planned, or are in the process of re-planning, their DTT frequency assignments to enable the release of the 790–862MHz band for use by mobile services. This release of spectrum is often referred to as the 'digital dividend'.

The EC's 800MHz decision specifies that the band will be used in a paired frequency arrangement (for LTE FDD), and that the assigned block sizes will be in multiples of 2×5MHz. This is illustrated below.

Figure 4.3: Frequency arrangements for the 800MHz band [Source: Analysys Mason, 2012]



32 UHF Bands IV and V refer to the radio spectrum from 470–862MHz.

33 Commission Decision of 6 May 2010 on harmonised technical conditions of use in the 790-862MHz frequency band, see http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:117:0095:0101:en:PDF.

Other issues

A key issue affecting the use of the 800MHz band for LTE is the potential for interference to digital terrestrial television (DTT) service providers that currently use the adjacent spectrum (470–790MHz) and previously used spectrum within the 800MHz band. In the UK, for example, the use of spectrum below 790MHz for DTT has resulted in the following requirements being incorporated into the 800MHz auction:

- There are some restrictions on the availability of the 800MHz band for use by LTE in certain locations across the UK whilst DTT services are still being migrated from the 800MHz band to spectrum below 790MHz.
- There are obligations that operators must comply with once 800MHz licences have been granted, to mitigate interference to DTT services in adjacent spectrum.[34]

The potential need for obligations on LTE operators in the Channel Islands to avoid interference to DTT is considered in Section 11.1.

4.2.3 The 900MHz band

Frequency characteristics

Figure 4.4: Summary of the 900MHz band's LTE characteristics contrasted to select other bands [Source: Analysys Mason, Global Suppliers Association, 2013]

	800MHz	900MHz	1800MHz	2.1GHz	2.6GHz
Number of LTE devices					
- handsets/tablets:	36	**N/A**[35]	49	44	43
- dongles/routers:	76	**N/A**	78	39	110
% of all global LTE devices compatible with band	21%	**N/A**	23%	16%	27%
Est. cell radii (km)					
- urban:	0.7–1.1	**0.7–1.1**	0.4–0.6	0.3–0.5	0.3–0.5
- suburban:	1.3–1.8	**1.3–1.8**	0.9–1.2	0.8–1.1	0.7–1
- rural:	5.1–6	**5.1–6**	3.7–4.4	3.4–4	3.1–3.6
Spectrum available in band	2×30MHz	**2×35MHz**	2×75MHz	2×60MHz	2×70MHz

34 Terrestrial television broadcasting formerly used spectrum in the 470–862MHz band, which includes the 800MHz band. Ofcom had originally planned to clear DTT channels 63 to 68 as part of the 'digital dividend', but extended this to clear channels 61, 62 and 69 in order to harmonise with the rest of Europe, where the 800MHz band uses DTT channels 61 to 69. As well as migrating DTT services out of the 800MHz band, PMSE services that previously used 'interleaved' spectrum within the 800MHz band also need to be moved to adjacent channels.

35 Given the limited popularity of this band, the GSA currently does not report information on devices using LTE900; it is however used in some handsets such as the Nokia Lumia 920 and the Sony Xperia Z.

As can be seen, the frequency characteristics for the 900MHz band are similar to those of the 800MHz band, in that the 900MHz is ideally suited to providing wide-area coverage, including hard-to-reach and indoor locations.

Although many regulators have liberalised 900MHz licence conditions, and a number have re-awarded 900MHz licences entirely to facilitate a move from 2G to 3G/4G,[36] relatively few operators have chosen to operate LTE900 networks to date. This is generally considered to be because mobile operators that have been assigned 900MHz spectrum for 2G services have typically planned to refarm 2G services to 3G initially, rather than to 4G. This has meant that the ecosystem for HSPA and HSPA+ devices for the 900MHz band is good, but availability of LTE900 devices is very limited.

Harmonisation background

The 900MHz band, along with the 1800MHz band, was originally harmonised across Europe for second-generation (GSM/GPRS) use, in accordance with the European Council Directive 87/372/EEC.[37] That decision established the 900MHz band for use by pan-European digital mobile communications, which was standardised in Europe via the Global System for Mobile (GSM) standards, initially in the 890–915MHz and 935–960MHz bands (the 'primary' GSM bands, or P-GSM), and then subsequently in the 880–890MHz and 925–935MHz bands (the 'extended' GSM bands, or E-GSM).[38]

Recognising that GSM voice services are in decline in Europe, and that data services are expected to be the main driver of future growth, the EC published Decisions 2009/766/EC and 2011/251/EU in 2009 and 2011, respectively, on the harmonisation of 900MHz and 1800MHz for use by Universal Mobile Telecommunications System (UMTS) and LTE.[39] These decisions open the P-GSM, E-GSM and 1800MHz bands to use by UMTS and LTE, with frequency arrangements moving from the 200kHz frequency spacing that the GSM standard employs to 5MHz carrier spacing suitable for UMTS/LTE. However, the Decisions note that current use of each band by second-generation GSM services in Europe should be protected '*as long as there is reasonable demand for the service*' (see paragraph 4 of the Decision).

Other issues

As noted in the introduction to this section, the current 900MHz spectrum assignments in Guernsey and Jersey are weighted towards two operators: Jersey Telecom in Jersey and Sure in Guernsey. Between them, these operators have access to the majority of the 900MHz band on each island. We also note that for Airtel-Vodafone, existing 900MHz assignments are in block of less

36 Countries that allow (or will, following an auction) use of LTE in the 900MHz band include multiple European countries and several Asian countries.

37 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:1987:196:0085:0086:EN:PDF.

38 It is noted that the Channel Islands are not bound by EC Decisions, but there are benefits to operators and consumers in the Channel Islands if compatible choices to those in the EC Decisions are made.

39 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:106:0009:0010:EN:PDF.

than 2×5MHz. Since this is the minimum practical spectrum block for LTE deployment, this may put Airtel-Vodafone at a commercial disadvantage compared to the other existing operators.[40]

To date, no decisions on liberalising 900MHz licences to enable 3G/4G use have been made in the Channel Islands, although Ofcom has liberalised 900MHz licences for 3G use in the UK.

4.2.4 The 1800MHz band

Frequency characteristics

Figure 4.5: Summary of the 1800MHz band's LTE characteristics, contrasted with selected other bands [Source: Analysys Mason, Global Suppliers Association, 2013]

	800MHz	1800MHz	2.1GHz	2.6GHz
Number of LTE devices				
- handsets/tablets:	36	**49**	44	43
- dongles/routers:	76	**78**	39	110
% of all global LTE devices compatible with band	21%	**23%**	16%	27%
Est. cell radii (km)				
- urban:	0.7–1.1	**0.4–0.6**	0.3–0.5	0.3–0.5
- suburban:	1.3–1.8	**0.9–1.2**	0.8–1.1	0.7–1
- rural:	5.1–6	**3.7–4.4**	3.4–4	3.1–3.6
Spectrum available in band	2×30MHz	**2×75MHz**	2×60MHz	2×70MHz

The 1800MHz frequency band, whilst not providing the same superior propagation characteristics as the 800MHz and 900MHz bands, is nevertheless considered to offer a reasonable compromise between coverage and capacity. In particular, the wider bandwidth available in the 1800MHz band (2×75MHz in total) means that operators are typically assigned larger amounts of spectrum in this band, enabling them to deploy wider LTE carriers (e.g. 2×20MHz rather than the 2×10MHz per operator that is more typical in the 800MHz or 900MHz bands).

The quantity of spectrum that operators have available in each band is important in terms of the theoretical downlink data speeds that can be provided, since the maximum speeds achievable from LTE are directly affected by the carrier sizes deployed.

Although LTE carriers can use just 2×5MHz of spectrum to operate, if users are to benefit from the highest downlink speeds available (up to 156Mbit/s) the carrier size should be of 2×20MHz. Furthermore, carrier sizes greater than 40MHz can allow future LTE, a solutions to provide downlink speeds of up to 1Gbit/s using MIMO.

For this reason, the 1800MHz band is becoming one of the most popular bands for initial LTE deployment. This was confirmed by a recent announcement by the GSA stating that 1800MHz is

40 The LTE standard theoretically supports channel widths smaller than 5MHz but in practice, 5MHz is the minimum bandwidth that vendors have implemented in 4G base station equipment and in devices.

the most popular band for LTE deployments, and is used in over 37% of the 113 LTE networks that are now operating globally.[41]

As shown above, the number of available LTE smartphones is largest in the 1800MHz band, although the 2.6GHz band currently has more devices overall. This is mostly due to the number of dongles available for the 2.6GHz band – with the higher frequency more suited to high-capacity, high-speed, dongle-based data services. It can also been seen from Figure 4.6 below, that LTE1800 handsets currently have a more consistent backing from the larger manufacturers than the other main LTE bands.

Figure 4.6: Comparison of the bands supported in LTE devices by the largest manufacturers (as ranked by global handset sales) [Source: Global Suppliers Association, Gartner]

	Global handset sales[42] (million)	Global smartphone sales (million)	Support for 800MHz	Support for 1800MHz	Support for 2.1GHz	Support for 2.6GHz FDD
Samsung	98.0	55.0	✓✓	✓✓	✓	✓✓✓
Nokia	82.3	7.2	✓✓	✓✓	✓✓	✓✓
Apple	23.6	23.6		✓✓	✓✓	
ZTE	16.7		✓✓	✓✓		✓✓
LG	14.0		✓	✓✓	✓	✓
Huawei	11.9		✓✓	✓✓	✓	✓✓
TCL	9.3		No LTE devices			
RIM	8.9	8.9	Focus on China mobile's TDD 2300			
Motorola	8.6		Only focus on US bands (US700, AWS)			
HTC	8.4		✓	✓✓		✓✓
Pantech	Unknown	Unknown		✓✓✓		

Harmonisation background

The situation in the 1800MHz band is similar to that in the 900MHz band. Originally, the 1800MHz band, comprising spectrum in the 1710–1785MHz and 1805–1880MHz bands, was reserved in Europe for GSM1800 systems. GSM1800 systems were typically introduced some years after GSM900 in many European countries, and allowed European governments to increase competition in the cellular market by introducing new GSM1800 operators (e.g. T-Mobile and Orange in the UK, before their merger), as well as to provide existing GSM900 operators with additional capacity in the 1800MHz band.

As noted above, the EC's Decisions 2009/766/EC and 2011/251/EC published in 2009 and 2011 respectively now establish the 1800MHz band for use by UMTS and LTE systems. In the UK, these EC Decisions prompted Ofcom to liberalise EE's 1800MHz licence for LTE use (although

41 http://www.gsacom.com/news/gsa_367.php.

42 This includes all global mobile device sales to end users for the Q3 2012 period.

Ofcom is yet to confirm similar liberalisation for Vodafone's and O2's 900MHz licences, which can currently be used for UMTS, but not for LTE).

Other issues

We note that while it is reasonable to conclude that the 900MHz band currently has demand for continued GSM and HSPA/HSPA+ use within the Channel Islands and therefore would likely be at least partially required by existing operators to retain 2G/3G services, this is not the case of the 1800MHz band, where some spectrum is currently unassigned. Spectrum in the 1800MHz band not assigned for 2G use could therefore be made available immediately for 4G. Decisions on liberalising existing 2G spectrum licences in the 1800MHz band for 3G/4G use, and on allocating unassigned 1800MHz spectrum, have not been made as of yet.

We also note that some of the existing assignments per operator in the 1800MHz band in Guernsey and Jersey are in blocks of less than 2×5MHz. Since this is the minimum practical carrier size for LTE deployment, this may put the operators with the smaller assignments at a commercial disadvantage, as with the 900MHz band.

4.2.5 The 2.1GHz band

Frequency characteristics

Figure 4.7: Summary of the 2.1GHz band's LTE characteristics contrasted with selected other bands [Source: Analysys Mason, Global Suppliers Association, 2013]

	800MHz	1800MHz	2.1GHz	2.6GHz
Number of LTE devices				
- handsets/tablets:	36	49	**44**	43
- dongles/routers:	76	78	**39**	110
% of all global LTE devices compatible with band	21%	23%	**16%**	27%
Est. cell radii (km)				
- urban:	0.7–1.1	0.4–0.6	**0.3–0.5**	0.3–0.5
- suburban:	1.3–1.8	0.9–1.2	**0.8–1.1**	0.7–1
- rural:	5.1–6	3.7–4.4	**3.4–4**	3.1–3.6
Spectrum available in band	2×30MHz	2×75MHz	**2×60MHz**	2×70MHz

The 2.1GHz band is widely used around the world for 3G services (using the UMTS standard, and its successor, HSPA/HSPA+, as described in Section 3.1). However, as shown, the propagation characteristics of this band are less favourable for mobile communications than the lower bands, which is one of the reasons why 3G network coverage typically lags behind 2G coverage in many European markets.

This affects the coverage in both rural and urban areas:

- In rural areas, a network operating at 2.1GHz or above (e.g. 2.6GHz, as described in the next section) needs around three to four times as many base stations to cover the same area as a network operating at 800MHz or 900MHz. Hence, the cost of deploying a mobile network in rural areas with 2.1GHz or 2.6GHz frequencies will be approximately four times higher than with 800MHz or 900MHz.
- In urban areas, a network (defined using outdoor targets) operating at 2.1GHz or 2.6GHz will penetrate less far into buildings compared to a network operating at 800MHz or 900MHz, which will affect the quality of service for users inside the buildings.

In terms of the device ecosystem for the 2.1GHz band, the widespread use of this band for 3G/HSPA/HSPA+ services both in Europe and around the world has meant that the majority of 3G smartphones will operate in this band. However, as shown, there are a growing number of devices available that also support LTE operation in the 2.1GHz band, with it recently becoming one of the more popular bands for LTE devices, particularly in Asia.

Harmonisation background

The 2.1GHz band (1920–1980MHz and 2110–2170MHz) was originally identified as being the core band for third-generation (UMTS) deployment in Europe in accordance with a European Communications Committee (ECC) Decision, ERC/DEC/(97)07. This ECC decision reserved 155MHz of spectrum for terrestrial UMTS systems (comprising the paired bands identified above, and unpaired bands 1900–1920MHz and 2010–2025MHz), as well as reserving 30MHz of paired spectrum (1980–2010MHz paired with 2170–2200MHz) for satellite UMTS systems. The ECC decision was adopted as European Union policy through the ‘UMTS Decision’ (Decision 99/128/EC), published by the European Commission in 1999. The UMTS Decision described requirements for licensing of UMTS networks across Europe and in particular, required EU Member States to issue 3G licences by 1 January 2002.[43]

More recently, the original ECC Decision ERC/DEC/(97)07 has been replaced by a later decision, ECC/DEC/(06)01, describing a harmonised scheme for licensing of UMTS spectrum, including necessary guard bands at band edges.

The EC’s UMTS Decision has remained in place until very recently, when in November 2012, the European Commission announced a new EC Directive that opens use of the 1920–1980MHz and 2110–2170MHz bands for LTE (Commission Decision C(2012)7697).[44] The new decision mandates European governments to make 2.1GHz spectrum available for 4G/LTE use by 30 June 2014.[45]

43 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31999D0128:EN:NOT.

44 https://ec.europa.eu/digital-agenda/en/news/commission-implementing-decision-c2012-7697.

45 It is noted that the Channel Islands are not bound by EC Decisions, but there are benefits to operators and consumers in the Channel Islands if compatible choices to those in the EC Decisions are made.

Other issues

We note that CICRA has already redistributed 3G spectrum assignments in the 2.1GHz band between operators so that each operator has similar assignments on each island. These assignments are also likely to be suitable for 4G and so further re-assignment is unlikely to be required in this band.[46] We note, however, that a decision on conditions for liberalising 3G spectrum licences for 4G use has not yet been taken in the Channel Islands.

4.2.6 The 2.3GHz band

Frequency characteristics

Figure 4.8: Summary of the 2.3GHz band's LTE characteristics contrasted with selected other bands [Source: Analysys Mason, Global Suppliers Association, 2013]

	800MHz	1800MHz	2.1GHz	TDD 2.3GHz	2.6GHz
Number of LTE devices					
- handsets/tablets:	36	49	44	**8**	43
- dongles/routers:	76	78	39	**60**	110
% of all global LTE devices compatible with band	21%	23%	16%	**12%**	27%
Est. cell radii (km)					
- urban:	0.7–1.1	0.4–0.6	0.3–0.5	**N/A**	0.3–0.5
- suburban:	1.3–1.8	0.9–1.2	0.8–1.1	**N/A**	0.7–1
- rural:	5.1–6	3.7–4.4	3.4–4	**N/A**	3.1–3.6
Spectrum available in band	2×30MHz	2×75MHz	2×60MHz	**100MHz**	2×70MHz

The higher frequencies of the 2.3GHz band mean that it is ideally suited to providing additional capacity within mobile networks to cater for areas of high traffic demand, rather than to provide wide-area coverage. Additionally, 2.3GHz is considered ideally suited for broadband services (whether fixed or mobile), given the ability of TDD to change the portion of uplink versus downlink to better suit asymmetrical broadband traffic profiles.[47]

We note that the propagation characteristics of the band would sit between 2.1GHz and 2.6GHz, implying similar sized cell radii for use with mobile broadband (i.e. dongle) services. However, with the additional external household antenna that is frequently used for FWA systems, the cell radii could be extended significantly.

The 2.3GHz band is standardised as Band 40 within the 3GPP specifications for LTE. The 3GPP specifications designate this band for use by the TD-LTE mode of LTE, which is the mode that is less widely used in Europe at present.

46 http://www.cicra.gg/_files/OUR1108.pdf.

47 See http://www.analysysmason.com/About-Us/News/Insight/Unpaired-spectrum-article-Jun2012/

There are no TD-LTE mode networks using the 2.3GHz band in Europe so far, although mobile operators in other world regions have been awarded spectrum in this band for the provision of 4G services. To date, this band has been most widely used in Asia. In the USA, mobile operator AT&T has recently acquired 2.3GHz spectrum through a spectrum trade – although reports suggest that AT&T intends using this spectrum for FD-LTE rather than TD-LTE services (which is currently not standardised by 3GPP).[48]

According to the GSA, there are eleven TD-LTE networks operating globally, of which four are being deployed in the 2.3GHz band (the majority of other TD-LTE networks use the 2.6GHz band). A number of further trial TD-LTE networks are also being tested in 2.3GHz band ahead of full commercial launch. For this reason, there is some but only limited device availability, with most of the 2.3GHz-compatible devices being of a dongle rather than a smartphone format, although smartphones supporting the TD-LTE mode are now emerging.

Harmonisation background

The 2.3GHz band refers to spectrum in 2.31–2.4GHz, which is allocated on a co-primary basis to fixed and mobile services across Europe. In both the UK and the Channel Islands, this spectrum is managed by the UK Ministry of Defence (MOD), but also shared with various other uses, including secondary allocations to amateur and amateur satellite services.

The ITU World Radio Conference in 2007 (WRC-07) identified the 2.3GHz band for use by IMT systems. The 2.3GHz band has subsequently been standardised for TD-LTE use in the 3GPP specifications, but to date, LTE networks using the 2.3GHz band have been launched in relatively few countries, mainly in Asia.

In September 2012, a study group within the ECC has started work to develop a harmonised European decision for use of the 2.3GHz band for LTE systems. This work is expected to conclude in 2014. It is therefore to be expected that the 2.3GHz band may gradually become available for TD-LTE use across Europe once the harmonised decision is in place.

In the UK, plans are already under way for the MOD to release part of the 2.3GHz band from defence use, for commercial operations. A UK government consultation document published in March 2011 indicates that the MOD has identified around 160MHz of spectrum from parts of the 2310–2390MHz and the 3400–3600MHz bands for release for commercial wireless broadband use.[49] Recent reports suggest that the process to award spectrum released by the MOD in the 2.3GHz and 3.4GHz bands will start towards the end of 2013 in the UK.[50]

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48 http://www.dailywireless.org/2012/08/02/att-buys-2-3-ghz-from-nextwave/.

49 http://www.culture.gov.uk/images/publications/Spectrum_Release.pdf.

50 See http://www.bbc.co.uk/news/business-20757040.

Other issues

Given the lack of use of this band for LTE services to date in Europe, it is considered that 2.3GHz will not be a key candidate band to support early LTE service launch in the Channel Islands, due to the limited equipment ecosystem and a lack of suitable devices. The UK MOD's award of 2.3GHz spectrum may be one of the first awards of 2.3GHz spectrum in Europe, although regulators in Sweden and Ireland have also consulted on the possibility of using 2.3GHz spectrum for LTE.[51]

Accordingly, we have not considered use of this band within our 4G demand estimates described in the remainder of this report.

As part of this study, we were asked to consider the possible use of 2.3GHz or other similar spectrum to provide international fixed links between the Channel Islands and the UK/France and to comment on the suitability of 2.3GHz spectrum to provide wireless broadband connectivity between the Channel Islands, and the UK/France.

We note that the UK Frequency Allocation Table (FAT), which covers the UK mainland and coastal waters including the Channel Islands and the Isle of Man, designates the 2.3GHz band in the UK as being managed by MOD. Given the management of the band by the MOD, and the restrictions on the MOD selling this spectrum in the Channel Islands due to a lack of spectrum trading provisions in the Channel Islands, any use of the 2.3GHz band either in the Channel Islands or between the Channel Islands and the UK would require the Channel Islands' Government/CICRA to liaise with the UK MOD in the first instance, and for the MOD to willingly transfer this spectrum back to civil authority for it to be relicensed. If the 2.3GHz band were to be used to provide a fixed link between the Channel Islands and France, additional negotiations would be required with the French regulator/government as the 2.3GHz band is also used by the French military.

51 For example, see http://www.comreg.ie/radio_spectrum/2_3ghz_briefing.714.1021.html.

4.2.7 The 2.6GHz band

Frequency characteristics

Figure 4.9: Summary of the 2.6GHz band's LTE characteristics contrasted with selected other bands [Source: Analysys Mason, Global Suppliers Association, 2013]

	800MHz	1800MHz	2.1GHz	FDD 2.6GHz	TDD 2.6GHz
Number of LTE devices					
- handsets/tablets:	36	49	44	**43**	**13**
- dongles/routers:	76	78	39	**110**	**72**
% of all global LTE devices compatible with band	21%	23%	16%	**27%**	**15%**
Est. cell radii (km)					
- urban:	0.7–1.1	0.4–0.6	0.3–0.5	**0.3–0.5**	**N/A**
- suburban:	1.3–1.8	0.9–1.2	0.8–1.1	**0.7–1**	**N/A**
- rural:	5.1–6	3.7–4.4	3.4–4	**3.1–3.6**	**N/A**
Spectrum available in band	2×30MHz	2×75MHz	2×60MHz	**2×70MHz**	**50MHz**

As can be seen, the 2.6GHz band is one of the most popular bands in terms of LTE device availability (though focused mainly on dongles rather than smartphones), due to the number of countries in Europe and around the world where 2.6GHz 4G licences have been issued.

However, the 2.6GHz band is more suited to providing 4G capacity in areas of very high traffic demand within 4G networks, rather than to support wide-area coverage, for the reasons described previously. As can be seen, there is a significant reduction in cell range experienced from 4G services operating in 2.6GHz spectrum compared to lower bands, and as such a significant increase in cost.

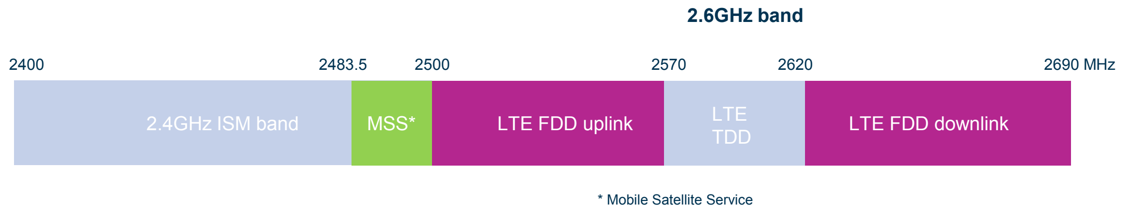
Harmonisation background

The 2.6GHz band comprises 190MHz of spectrum between 2500MHz and 2690MHz. At an international level, the band is allocated to mobile services in all three ITU regions, and was identified for use by IMT systems – the ITU's definition of 3G/4G technologies – at the WRC in 2000 (WRC-2000). The band sits alongside the 2.4GHz Industrial, Scientific and Medical (ISM) spectrum, used extensively around the world for licence-exempt wireless systems such as WiFi; at 2690MHz, it is adjacent to an international radio astronomy band. At a European level, CEPT ECC and EC decisions on the harmonised use of spectrum within the 2500–2690MHz band have been published as ECC Decision (05)05 and EC Decision 2008/477/EC, respectively.[52]

[52] Commission Decision of 13 June 2008 on the harmonisation of the 2500–2690MHz frequency band for terrestrial systems capable of providing electronic communications services in the Community ((2008/477/EC), available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:163:0037:0041:EN:PDF.

EC Decision 2008/477/EC recommends that Member States issue licences in the 2.6GHz band in accordance with the harmonised band plan described in ECC Decision (05)05. This band plan divides the spectrum into 14 paired blocks of 5MHz, separated by 120MHz, with the 2570–2620MHz sub-band divided into ten 5MHz blocks of unpaired spectrum. This is illustrated below.

Figure 4.10: Frequency arrangements for the 2.6GHz band [Source: Analysys Mason, 2012]



Other issues

A key issue affecting the use of the 2.6GHz band for LTE is the potential for LTE networks to interfere with air traffic control (ATC) and/or maritime or military radar using the adjacent band (2.7–3.1GHz). In the UK, this issue has led to Ofcom proposing a series of coordination requirements upon LTE networks when deployed using 2.6GHz frequencies. Ofcom and other UK government departments have also initiated a programme of S-Band radar upgrades, aimed at improving the immunity of radar to LTE interference.

The restrictions that are being proposed by Ofcom on the use of the 2.6GHz band are further described in Section 11.2.

4.2.8 The 3.4GHz band

Frequency characteristics

Figure 4.11: Summary of the 3.4GHz band's LTE characteristics contrasted with selected other bands [Source: Analysys Mason, Global Suppliers Association, 2013]

	800MHz	1800MHz	2.1GHz	2.6GHz	TDD 3.4GHz
Number of LTE devices					
- handsets/tablets:	36	49	44	43	**0**
- dongles/routers:	76	78	39	110	**7**
% of all global LTE devices compatible with band	21%	23%	16%	27%	**1%**
Est. cell radii (km)					
- urban:	0.7–1.1	0.4–0.6	0.3–0.5	0.3–0.5	**N/A**
- suburban:	1.3–1.8	0.9–1.2	0.8–1.1	0.7–1	**N/A**
- rural:	5.1–6	3.7–4.4	3.4–4	3.1–3.6	**N/A**
Spectrum available in band	2×30MHz	2×75MHz	2×60MHz	2×70MHz	**160MHz**[53]

The 3.4GHz band is typically used for fixed wireless access services in Europe and we note that spectrum has been assigned in this band in the Channel Islands for this purpose. The 3.4GHz band was identified for use by IMT systems at the ITU's World Radio Conference in 2007, WRC-07. However, the band has not subsequently been incorporated into 3GPP specifications for LTE, and studies into the appropriate frequency arrangements (either FDD or TDD) are continuing.

The only operator thought to be deploying LTE technology in the 3.4GHz band to date is UK Broadband in the UK. It announced in 2012 that it intended to roll out TD-LTE services using its 3.4GHz spectrum. However, it is understood that there are no mobile devices available to support this service at present and so the system uses 'household MiFi' devices (incorporating a fixed connection to a home or building using 3.4GHz frequencies, and then coverage within the building using WiFi). The service is also not widely rolled out and is limited to coverage in a small area of London. UK Broadband also provides a number of fixed wireless access systems in other parts of England and Wales, mainly to public-sector customers.

As noted below, the UK government has announced that the MOD will release further spectrum (over and above that already awarded to UK Broadband) in the 3.4GHz band. This spectrum may be suitable for small cell LTE deployments (i.e. pico-cells), but it is less suitable for wide-area coverage in comparison to the other frequency bands considered in previous sections, as a result of higher propagation losses, resulting in a reduction in cell area. However, with the use of external household antennas, as are used for FWA systems, the cell radii could be extended significantly, as

53 There is a total of 200MHz of spectrum potentially available in the 3.4–3.6GHz band but 40MHz (2×20MHz) has already been awarded to Newtel in Guernsey and Jersey. Sure has also been assigned 2×30MHz in the 3.6–3.8GHz band.

there is no building penetration loss (which significantly reduces the range when considering indoor service).

Harmonisation background

Internationally, 3400–3600MHz frequencies (referred to as the 3.4GHz band) are allocated for fixed, mobile, fixed satellite (space to Earth) and radiolocation services, and the adjacent 3600–3800MHz band is allocated to fixed and fixed satellite services (space to Earth), with mobile use on a secondary basis.

For a number of years in Europe, parts of the 3.4GHz band have been used for fixed wireless access systems, sharing with fixed satellite earth stations, fixed links, programme making and special events (PMSE), and defence systems. The success of these fixed wireless access services has been mixed. In the UK, a fixed wireless operator called UK Broadband was licensed to use a 20MHz paired block of spectrum in the 3.4GHz band as a result of an Ofcom auction that took place in 2003, using spectrum released from the MOD. The operator has not subsequently rolled out a nationwide network, but is understood to be using the spectrum to support a number of small-scale local authority wireless systems.

An ECC Decision, ECC/DEC (11)06, on harmonised frequency arrangements for mobile/fixed communications networks (MFCN) operating in the 3400–3600MHz and 3600–3800MHz bands was published in December 2011. This decision opens up the band for use by mobile systems in Europe (previously it was designated for use by fixed wireless access), including 4G systems. However, there are alternative frequency arrangements included in the Decision, depending on whether countries choose to deploy the band as an unpaired or a paired band. The Decision indicates TDD as being the 'harmonised' European approach to using the band for IMT but indicates that the Decision will be reviewed by the end of 2013, subject to market developments.

Other issues

Given the lack of use of this band for LTE services to date in Europe, it is not considered that 3.4GHz will be a key candidate band to support early mobile broadband service launch in the Channel Islands, due to the limited equipment ecosystem and a lack of suitable devices. However, it could be suitable to provide fixed wireless broadband services to homes and businesses, and is considered to be a potential band for use by the main operators for either mobile or FWA services, if spectrum demand exceeds the availability of the other assigned bands considered in our spectrum demand estimation described in Section 6.

It is understood that a consultation document on the award of spectrum in the 3.4GHz band is to be issued shortly by CICRA.

5 Summary of the Channel Islands' mobile and fixed markets

Given the population size of both Bailiwicks, the Channel Islands have a relatively strong mobile telecoms market with relatively high levels of competition, with three main network operators (JT, Sure and Airtel-Vodafone) operating across both Bailiwicks. These companies also all compete to some extent in other parts of the islands' communications market, including fixed calls, broadband access and business services.

It is noted that the licence change required for operators to move to 4G varies by Bailiwick, with Jersey's telecoms licences already being issued in a technology neutral way compared to the licences in Guernsey which are technology specific. For example, Sure only requires a single 'Class 2' licence[54] to operate in Jersey, but requires separate 2G/3G and mobile/fixed licences to operate in Guernsey.[55]

Below we summarise the key differential market features of both Bailiwicks.

5.1 Jersey's telecoms market

The Bailiwick of Jersey comprises the Island of Jersey and the surrounding small uninhabited islets. Jersey has a population of approximately 97 940 as of the end of 2012, with 69% of people between 15 and 64 years of age. The island also has a relatively high population density of 844 people per km^2 (relating to a total land area of $116km^2$), with 58.9%[56] of the population living in the island's three main parishes i.e. St Helier, St Clement and St Saviour. Jersey's gross domestic product (GDP) stands at approximately GBP35 000[58] per capita, significantly higher than the UK average of GBP22 900 per capita and mobile penetration currently stands at 128%, just above the UK's mobile penetration rate of 122%.[57]

Jersey's main industries are based around tourism, banking and finance, dairy and light electronics.[58] The island's key sector is finance, which is estimated to account for approximately half of the island's output. Given this, a large proportion of the island's mobile revenues are generated from roaming business customers visiting Jersey, especially from the UK.

54 http://www.cicra.gg/_files/080415%20CandW_Jersey%20_Class%20II_licence_in_effect.pdf.

55 Sure's 2G licence: http://www.cicra.gg/_files/CWG%20licence%20mod%20010911.pdf,
Sure's 3G licence: http://www.cicra.gg/_files/CWG%203G%20mobile%20licence.pdf,
Sure's mobile licence: http://www.cicra.gg/_files/guernsey_telecoms_mobile_licence.pdf,
Sure's fixed Licence http://www.cicra.gg/_files/guernsey_telecoms_licence.pdf.

56 2011/03/27 census : http://www.gov.je/Government/Census/Pages/Census.aspx.

57 UK numbers based on reported operator total subscriber figures for Q2 2012.

58 CIA World Factbook: https://www.cia.gov/library/publications/the-world-factbook/geos/je.html.

Mobile

Jersey's incumbent mobile operator is Jersey Telecom, which operates in both Jersey and Guernsey under the JT brand and is owned by the Jersey government. We note that, in November 2012, the government agreed to sell back preference shares in JT to raise money for other government infrastructure projects. However, as preference shares are equivalent to debt (rather than equity), this did not affect the government's share holdings and we are not aware of any plans by the government to sell the company following its previous considerations in 2007.[59]

The other two main operators, Sure and Airtel-Vodafone, each control roughly equivalent market shares. In addition to these three main network operators, a minor machine-to-machine (M2M) network operator, Marathon, owns spectrum on the island, but does not offer services directly to handset consumers.

There is evidence of demand from external companies to enter the market, with potential new entrant Clear Mobitel applying for paired spectrum in the 2.6GHz band in 2009 – however, to date no licence has been awarded. A more detailed account of this can be found in the Channel Islands Competition and Regulatory Authorities Pan-Channel Island Consultation on 800MHz and 2.6GHz Spectrum Awards.[60]

Fixed

Jersey Telecom is also active in the fixed telecoms market in both Jersey and Guernsey, where it operated under the name Wave until rebranding to Jersey Telecom in January 2012.

Currently, Jersey Telecom is in the process of building a full fibre point-to-point network across the whole island, offering services of up to 1Gbit/s in connected areas. The project began in December 2011 and the company aims to have the network pass each household on the island by 2013, with full connection of every household taking a possible further three years.

Sure, a wholly owned subsidiary of Cable & Wireless Communications (CWC), acts as the other major fixed line operator in Jersey. As discussed below, Sure is in the process of being sold by CWC to the Bahrain Telecommunications Company (Batelco).

Additionally, the operators Newtel (under the brand Y:Tel) and Airtel-Vodafone are active in the Jersey fixed telecoms market, offering home phone services using FWA technologies to compete against JT, with the key advantage of being able to remove the need to pay line rental costs. However, the degree of competition in the Jersey fixed-line market remains limited, with Jersey Telecom retaining a dominant market share.

59 In 2007, JT's board agreed with Treasury and Resources Minister, Senator Terry Le Sueur, that the Company should be sold. However, this decision was reversed later in the year, and so the company was not sold.

60 http://www.cicra.gg/_files/CICRA%201228.pdf.

5.2 Guernsey's telecoms market

The Bailiwick of Guernsey comprises the islands of Guernsey, Sark and Alderney, plus the smaller islands of Brecqhou, Herm, Jethou and Lihou.

The Bailiwick of Guernsey has a population of approximately 63 330 as of the end of 2012, with 68% of people between 15 and 64 years of age. The Bailiwick also has a relatively high population density of 812 people per km^2 (relating to a total land area of $78km^2$), with 43.6% of the population living in the island's two main parishes i.e. St Sampson and St Peter Port. Guernsey's gross domestic product (GDP) stands at GBP30 000 per capita[61], higher than the UK average of GBP22 900 per capita, but below that of Jersey. Guernsey's current mobile penetration stands at 110%, slightly lower than the UK's mobile penetration rate of 122%.

Guernsey's main industries are based around financial services, such as banking, fund management and insurance.[62] Tourism, while still an important sector, has been declining recently, though it is thought that upgrades to the main island's runway should help improve this. As with Jersey, a significant proportion of the island's mobile revenues are generated from roaming business customers again mainly travelling from the UK.

Mobile

The Bailiwick's incumbent is Sure/CWC, which controls the majority of the mobile market. Currently, Sure is in the process of being sold to Batelco[63] by CWC, as part of a GBP422 million deal, which includes all of CWC's Monaco and Islands divisions (including Sure's operations on Jersey, Guernsey and the Isle of Man). The deal is provisional on all necessary regulatory approvals being granted; in the absence of any objections, it is assumed that the sale will complete early in 2013.

The other two operators, Jersey Telecom and Airtel-Vodafone, each have roughly equivalent market shares. Jersey Telecom, as discussed above, is owned by the Jersey Government, whereas Airtel-Vodafone is a partnership between Bharti Airtel (an Indian operator active in multiple countries across the world) and Vodafone (one of the world's largest operators, based in the UK).

Fixed

As with the mobile market, Sure is the fixed-line incumbent. In addition, Jersey Telecom (which used to operate on the island under the name of Wave) offers products using LLU. The

61 Guernsey Facts and Figures 2012, http://www.gov.gg/CHttpHandler.ashx?id=77705&p=0.

62 CIA World Factbook, https://www.cia.gov/library/publications/the-world-factbook/geos/gk.html.

63 Batelco is the incumbent fixed and wireless network operator in Bahrain. Batelco is listed on the Bahrain Stock Exchange, but it is majority-owned by the Government of Bahrain and other public Bahraini institutions.

competition in Guernsey's fixed market is particularly limited, with Sure maintaining a 90% market share at mid-2009.[64] This dominance is particularly prevalent in the residential market.

64 http://papers.ssrn.com/sol3/Delivery.cfm/SSRN_ID1583970_code927092.pdf?abstractid=1583970&mirid=1.

6 Approach to spectrum demand modelling

A key aspect of this study is to advise on demand for 4G spectrum in Guernsey and Jersey so that policy decisions on optimal assignment of 4G frequencies to existing and potential new operators can be assessed.

To address this, we have developed a model to estimate 4G spectrum demand in Guernsey and Jersey using assumptions on 4G availability, uptake and technology characteristics. In this section of the report, we describe the approach taken in spectrum demand modelling. Results of the modelling are described in the following section.

6.1 Overview of the calculation flow

Our model is based on a high-level spectrum demand calculation for a typical mobile broadband/fixed wireless access (FWA) operator. As traffic increases on its network, an operator has two options for increasing its network capacity: acquire more spectrum or deploy more sites. If it is more commercially attractive (taking into account the trade-offs of capital/operating expenditure and the cost of acquiring spectrum) to deploy new sites rather than attempt to acquire spectrum, then rationally the operator would do so, with the reverse also being true.

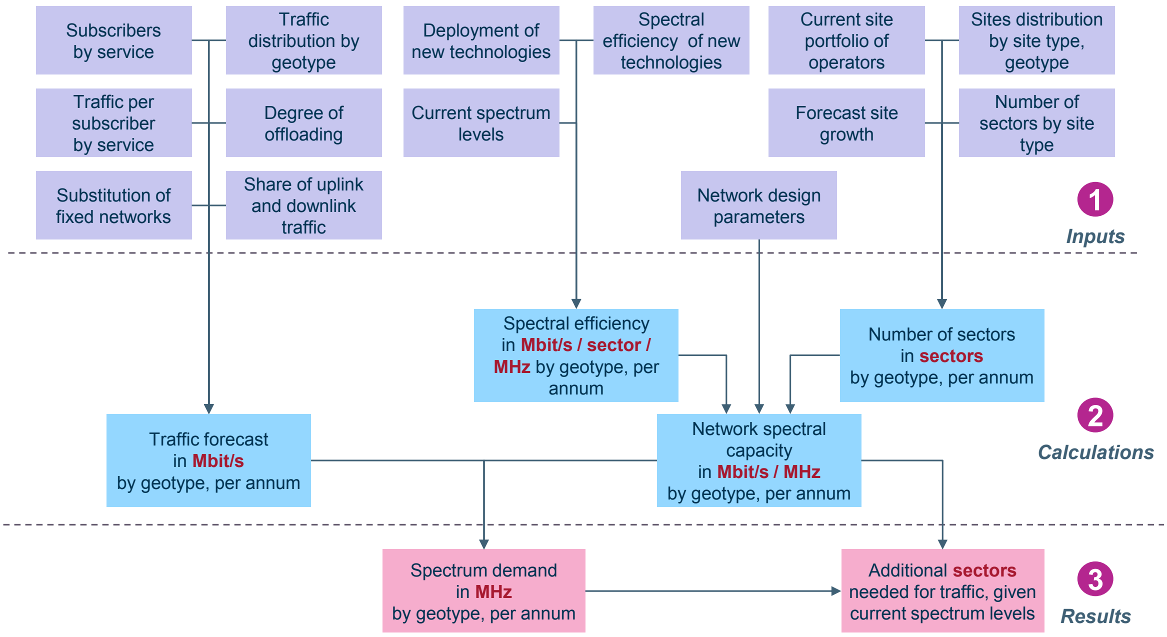
To allow for a calculation of the maximum spectrum demand required by an operator in the current context, it is therefore necessary to constrain one of these two factors to see how the other factor grows into the future. As such, we assume that the number of sites an operator has (including a set level of site growth over time) is fixed, and so an increase in traffic leads directly to an increase in the level of spectrum required, whereas an increase in the efficiency of the spectrum used, e.g. through deployment of new technologies, leads to a decrease in the level of spectrum required.

We note that to date in the Channel Islands, it has been the case that only a nominal fee is required to obtain rights to use additional spectrum, whereas the number of additional sites an operator can deploy has become increasingly constrained, particularly by planning conditions. As such, a fixed growth rate of the number of sites is considered a reasonable assumption for a plausible baseline for spectrum demand into the future.

Our model evaluates mobile broadband/FWA spectrum demand in two different geotypes, urban and rural, across both Bailiwicks independently. The model therefore includes appropriate segmentations of traffic and network analysis using operator data across all four regions (Urban and Rural Jersey, and Urban and Rural Guernsey) to support this analysis.

The overall flow of the model is designed to calculate the amount of spectrum required in order to carry the volume of traffic, which is forecast using the traffic per subscriber multiplied by a forecast number of subscribers, for each year of the modelling period up to 2026. The key inputs calculations and outputs from the model are summarised in Figure 6.1.

Figure 6.1: Model flow diagram [Source: Analysys Mason, 2012]



6.2 Key scenarios

We have calculated the spectrum and additional sector requirements for four key scenarios, testing the impacts of possible fundamental changes on the Channel Islands' markets by modifying certain key assumptions, while retaining the remaining base case scenario parameters detailed in Section 6.3. The four main areas we have tested through the use of scenarios are:

- The distribution of mobile spectrum within the market, including the split of new and existing spectrum between the three operators. This includes consideration of equal awards of new spectrum, redistribution of the 1800MHz band, and in the case of a four operator market (i.e. if a new entrant were to emerge), spectrum caps on sub 1-GHz spectrum to ensure a more even distribution of spectrum.

- The level of fixed broadband substitution by mobile operators within the Channel Islands' market. It is assumed in our base case (Scenario 2 as detailed in Section 7.1.2) that 4G mobile services provided by the existing three operators substitute about 15% of the forecast fixed services. However, we also consider the impact if even higher levels of mobile broadband substitution occurs.

- A market with four mobile operators in the long term (as compared to the current three), where it is assumed that a new entrant joins the market in 2013. It is noted that Clear Mobitel has provisionally been granted access to spectrum in the 2.6GHz band in Jersey, subject to confirmation. However, we do not presume that Clear Mobitel would be the new entrant. The purpose of this scenario is purely to assess whether sufficient 4G spectrum is available to support four operators in the market.

- The impact of the limiting site growth on the Bailiwicks, and hence a limit on the maximum possible number of base station sectors, on the operators demand for spectrum. It is already assumed in our base case that site growth is slightly lower in Guernsey than in Jersey, however we also consider the impact of reducing the growth across the whole Channel Islands even further.

To test these four areas, we use the following five scenarios as detailed in Section 7.1:

- Scenario 1: Assuming equal distribution of new 800MHz, 1800MHz and 2.6GHz spectrum between operators.
- Scenario 2 (Base case): Assuming a redistribution of new and existing spectrum in the 1800MHz band to give operators equal, contiguous, blocks.
- Scenario 3: Assuming larger growth in fixed substitution, reaching 30% of fixed traffic.
- Scenario 4: Assuming a new entrant to the mobile market, with redistribution of the 1800MHz band and spectrum caps for sub-1GHz spectrum.
- Scenario 5: Assuming low natural site growth across both Bailiwicks.

6.3 Input parameters and market assumptions

Below, we discuss in detail the key model parameters and market assumptions that were used in the modelling of future spectrum demand for each island. We note that sensitivity analysis has been undertaken for parameters the model is sensitive to, as shown in Section 7.2.

6.3.1 Mobile and fixed data traffic sources and adjustments

Two key sources of forecasts have been used to estimate both the mobile and fixed data traffic per subscriber seen in Jersey and Guernsey over the initial part of the model's timeline (2012–2016):

- Analysys Mason Research division's '*Wireless network traffic 2012–2017: Forecasts and analysis*' and '*Fixed Internet traffic worldwide: Forecasts and analysis 2011–2016*'
  - Specifically we have used the Western Europe, UK, and France forecasts from Analysys Mason's forecasts.
- Cisco's '*Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2012–2017*' and '*Visual Networking Index: Forecast and Methodology, 2011-2016*' and '*Visual Networking Index: The Zetabyte era*'
  - Specifically we have used the Western Europe forecast from Cisco's forecasts.

This data was adjusted in various ways as discussed below.

Adjustment for mobile broadband levels

One of the key adjustments needed for both analysts' mobile forecasts is to account for the inclusion of mobile broadband (MBB) traffic within the standard per user blended totals. The MBB traffic includes both dongles used on the move and dongles used for FWA traffic, and accounts for a significant proportion of the traffic due to an average dongle using 14 times the amount of traffic as the average smartphone and 498 times the data of a basic mobile phone.[65]

Given the convergence of mobile broadband (i.e. dongles) and traditional FWA technologies, both of which are used to provide substitution for fixed-line broadband, we consider these technologies and the traffic generated as interchangeable. Additionally, as the modelling considers fixed forecasts to calculate FWA data usage in the future, we have assumed that the standard per user mobile blended usage has a constant proportion of MBB users equivalent to that currently seen in the Channel Islands subscriber numbers, as supplied by operators. This ensures that any new FWA traffic is not double counted as additional mobile broadband usage in our forecasts.

Adjustment for mobile traffic offloading onto fixed networks

Offloading is mobile device traffic which is carried over the fixed network (e.g. via WiFi). Both forecasts assumed different levels of offloading progressing into the future. The Analysys Mason Research division assumed an offloading case approaching 63% in 2016, compared to Cisco's offloading case which only approached 46% in 2016.

Our discussions with operators have suggested that the overall Channel Islands specific offloading levels are likely to be lower than those seen elsewhere in Europe, and lower than those suggested by the Analysys Mason Research division for the UK. This is possibly due to the lower levels of peak traffic seen across the Channel Islands, related in part to the smaller number of extremely busy large public spaces (such as sports stadiums, train stations or large international transit airports) when compared to the UK.

To allow for sensitivity testing of the level of mobile offloaded traffic in the model, the analyst forecasts were adjusted to give the total level of traffic pre-offloading. As such, the mobile offloaded traffic was added back in to the mobile forecasts and conversely removed from the fixed forecast. Following this adjustment to find the pre-offloading total market traffic, a model-defined level of offloading was then removed from the mobile traffic and the same level added to the total fixed traffic inside the model (before any traffic converted to FWA was considered[66]).

Robustness of data forecasts

As traffic forecasts are one of the key variables of the demand model, it is important to ensure they are as robust as possible. The future traffic levels are dependent upon the assumptions made by the

65 http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.html.

66 This means that an increase in the percentage of fixed traffic converted to FWA reduces the effective level of offloading.

analysts, and as can be seen below the Cisco and Analysys Mason numbers diverge into the future as the level of uncertainty grows. We consider that in the case of modelling future peak spectrum demand, it can be appropriate to use higher forecasts, as it is harder to reorganise spectrum once issued, and any release of new spectrum can take time and require additional cost to all parties. However, despite Cisco recently reducing its forecasts, we believe that they are still too high, as was detailed in a recent Analysys Mason Research Insight article.[67] As such, an average of the Cisco and Analysys Mason Research forecasts gives an appropriate level of traffic to consider future spectrum requirements in this context.

In order to further qualify the robustness of the traffic forecasts, we have time-shifted the forecast curve to ensure current Channel Islands usages are accurately reflected, and to check our forecast beyond 2017, we have undertaken a bottom-up cross-check of our calculated forecasts. To check the impact of using the different analyst forecasts on the spectrum demand, we have also sensitivity-tested the spectrum requirements using both the full Cisco forecast and full Analysys Mason Research forecast to drive the demand model, as detailed in Section 7.2.3.

Forecasting methodologies

According to Cisco, its forecast modelling multiplies Cisco's estimates of traffic per user for various device types (segmented by a "high degree of application, segment, geographic, and device specificity") by the number of devices and relevant application take-up rates/growth in connections. The forecasts are informed by a range of different wireless network analysts and organisations.[68] In addition, Cisco uses proprietary information from the "Cisco Global Internet Speed Test" to derive average device speeds across various geographies, and "IBSG Connected Life Market Watch" to derive WiFi offloading levels. We note that Cisco's forecasts are mainly driven by video usage, and have a high emphasis on cloud applications and content streaming.

The Analysys Mason Research traffic modelling is based on its own core forecasts of subscribers and traffic, with current traffic and subscriber data taken from national regulatory authorities, and national non-profit trade bodies such as the CTIA, where available. In addition, traffic data points from individual operators are considered to inform traffic usage bounds, with the operators' differing business models considered to understand variations between operators. The data is collected on a quarterly basis from operators and regulators, and cover all global regions and over 50 individual national markets. The forecasts are further informed by Analysys Mason Research's use of device usage trackers to gather device usage data from a panel of consumer smartphone users in France, Germany, Spain, the UK and the USA during August and September 2011, in partnership with Arbitron Mobile, specifically in the consideration of WiFi offload traffic levels.

Finally, the Analysys Mason Research forecasts are cross-checked by calculating the cost of carriage of the forecast levels of cellular traffic and assessing whether that capital cost fits within

67 http://www.analysysmason.com/About-Us/News/Insight/Cisco-mobile-data-forecasts-Feb2013/.

68 Cisco notes these as "Informa Telecoms and Media, Strategy Analytics, Infonetics, Ovum, Gartner, IDC, Dell'Oro, Synergy, ACG Research, Nielsen, comScore, Arbitron Mobile, Maravedis and the International Telecommunications Union (ITU)".

the typical range of values for capital intensity (capex/revenue) for mobile operators. As such, a check is made on the forecast output to ensure volumes cannot rise significantly or for any sustained period beyond the rate at which the unit cost of data transport declines.

6.3.2 Model traffic per subscriber forecasts

Both the mobile and fixed data traffic 'base case' forecasts are derived from an average of the Analysys Mason region forecast identified as the most representative by operators (UK) and Cisco (Western Europe) forecasts listed above, on a per-subscriber basis. As noted, an average is appropriate since Cisco's forecasts are generally considered to be aggressive in terms of future traffic levels and so blending this with Analysys Mason Research's figures results in a more modest forecast. The forecasts used in the model are shown in Figure 6.2 for mobile traffic and in Figure 6.3 for fixed traffic. While, as can be seen, the 'base case' forecast still demonstrates very high levels of growth, this is deemed appropriate when considering the peak spectrum demand.

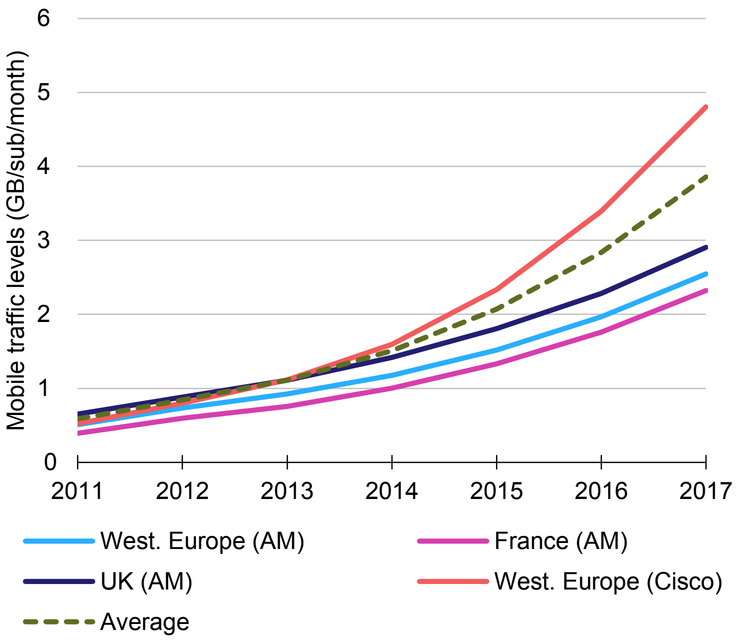


Figure 6.2: Comparison of mobile traffic forecasts [Source: Analysys Mason, Cisco, 2013]

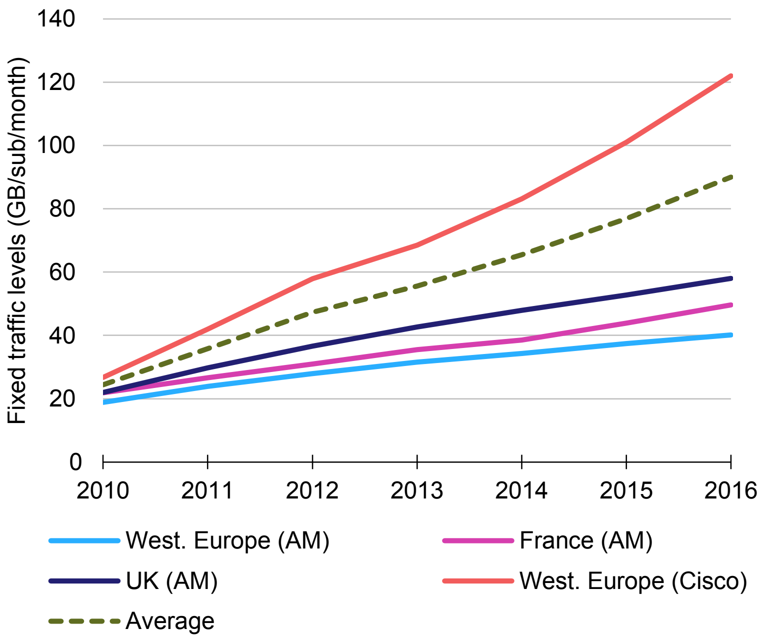


Figure 6.3: Comparison of fixed traffic forecasts [Source: Analysys Mason, Cisco, 2013]

In order to cover the entire time period of the model, both traffic forecasts were further extended using a constantly decreasing growth rate from 2017 onwards. Our consideration of the existing forecast growth rate, and a tendency for real trends to approach an S-curve approximation over significant periods of time, led us to assume a deceleration in the growth rate of –15% per annum i.e. the analysts' final year growth rate is reduced each year following the end of the analyst forecasts.

In order to increase the appropriateness of the forecasts, each forecast was checked to see if it required time-shifting to match the current level of data consumer per subscriber across the Channel Islands. It was determined that the fixed forecast should be shifted to occur one year later, whereas the mobile forecast did not need shifting, as shown in Figure 6.4 and Figure 6.5.

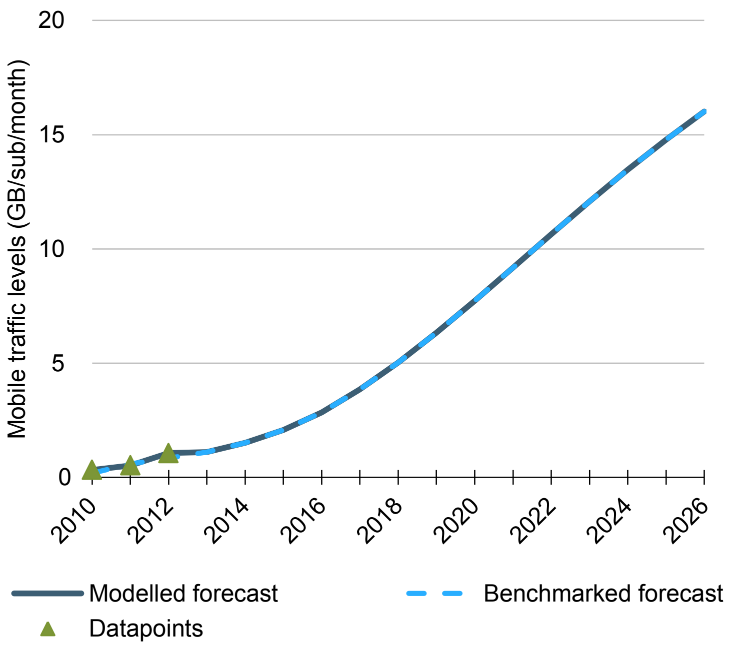


Figure 6.4: Time-shifted mobile traffic forecasts (including Channel Islands current usage levels) [Source: Analysys Mason, 2013]

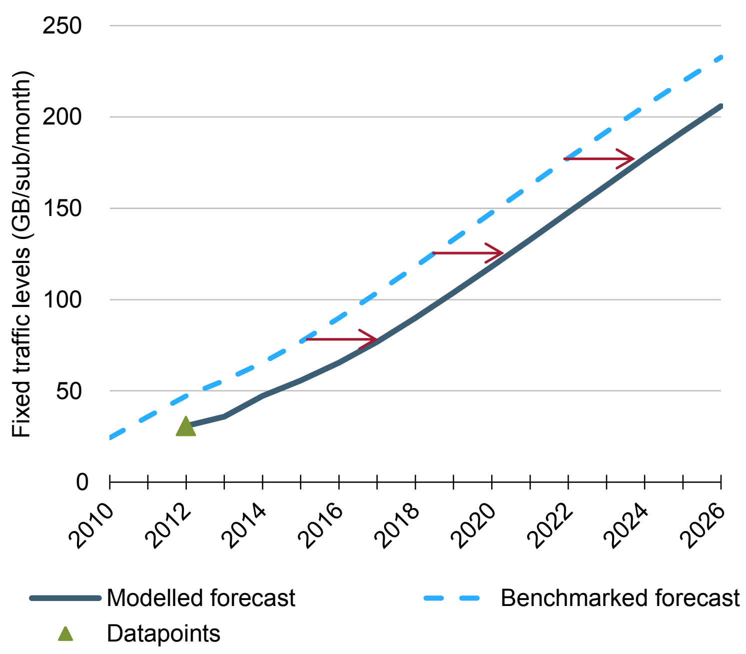


Figure 6.5: Time-shifted fixed traffic forecasts (including Channel Islands current usage levels) [Source: Analysys Mason, 2013]

Bottom-up cross-check of forecasts

Above we have detailed the creation of long-term forecasts for both mobile and fixed traffic within the Channel Islands on a per subscriber basis. We note that, as with any forecast, the level of uncertainty in the traffic level increases as we move away from the present year, and as such it is sensible to apply a bottom-up cross-check to ensure that the forecast figures seem sensible even at the end of the 15-year forecast.

In order to check the traffic levels generated in our forecasts, we have converted the level of traffic to the equivalent length of content (in minutes) that could be consumed using the same amount of data. For simplicity, we have assumed here that the data is exclusively used for a single service, but note that in practice subscribers use a range of different services (e.g. browsing the Internet, sending emails, etc.) beyond the content considered, as well as consume a mix of content within any month. As such, these figures are not meant to imply that each subscriber would actually consume this level of content in practice, but rather provide a theoretical upper limit on the level of content consumption that could occur.

We have considered four service types in our consistency checks, covering both radio and TV, with the assumption that the visual mobile services use approximately half the data rate of fixed services due to the significantly smaller screen size of the majority of mobile devices. Services considered are:

- Radio: we assume that on average both fixed and mobile Internet radio services require a bit rate of 160kbit/s[69]

69 For the music streaming service Spotify operates a range of streaming qualities, with fixed streaming normally operating at 160kbit/s, though premium subscribers can use 320kbit/s. In comparison, Spotify's mobile streaming can operate ranging between 96kbit/s and 320Kbit/s (with 96kbit/s recommended given most mobile users' concern over data usage).

- TV (standard definition): we assume that on average fixed SDTV services require a bit rate of 2Mbit/s, whereas mobile SDTV would require a bit rate of 1Mbit/s
- TV (high definition): we assume that on average fixed HDTV services require a bit rate of 10Mbit/s, whereas mobile HDTV would require a bit rate of 5Mbit/s
- TV (3D): although it has not yet become common place to stream 3D services, it is estimated that on average fixed 3DTV services will require a bit rate of 18Mbit/s, whereas mobile 3DTV requires a bit rate of only 9Mbit/s.

Figure 6.6 below shows the results of our analysis for the mobile data traffic forecast.

Figure 6.6: Bottom-up check of mobile data traffic per average subscriber in terms of minutes per day equivalent media consumption [Source: Analysys Mason, 2013]

Year	Radio (min/sub/day)	SDTV (min/sub/day)	HDTV (min/sub/day)	3DTV (min/sub/day)
2012	10	1.6	0.3	0.2
2019	125	20	3.9	2.2
2026	409	64	13	7.1

The results of our mobile forecast cross-checks do not seem to highlight any serious issues, with users predicted to be watching roughly 13 minutes of HD quality Internet video on their mobile device per day by 2026. This is significantly more data than is currently consumed, but is considered realistic given that it only equates to three to four YouTube clips per day, or using a mobile-enabled tablet to stream one film every week.

Figure 6.7 below shows the results of our analysis for the fixed data traffic forecast.

Figure 6.7: Bottom-up check of fixed data traffic per average subscriber in terms of minutes per day equivalent media consumption [Source: Analysys Mason, 2013]

Year	Radio (min/sub/day)	SDTV (min/sub/day)	HDTV (min/sub/day)	3DTV (min/sub/day)
2012	610	47	9.6	5.3
2019	2100	170	33	19
2026	4200	330	66	37

The results of our fixed forecast cross-checks do not highlight any serious issues, with users predicted to be watching just over an hour of HD quality Internet video on their computers (or Internet connected TVs) per day. While this is significantly larger than seen for mobile, it is to be expected as the majority of content consumption happens within the house. Given the move of the islands towards super-fast broadband, it is considered reasonable that HDTV, and possibly even 3DTV, could become the norm when streaming over the Internet. In addition, it is worth noting that the majority of fixed connection subscriptions are shared by households, so these forecasts are actually lower on a per-person basis, and would include some households streaming simultaneously using multiple devices. To put this in context, Ofcom reported that UK viewers watch an average of four hours of TV per day in 2011, with 37% of adults with home Internet watching online TV and 5% of households now owning Internet connected TVs.[70]

6.3.3 Subscriber forecasts

In order to calculate the total level of traffic generated, the traffic per subscriber forecasts (as discussed in Section 6.3.2) are multiplied with the number of subscribers on each operator's network.

To gain the overall size of the mobile market, and the number of subscribers, for both Jersey and Guernsey, we have used forecasts from analysts Wireless Intelligence adjusted in current years for the actual reported operator numbers, and blended with the operators own forecasts where supplied. We consider that Wireless Intelligence's numbers, as a respected third-party analyst, are not likely to be significantly biased towards one operator or another, but rather suggest an independent view on the progression of the market into the future. However at the same time we recognise that the operators have a deep understanding of the Channel Islands markets and are in a good position to judge its future development. While ideally it would be useful to compare our blended forecast with further independent views, we were unable to find any further third-party forecasts given the relatively small size of the market.

One issue with the Wireless Intelligence forecasts is that they do not consider the possibility of a new entrant into either market. As such we have assumed that while the overall number of subscribers will remain as forecast, the distribution of subscribers between operators will change in our modelling scenarios involving introduction of a new entrant. The new operator is assumed to remove subscribers from all three existing operators in proportion to their market share.

For fixed subscribers, we use the CICRA fixed broadband subscriber data for 2011 and assume a straight line increase in subscribers until full household penetration of the Channel Islands in 2020.

Long-term operator subscriber trends

While the number of mobile subscribers up to 2017 has been forecast as detailed above, we do not have third-party forecasts for the period beyond 2017 and have therefore used Analysys Mason's own assumptions on how the market might develop. A key consideration in the number of subscribers per network is how the market shares of existing mobile operators might evolve beyond 2017. Given the large amounts of uncertainty present in the development of the mobile market over such a long period of time, we have decided to assume that under the 'base case' the long-term market share for each operator will move to half way between the 2017 market share and the market equilibrium (i.e. 33% market share if there are three operators). This means that the incumbents' market share declines slightly from 2017 onwards, whereas the two smaller operators' market share increases.

70 See http://stakeholders.ofcom.org.uk/market-data-research/market-data/communications-market-reports/cmr12/uk/

In the case of an additional operator joining the market, the new entrant continues to gain market share up to a level of 15% by the end of 2026, which as above, continues to be removed proportionally from the existing operators. Both the three operator and four operator markets are demonstrated in the confidential Annex D. In addition, we have sensitivity-tested the long-term trend in Section 7.2.4, which considers the spectrum demand if the market shares instead remained flat following 2017.

6.3.4 Split of traffic by geotype

The traffic within our modelling is split into 4 geotypes, split by both specific Bailiwick and the population density of parishes, where a population density above 1000 people per km^2 was defined as urban and below this level was defined as rural. Our four geotypes are:

- Jersey, urban: this includes the parishes of St Helier, St Clement, and St Saviour
- Jersey, rural: this includes all other parishes
- Guernsey, urban: this includes the parishes of St Sampson and St Peter Port
- Guernsey, rural: this includes all other parishes.

The geotypes were designated by parish, given the availability of information at this level, and the split was defined by population density as this is considered to have the most significant impact on wireless network dimensioning.

Region	Area	Population	Traffic
Jersey, urban	19%	58%	See Annex D
Jersey, rural	81%	42%	
Guernsey, urban	20%	45%	
Guernsey, rural	80%	55%	

Figure 6.8: Mobile traffic split by geotype within Bailiwick [Source: Analysys Mason, 2013]

In general, urban geotypes produce a significant proportion of all traffic due to both their high relative populations and migration of workers into the region during daytime for both work and/or leisure. To capture this, we have allocated traffic between islands using operator and regulator information, and then split this between geotypes using operator figures as noted in the confidential Annex D.

6.3.5 Busy-hour traffic and network utilisation parameters

Busy-hour traffic

Over each yearly 'increment' modelled, the level of traffic carried at any point in time can vary significantly, reflecting various daily activities such as sleeping, commuting or work hours which cause peaks and troughs to occur in data usage. The particular hours in the year that carry a significantly high level of traffic are referred to as 'busy hours', and networks are generally dimensioned around these hours to ensure a suitable level to meet the traffic requirements in the majority of the year.

In order to convert the level of traffic seen each year into the amount in any particular hour, it is not appropriate to divide it evenly to find the average hour, but rather we wish to find the traffic in the average 'busy hour'. We note that this does not mean dimensioning the network for the absolute peak busiest hour in the year, but normal for the average busiest hour in a typical working day. As such, we apply the following assumptions to derive the average busy-hour traffic, informed from our previous network modelling experience:

- we assume that the traffic carried in all busy hours is approximately 10% of the total annual traffic
- we assume that the busy-hour traffic carried in weekday busy hours is approximately 83% of the traffic carried in all busy hours
- there are 250 weekday busy hours per year relating to one 'busy hour' per working day.

By combining these assumptions, we get a model busy-hour multiplier of 0.03%, which represents the amount of total annual data traffic that is generated in the average 'busy hour'. We assume that this percentage remains constant over the period modelled.

Network utilisation

In dimensioning the traffic to be carried across the network, we recognise that in reality the traffic is not split evenly across each site. Rather sites, even within the same geotype, have a significant range of traffic loading profiles. While it is assumed that the busiest cells will mostly be further split into multiple sites and sectors to reduce the load on any given cell, a lack of good sites at certain points may restrict this leaving some cells which are still overburdened. In addition, in the lightest traffic cells the minimum network provision may still be significantly more than is actually needed.

To model this key parameter of the network dimensioning calculations, we have assumed a standard distribution of traffic across sites, modelled as a natural log curve based on our experience of other European operators' networks. This relative traffic distribution is then scaled to reflect the level of acceptable congestion assumed within the Channel Islands networks, as shown in Figure 6.9. From this curve, the level of network utilisation during the busy hour can be calculated, which reflects the traffic carried on the network during the busy hour compared to the network's overall total capacity.

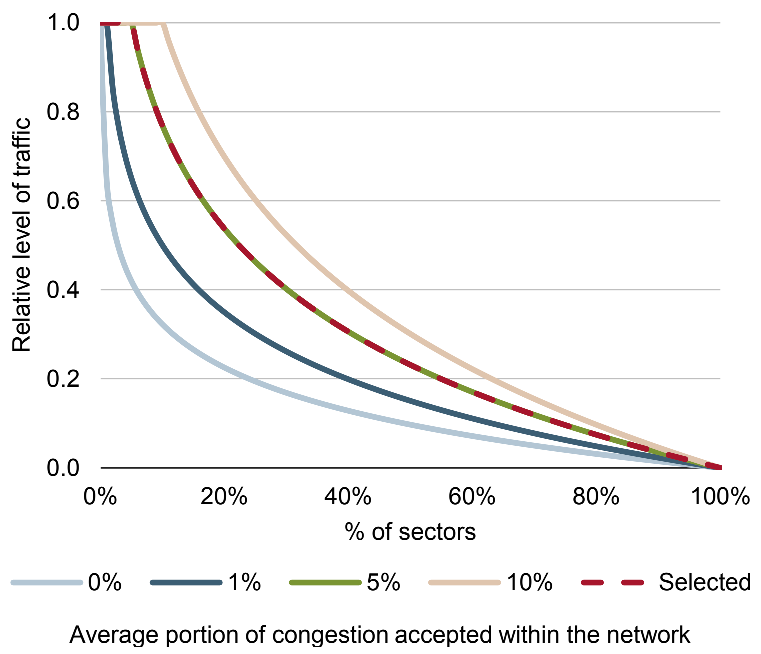


Figure 6.9: Relative traffic levels across network sites during the modelled busy hour, assuming known portions of sites are congested [Source: Analysys Mason, 2013]

It is assumed that, given operators' tendency to slightly overprovision the network, only 5% of sites are accepted as congested during our modelled average busy hour (where the modelled busy hour is defined as above). This gives an overall network utilisation of 36%, calculated as the area under the 'selected' curve in Figure 6.9.

The selected level of congestion is slightly higher than that seen in the Channel Islands operator information, as shown in the confidential Annex D. However, it is believed that as the operators' networks further develop and higher levels of data traffic are seen across sites (of which consumers are more accepting of congestion), operators will accept a higher portion of fully utilised sites during the busy hour and hence achieve an overall higher network utilisation.

We consider it unlikely that the utilisation curve will develop further beyond this point, as previous experience working with operators has shown that, while the overall traffic levels will increase in the long term, the relative distribution of traffic across the network tends to remain relatively static, with the constant evolution of traffic demand restricting optimisation of the network beyond that considered.

Ratio of downlink to uplink traffic for mobile and fixed networks

We have assumed a ratio of downlink to uplink traffic of 89:11 for mobile data traffic and 79:21 for fixed data traffic throughout the modelled period. For mobile traffic, this ratio is based on an average of the Channel Islands operator information. However, for fixed traffic this ratio is based on previous Analysys Mason network modelling experience gained from projects for both European operators and regulators.

Sector capacity dedicated to voice only

Of the total 2G/3G sectors, a set number is reserved for voice services only, and while for 3G services the reservations tend to be dynamic, for 2G services a fixed percentage is set. In our modelling, this is modelled as a blended portion of the total sectors available in each geotype that are not available for meeting the data traffic demand. From operator data and previous European network modelling experience, it is assumed that in 2011, 27% of sectors in the urban geotypes and 39% in the rural geotypes were reserved for voice services and that this decreases over time to 0% in both geotypes by 2020.

6.3.6 Spectral efficiency of current and new spectrum holdings

One of the key factors determining the total spectrum requirements for operators is the technology used in each available spectrum band, and the relative spectral efficiency of each technology. To calculate the spectrum demand, a blended spectral efficiency is assumed across all sectors, where this is calculated as the average technology efficiency weighted by the amount of spectrum it operates on.[71] Below we discuss the factors affecting the change of technologies in bands as well as the release of new spectrum, both of which have an impact on the blended spectral efficiency.

It is assumed that over time operators will tend to want to move to more efficient technologies and reduce costs by closing down older networks, but this does not necessarily mean that operators will do so directly following availability of a new technology. Rather the upgrade of a band to a new technology is seen by operators as a commercial decision and with operators having various drivers both encouraging and discouraging technological upgrade.

In favour of quick upgrading of new technologies and decommissioning of old technologies, is the fact that newer technologies allow for more efficient transferal of data, increasing the speed of transmission and as well as decreasing the cost per MB of transmission. These two factors are especially useful as operators experience increased subscriber data usage coupled with falling revenues per subscriber from traditional services. The move to a new technology is also seen as an opportunity to gain market share, especially amongst higher ARPU ‘first-movers’, as well as allowing a move to new services (and pricing methods) to increase the ARPU of existing customers.

However, against these factors, operators weigh the large cost of investing in a new technology, including the possible write off of existing network investment. New investment cost could include possible requirements to moving existing customers over to new compatible devices, so as to not strand them when the existing infrastructure is decommissioned, though this is reduced by the relatively small size of the Channel Islands markets. In addition, decommissioning of existing networks may lead to a reduction in roaming revenues, which is especially important in tourist heavy countries such as Jersey and Guernsey.

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71 Given we define year-end technology, and changes in technology take time to be fully effective due to handset replacement cycles, we assume the traffic carried over year Y_n encounters the average spectral efficiency T_{n-1} and T_n, where T is the network spectral efficiency at that year end.

Another factor that will affect the upgrade decision moving into the future is that newer technologies are no longer seeing such large increases in speeds and efficiencies over current technologies. For example, the initial user speeds experienced under LTE (from networks deployed using 3GPP Release 8 infrastructure) seem in practice to be only slightly better than the efficiency achievable using HSPA+ (also 3GPP release 8).

Technology deployment timings

Overall we were unable to confirm with operators a consistent set of plans for the evolutionary path of network technologies on the Channel Islands. Specifically, we had a range of possible answers for timings associated with shutdown (and refarming of spectrum) of the legacy 2G and 3G networks. This market ambiguity seems to stem from operators having various views of the future market development, all of which were highly dependent upon how international markets (and especially international roaming) developed in the future.

As such, with the business case trade-offs mentioned above in mind, and given our current best views of market developments in the rest of Europe (including specifically the UK), we have made various assumptions relating to the use of spectrum with different technologies within our modelling, which we have discussed with operators. The spectral efficiency of different technologies considered to be used in each band is discussed above in Section 3.4, and the timings of our model deployment of these technologies are detailed below:

- GSM will remain deployed in the 900MHz band until 2019 (inclusive), allowing GSM international roaming and support for existing 2G subscribers using legacy handsets until such time as these disappear from the market. In parallel, it is assumed that VoLTE will be deployed before 2019, so that loss of voice coverage is not a factor in the decision to decommission 2G or 3G services.

- Operators will look to upgrade from HS(D)PA networks to HSPA+ by 2013 with an initial focus being on deployment of HSPA+ in the 2.1GHz band. The long-term forecast is that HSPA+ networks will be switched-off by 2022.

- LTE will be introduced from 2013. In addition to the bands clearly designated for LTE use (800MHz and 2.6GHz bands), we assume that the unassigned spectrum in the 1800MHz band will also be used for providing LTE-based services.

- We assume that LTE-A is progressed in three stages, related to introduction of more efficient small-cell (i.e. relay node) deployments and development of practical MIMO usage in consumer handsets. LTE-A is initially assumed to be introduced from 2017 onwards (with an uplift of 15% efficiency over LTE), mainly in those bands previously used for LTE. The second phase is deployed from 2019 (with an uplift of 30% efficiency over LTE), and the final phase is deployed in 2025 (with an uplift of 45% efficiency over LTE).

Spectrum distribution

Our model assumes availability of spectrum for immediate 4G/LTE deployment in the 800MHz, 1800MHz[72] and 2.6GHz bands. In addition, we assume that operators can refarm existing 2G and 3G spectrum for 4G use, where practical, once 2G and 3G networks are switched off (as noted above) in the 900MHz and 2.1GHz bands. As this adds a significant amount of spectrum with relatively high efficiency, it has a significant effect on the overall blended spectral efficiency and therefore the spectrum demand seen. In our modelling, we do not consider spectrum in the 700MHz band, or the unpaired TDD spectrum in the 2.1GHz, 2.3MHz, 2.6GHz or 3.4GHz bands. However, we note that all of these bands could be used in situations where spectrum demand exceeds supply in the other allocated bands.

It is noted that Airtel-Vodafone assignments of 2×5MHz of 900MHz spectrum in Guernsey and 2×5MHz of 1800MHz spectrum in Jersey are both assigned in non-contiguous blocks. As such, we assume this cannot be refarmed for 4G use since a minimum contiguous block of 2×5MHz is assumed to be required in practice. In the same way, Sure has non-contiguous blocks of spectrum in the 1800MHz band in Jersey, with one block only of 2×1.8MHz in width.

Therefore, it is assumed in the modelling that any spectrum split into non-contiguous blocks that are too small for use by the current assigned technology is either left unused or returned to the regulator.

The split of new spectrum is varied for some of the scenarios considered. However, in our base case (Scenario 2), spectrum in the 800MHz and 2.6GHz bands is distributed equally, resulting in each of the three operators receiving an additional 2×10MHz and 2×20MHz of spectrum in the 800MHz and 2.6GHz bands respectively. Under our base case, it is assumed that the 1800MHz spectrum, including the existing assignments, is redistributed so that each operator holds 2×25MHz of 1800MHz spectrum in total following the redistribution.

In the case of a new entrant, we have assumed a slightly more complex split, including a sub-1GHz cap, redistribution of the 1800MHz band (with existing operators ending with 2×20MHz and the new entrant receiving 2×15MHz), and an additional 2×10MHz in the 2.6GHz band to those affected by the sub-1GHz cap.

6.3.7 Forecast number of sites and sectors

We have considered two cases of site growth across Jersey and Guernsey, a conservative level of site growth, and a higher level of site growth (which is used in the base case). The difference between these is demonstrated in our scenario testing in Section 7.2.

We have modelled two types of site: macro sites and small-cell (i.e. micro/pico/femto) sites. We assume that macro sites can have up to a maximum of three sectors available to carry (data) traffic. Small-cell sites, (i.e. those deployed at lower powers to provide additional capacity primarily in

[72] In the parts of the 1800MHz band not already assigned for 2G use.

urban areas) have only a single sector to carry traffic. Given the relatively low number of small-cells in the networks currently, and global operator trends to move towards heterogeneous networks,[73] it is assumed that small-cell growth will be higher than macro growth over the period of our modelling.

In both our base and conservative cases, the macro site growth is assumed to be lower in Guernsey than Jersey due to the stricter planning regime (though this is partially rectified by the inclusion of site sharing obligations within Guernsey operators' licences). The total level of site growth is defined by site type, by island and by geotype, as shown in Figure 6.10 and Figure 6.11.

	Urban site growth ratio (2011 vs. 2026)	Rural site growth ratio (2011 vs. 2026)	Compound annual growth rate
Jersey macro sites	170%	150%	3.0%
Guernsey macro sites	150%	130%	2.0%
Jersey/Guernsey small-cell sites	200%	200%	4.7%

Figure 6.10: Base case site growth across both Channel Islands [Source: Analysys Mason, 2013]

	Urban site growth ratio (2011 vs. 2026)	Rural site growth ratio (2011 vs. 2026)	Compound annual growth rate
Jersey macro sites	125%	125%	1.5%
Guernsey macro sites	115%	115%	0.9%
Jersey/Guernsey small-cell sites	130%	130%	1.8%

Figure 6.11: Conservative case site growth across both Channel Islands [Source: Analysys Mason, 2013]

It is assumed that the total number of sectors increases from the current level (an average of 2.5 sectors per macro site per operator) to a maximum level of 3 per operator on each macro site as detailed above, with the single sector per small-cell site remaining unchanged. We note that any new operator is assumed to build an equivalent of 33% of the total current existing sectors across both islands, corresponding to an instantaneous network roll-out.

In practice, a new operator's site roll-out would likely be achieved through a combination of new site build and site sharing and would occur over a matter of years, but as the network is unlikely to be spectrum constrained during this period given its limited traffic, this simplification will not significantly affect the overall result.

We note that in the case of a new entrant, the Channel Islands governments would need to carefully consider the impact of new sites required. While some increased site sharing on existing sites may be available, the physical limits of space available for a new entrant on sites (and towers)

73 Heterogeneous networks are blended small-cell and macro networks that use improvements in LTE-A (such as relay nodes) and the reducing costs of small cells to provide increased capacity via the heavy deployment of micro-, pico- or femto-cells in traffic-heavy parts of the network.

may limit the amount of sharing possible beyond the current level for some sites. This may be balanced by any new sites also providing (perhaps limited) opportunity for existing operators to improve their current network layouts.

Full details of assumptions on the development of sites and sector numbers over time per existing network are given in the confidential Annex D.

7 Results of the modelling

The following section is split into three parts. Initially, we report the results for the Channel Islands spectrum demand under our stated scenarios. Then we consider the effects of variations in some of the more sensitive model parameters. In the final part, we draw out some of our conclusions as informed by the spectrum modelling, and discuss the implications for the Channel Islands and its future spectrum policy.

7.1 Scenario-based results

Below we consider in turn each of the scenarios discussed above in Section 6.2. The scenarios all use the same starting demand model but with small changes to some of the inputs, as discussed in each section, to determine how the spectrum demand changes under particular conditions.

7.1.1 Scenario 1: Assuming equal distribution of new 800MHz, 1800MHz and 2.6GHz spectrum between operators

Our initial scenario compares the spectrum requirements for our base case traffic levels, against the spectrum assignments for each existing operator, assuming that new spectrum for 4G deployment is released in the 800MHz, part of the 1800MHz and 2.6GHz bands in 2014.

In this scenario, new spectrum is assigned equally in 2×5MHz blocks to each of the operators. This equates to each operator gaining 2×10MHz, 2×15MHz and 2×20MHz in the 800MHz, 1800MHz and 2.6GHz bands, respectively, across each Bailiwick. Given the minimum carrier size requirements of HSPA+ and LTE services, it is assumed that any operators with non-contiguous spectrum under 2×5MHz in size let these small parts of their allocations remain fallow or hand them back once the band moves to 3G or 4G, and as such they are removed from the spectrum totals below.[74]

This scenario assumes our base case level of traffic, with assumptions of 30% of mobile traffic being offloaded onto WiFi, and 15% of the current fixed network traffic being substituted onto mobile broadband technologies. In addition, this scenario assumes the base case site growth, which is the higher of the two cases detailed in Section 6.3.7.

74 This includes: 2×5MHz (non-contiguous) at 900MHz and 2×1.2MHz at 1800MHz used by Airtel-Vodafone in Guernsey; 2×1.8MHz at 1800MHz used by Sure in Jersey; and 2×5MHz (non-contiguous) at 1800MHz used by Airtel-Vodafone in Jersey.

The results of our Scenario 1 analysis are shown below.

Figure 7.1: Spectrum analysis for ***Airtel-Vodafone*** *under Scenario 1 [Source: Analysys Mason, 2013]*

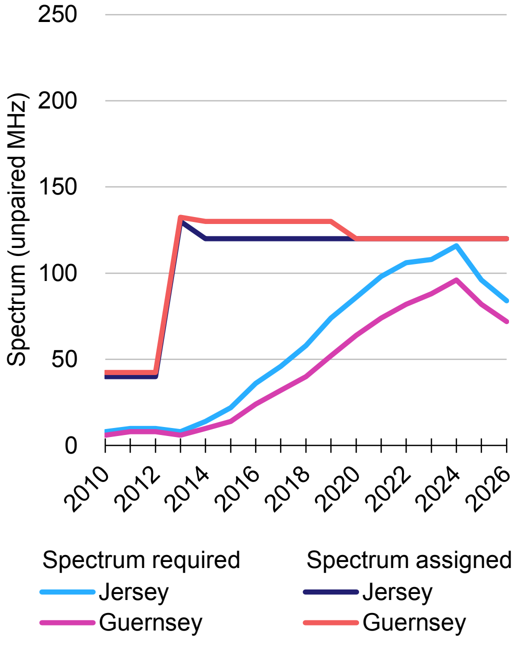


Figure 7.2: Spectrum analysis for ***Jersey Telecom*** *under Scenario 1 [Source: Analysys Mason, 2013]*

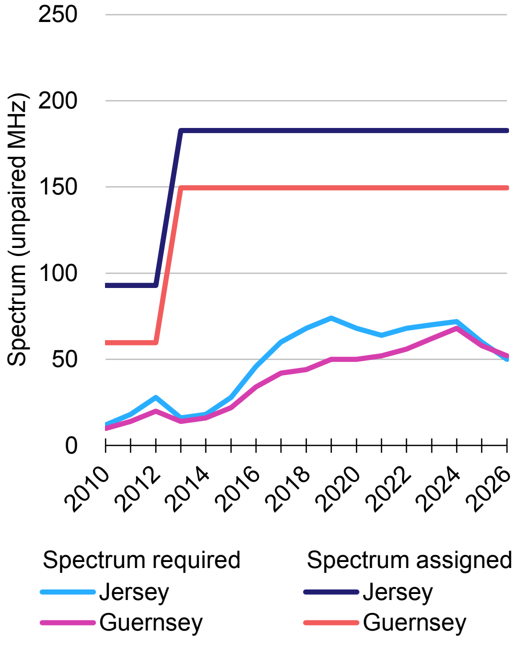


Figure 7.3: Spectrum analysis for ***Sure (C&W)*** *under Scenario 1 [Source: Analysys Mason, 2013]*

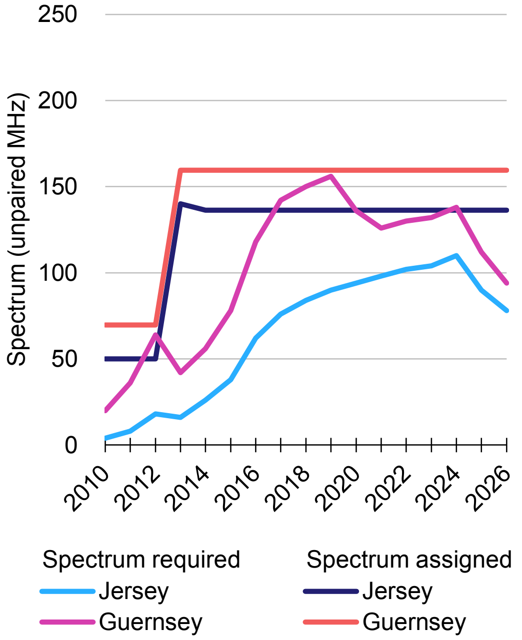
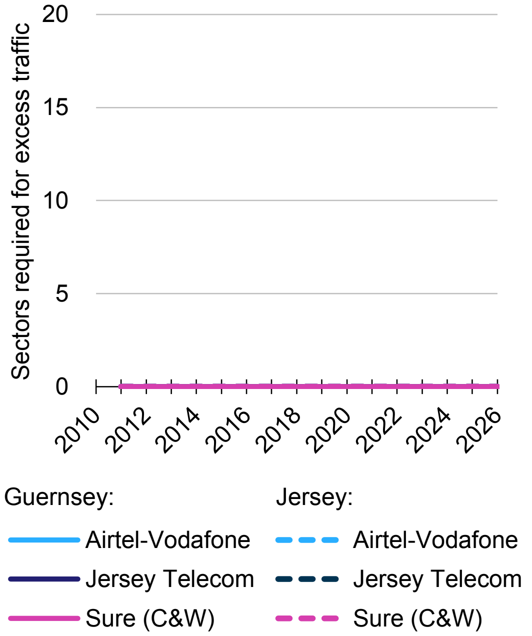


Figure 7.4: Additional sectors required to carry excess traffic beyond assigned spectrum [Source: Analysys Mason, 2013][75]



[75] Figure 7.4 demonstrates that there is no requirement for new sectors beyond the assigned spectrum.

As can be seen in Figure 7.1, Figure 7.2 and Figure 7.3, the level of spectrum assigned to each operator is just sufficient for all operators under this case. Sure comes closest to surpassing its assigned level of spectrum, specifically in the urban Guernsey geotype. This is primarily due to the higher level of traffic being carried, in view of Sure's significant market share in Guernsey. In addition, Airtel-Vodafone approaches its assigned level of spectrum in both Guernsey and Jersey towards the end of the modelled period. This is attributable to Airtel-Vodafone having less spectrum available overall (since its 900MHz assignment is non-contiguous and not suitable for LTE use).

There are two key reductions in spectrum demand seen by Sure and JT; in 2020 (when refarming of 900MHz spectrum from GSM to LTE-A takes place) and in 2025 (when the move from our second LTE-A deployment step, 2.6bit/s per Hz, to the final stage of LTE-A deployment, 4.02bit/s per Hz, is assumed). Given Airtel-Vodafone's limited (and non-contiguous in Guernsey) 900MHz spectrum holdings, it only receives significant benefit from the second of these two developments.

These results suggest that an even distribution of new spectrum, without any reorganisation of current spectrum holdings, will only just meet predicted spectrum demand. However, Scenario 1 assumes that both a 30% WiFi offload and relatively high level of site growth can both be achieved. We note that in our discussions with operators, both of these assumptions were seen as relatively uncertain. Therefore, it is possible in this scenario that spectrum demand may exceed the spectrum available.

It is also worth noting that without the new 800MHz, 18000MHz and 2.6GHz spectrum assigned in 2014, both Sure and Airtel-Vodafone are unlikely to be able to meet their traffic demand within the next five years.

We note that when comparing the incumbents' spectrum demand in their home markets, Sure has a significantly higher demand despite Guernsey's lower population, and hence traffic levels. This is due to the smaller number of sites and lower relative site growth found in Guernsey, which leads to the Bailiwick having traffic distributed over relatively fewer sectors than is seen in Jersey.

7.1.2 Scenario 2 (Base case): In addition to new spectrum allocation, assuming a redistribution of new and existing spectrum in the 1800MHz band to give operators equal, contiguous, 1800MHz blocks

Scenario 2 compares the spectrum demand requirements for our base case traffic levels, against the spectrum assignments for each operator, assuming that all existing and new spectrum is evenly redistributed in the 1800MHz bands in 2014, and new 800MHz and 2.6GHz spectrum is distributed evenly as in Scenario 1, i.e. an additional 2×10MHz and 2×20MHz per operator in the 800MHz and 2.6GHz bands, respectively.

As with Scenario 1, it is assumed that Airtel-Vodafone's non-contiguous spectrum in the 900MHz band in Guernsey is not used for 4G. However, given the 1800MHz spectrum redistribution, it is assumed all operators' new and existing 1800MHz holdings are contiguous, since it may be more practical to re-align 1800MHz spectrum between operators (in view of the spare bandwidth available to facilitate this). In addition, Scenario 2 assumes the same traffic and site assumptions as were used in Scenario 1.

The results of our Scenario 2 analysis are shown below.

*Figure 7.5: Spectrum analysis for **Airtel-Vodafone** under Scenario 2 [Source: Analysys Mason, 2013]*

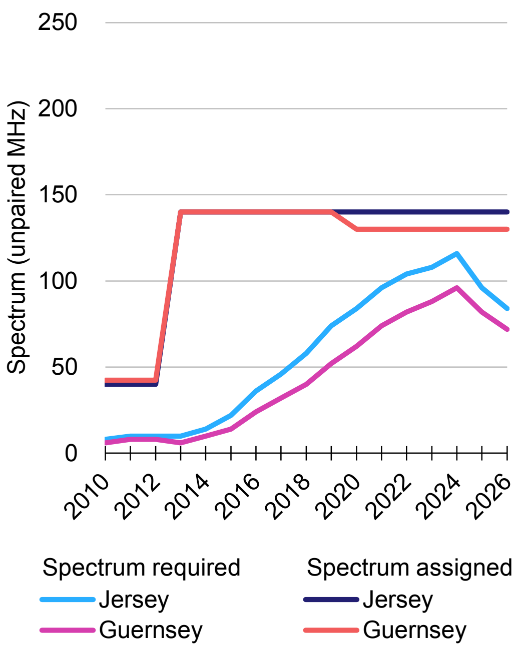


*Figure 7.6: Spectrum analysis for **Jersey Telecom** under Scenario 2 [Source: Analysys Mason, 2013]*

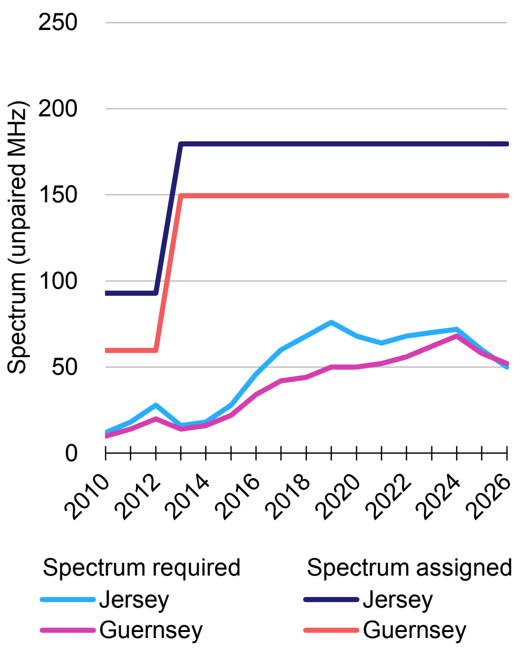


*Figure 7.7: Spectrum analysis for **Sure (C&W)** under Scenario 2 [Source: Analysys Mason, 2013]*

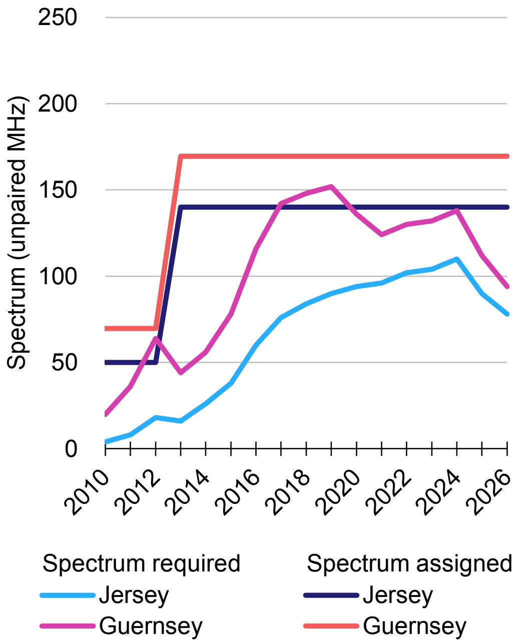
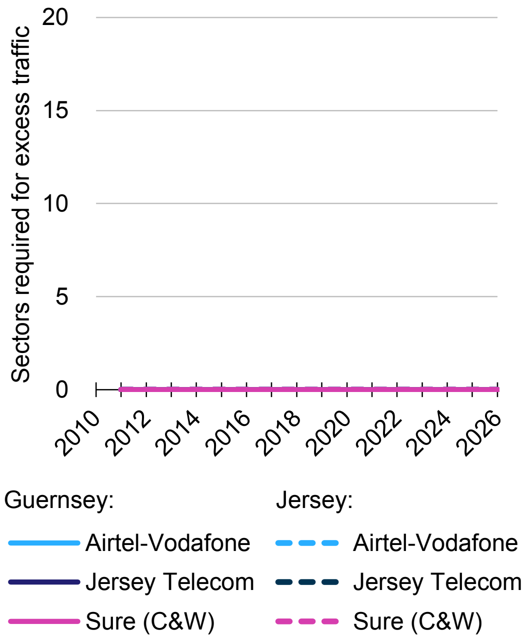


Figure 7.8: Additional sectors required to carry excess traffic beyond assigned spectrum [Source: Analysys Mason, 2013]



As shown in Figure 7.5, Figure 7.6 and Figure 7.7, the level of spectrum assigned to each operator is sufficient for all operators' demands under this scenario, similar to Scenario 1. However, in this scenario the margin of difference between the highest peaks of demand and the spectrum assigned is larger for both Sure and Airtel, operators which in Scenario 1 came very close to exceeding their assigned spectrum.

These results suggest that in the case of just the existing three operators, redistributing the 1800MHz spectrum to achieve contiguous blocks and to give each operator an even (2×25MHz) split of the 1800MHz band is beneficial to the overall market allocations, and should allow each operator some leeway for their spectrum demand to be slightly higher than that forecast in the modelling.

7.1.3 Scenario 3: Assuming larger growth in fixed substitution, reaching 30% of fixed traffic

Scenario 3 compares the spectrum requirements for base case mobile traffic levels plus a 30% level of fixed-mobile substitution, compared to the 15% substitution assumed in Scenario 2. As can be seen in Figure 7.9, this increases the total busy-hour traffic significantly, and therefore acts as a likely maximum level of traffic that would need to be carried via the mobile network at any point in time.

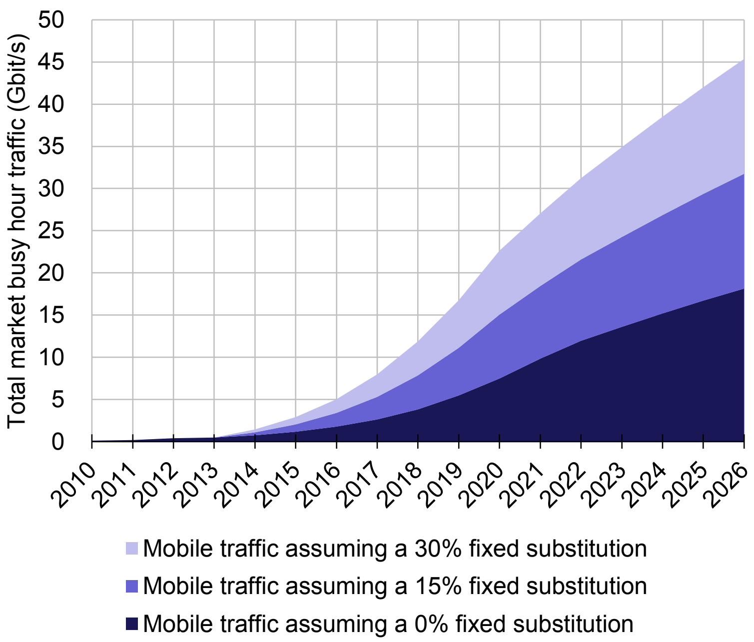


Figure 7.9: Total market busy-hour traffic for different levels of fixed traffic substitution [Source: Analysys Mason, 2013]

Other than the increased traffic assumptions, all other parameters are identical to those modelled in Scenario 2, including the spectrum assignments, with the 1800MHz spectrum assumed to be redistributed evenly between the 3 operators.

The results of our Scenario 3 analysis are shown below.

*Figure 7.10: Spectrum analysis for **Airtel-Vodafone** under Scenario 3 [Source: Analysys Mason, 2013]*

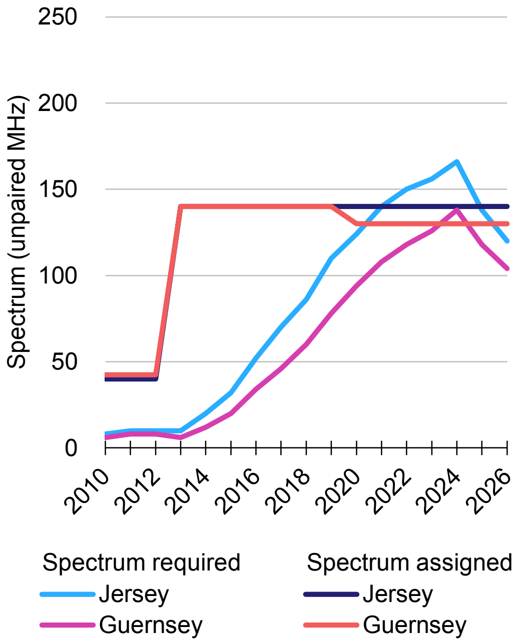


*Figure 7.11: Spectrum analysis for **Jersey Telecom** under Scenario 3 [Source: Analysys Mason, 2013]*

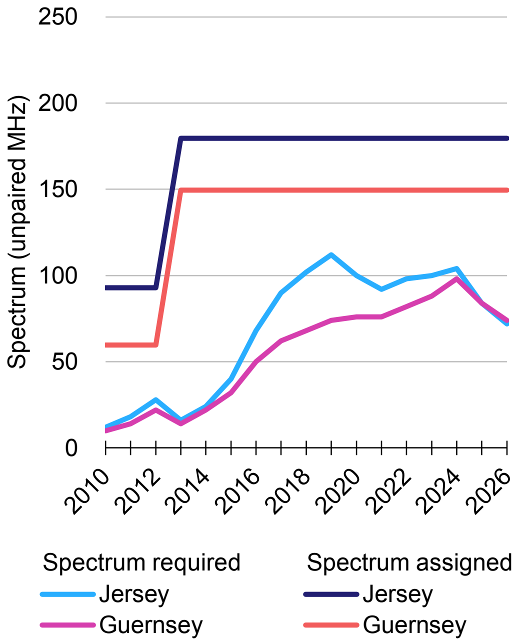


*Figure 7.12: Spectrum analysis for **Sure (C&W)** under Scenario 3 [Source: Analysys Mason, 2013]*

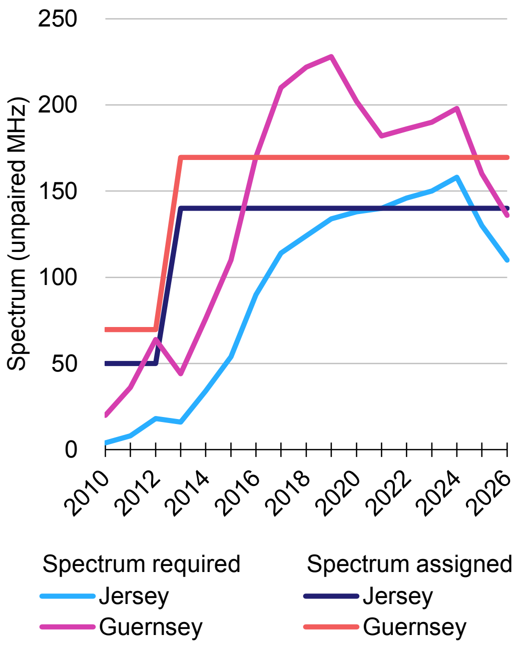
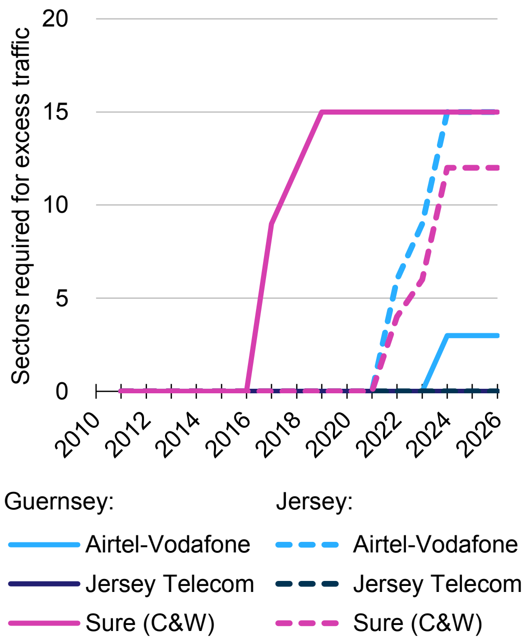


Figure 7.13: Additional sectors required to carry excess traffic beyond assigned spectrum [Source: Analysys Mason, 2013]



As shown in Figure 7.10, Figure 7.11 and Figure 7.12, under this scenario the level of spectrum assigned is only sufficient in JT's case. For both Sure and Airtel, demand exceeds the spectrum the operator has available, requiring either additional sectors to be built by both operators or access to additional spectrum. As shown in Figure 7.13, these sectors are located in both urban Jersey and Guernsey for Sure, whereas Airtel only has to build additional sectors in Jersey (again in the urban geotype). As the model assumes that full sectorisation of each existing site has already occurred by 2026, any increase in sectors would relate to a requirement for new sites to be built or a (possibly unfeasible) increase in site sharing.

This also highlights that even with JT's reduced spectrum levels due to reorganisation of the 1800MHz band, there is still no excess spectrum demand from JT even at our highest theoretical traffic levels, with a significant margin still existing in both Bailiwicks. This is due to the operator already having a significant number of sites in the market where their market share is high.

7.1.4 Scenario 4: Assuming a new entrant to the mobile market, with redistribution of the 1800MHz band and spectrum caps for sub-1GHz spectrum

Scenario 4 compares the spectrum requirements if a fourth operator enters the market. For simplicity we have assumed that the entrant is the same in both Jersey and Guernsey. However, we note that this does not necessarily need to be the case as the two Bailiwicks' traffic levels are treated independently.

In allocating new spectrum between the four operators, we have assumed a slightly more complex split compared to Scenario 2 to account for the additional operator:

- It is assumed that a new entrant would benefit from access to lower frequency 800MHz spectrum. Given the current inequality of low frequency spectrum holdings, we have assumed a cap of 2×20MHz of sub-1GHz spectrum would be applied in both Bailiwicks. This means that both JT in Jersey and Sure in Guernsey would not be able to acquire any new 800MHz given their existing 900MHz holdings unless they were able to relinquish 900MHz spectrum in return for new 800MHz spectrum, in which case vacated 900MHz spectrum could be assigned to a new operator.
- It is assumed that the 1800MHz band is redistributed, with each of the existing operators ending up with contiguous blocks of 2×20MHz and the new entrant receiving the balance.
- It is assumed that the incumbents that lost out on spectrum in the 800MHz band, receive an additional 2×10MHz in the 2.6GHz band in the relevant regions. The remaining spectrum is split evenly between all operators.

A summary of the operator assignments above is given in Figure 7.14.

Operator	800MHz band	1800MHz band	2.6GHz band
Airtel-Vodafone	J: 2×10MHz G: 2×10MHz	J: 2×20MHz G: 2×20MHz	J: 2×15MHz G: 2×15MHz
Jersey Telecom	J: 0MHz G: 2×10MHz	J: 2×20MHz G: 2×20MHz	J: 2×25MHz G: 2×15MHz
Sure (C&W)	J: 2×10MHz G: 0MHz	J: 2×20MHz G: 2×20MHz	J: 2×15MHz G: 2×25MHz
New entrant	J: 2×10MHz G: 2×10MHz	J: 2×15MHz G: 2×15MHz	J: 2×15MHz G: 2×15MHz

Figure 7.14: Modelled assigned spectrum for Jersey / Guernsey (including redistribution of 1800MHz) [Source: Analysys Mason, 2013]

The total market traffic assumptions are identical to those in Scenario 2. However, part of the traffic is carried by the new entrant, who enters the market in 2013 and reaches a market share of 15% by the end of 2026. In addition, the site assumptions in Scenario 4 are identical to Scenario 2 for the three existing operators, with the new entrant assumed to roll-out its network to the average of the three current operators' networks within the first year and then expand at the same growth rates as the other operators, as shown in Figure 7.15.

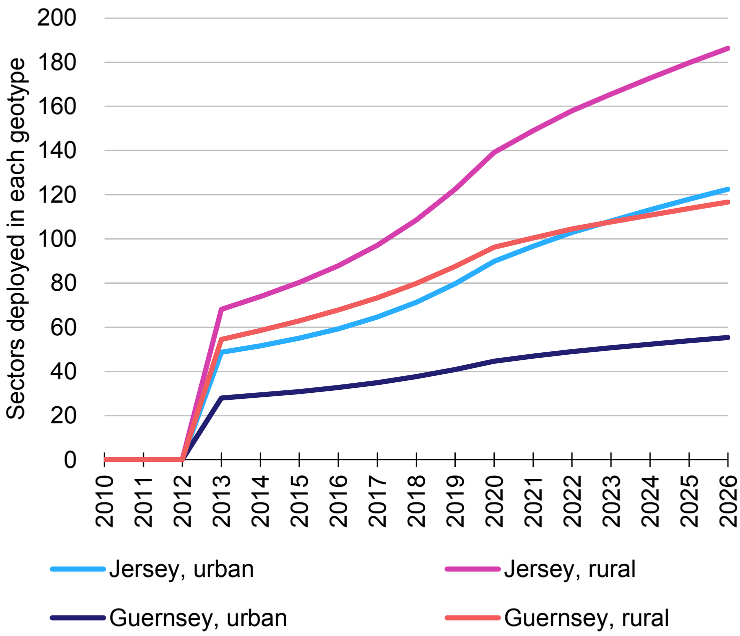


Figure 7.15: New entrant's network deployment profile [Source: Analysys Mason, 2013]

We note that in practice a new entrant is unlikely to roll-out its full network immediately, with the network more likely to be expanded partial in line with demand possibly using national roaming to fill-in any coverage holes. However, by assuming an immediate scale roll-out as shown in Figure 7.15, we are able to better compare the entrant's spectrum demands with that of other operators. This simplifying assumption is considered reasonable as the entrant is highly unlikely to be spectrum limited initially, given the low level of traffic on its network at the start.[76]

76 We note that the purpose of this modelling is not to determine the financial viability of a new entrant, but rather its demand for spectrum, and that in practice we assume the regulator would consider measures such as national roaming to encourage early roll-out.

The results of our Scenario 4 analysis are shown below.

*Figure 7.16: Spectrum analysis for **Airtel-Vodafone** under Scenario 4 [Source: Analysys Mason, 2013]*

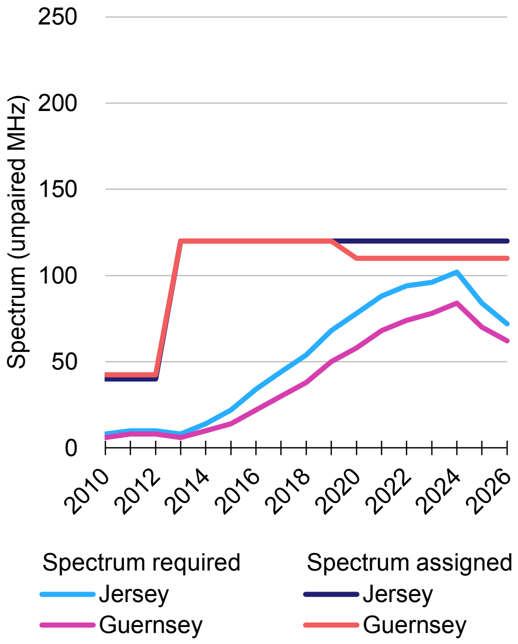


*Figure 7.17: Spectrum analysis for **Jersey Telecom** under Scenario 4 [Source: Analysys Mason, 2013]*

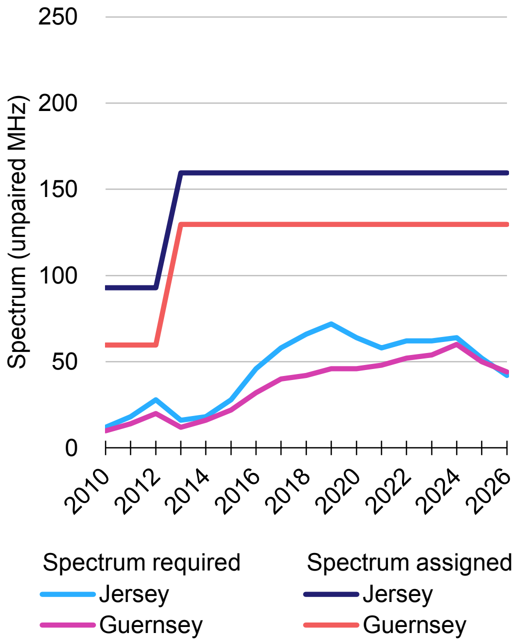


*Figure 7.18: Spectrum analysis for **Sure (C&W)** under Scenario 4 [Source: Analysys Mason, 2013]*

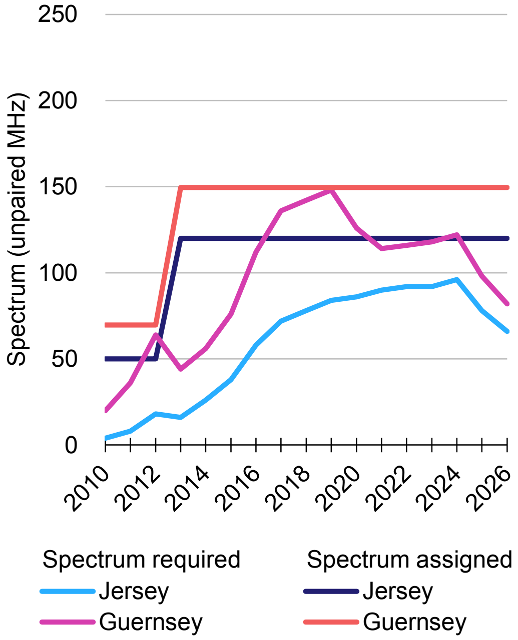
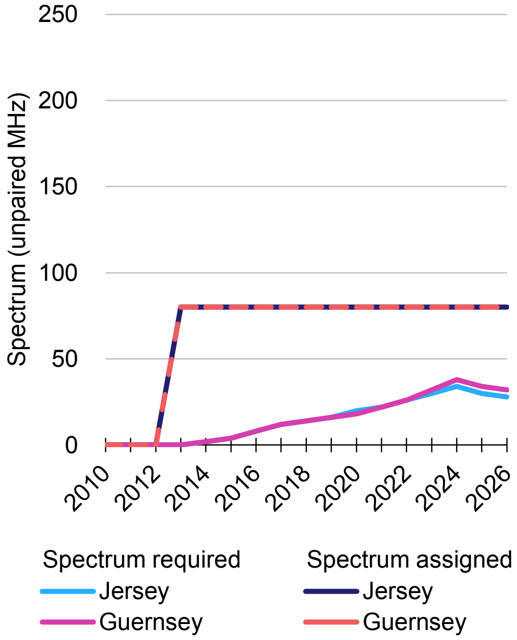


*Figure 7.19: Spectrum analysis for **New entrant** under Scenario 4 [Source: Analysys Mason, 2013]*



As can be seen in Figure 7.16, Figure 7.17 and Figure 7.18, the level of spectrum assigned to each operator is just sufficient for all operators under this case, with Sure's spectrum demand in Guernsey again almost exceeding its assigned level of spectrum.

While the new entrant reduces the amount of spectrum assigned to each operator, it also in turn reduces the level of traffic seen by each operator by gaining a portion of their market share. However, if the new entrant fails to gain market traction, or reduces the number of sites able to be deployed by other operators, the spectrum requirements could be increased for the current operators and exceed their reduced spectrum allocations. In effect, an inefficiently empty entrant network would put additional pressure on spectrum resources. We demonstrate this below in Figure 7.20 and Figure 7.22, for both cases using Sure as our example.

*Figure 7.20: Spectrum analysis for **Sure (C&W)** assuming the new entrant **gains no market share** but retains its spectrum [Source: Analysys Mason, 2013]*

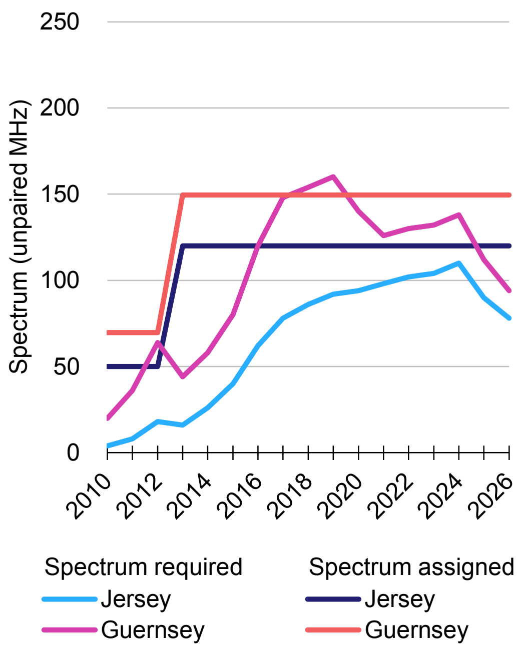


*Figure 7.21: Additional sectors required to carry excess traffic beyond assigned spectrum assuming the new entrant **gains no market share** [Source: Analysys Mason, 2013]*

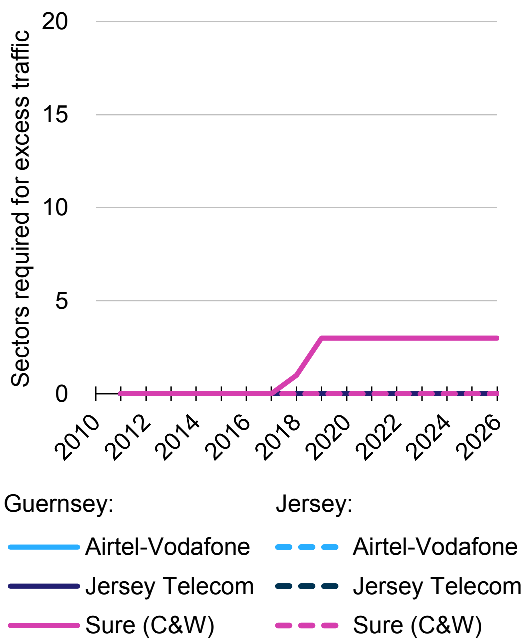


Figure 7.22: Spectrum analysis for ***Sure (C&W)*** *assuming the new entrant* ***reduces the site growth*** *to our low case scenario (as in Section 7.1.5) [Source: Analysys Mason, 2013]*

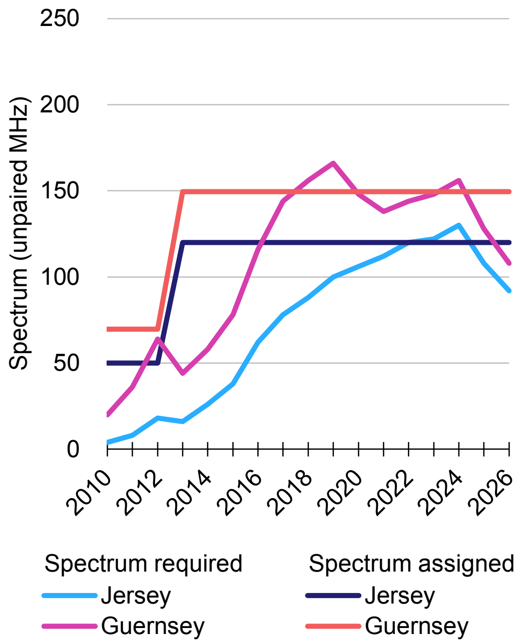
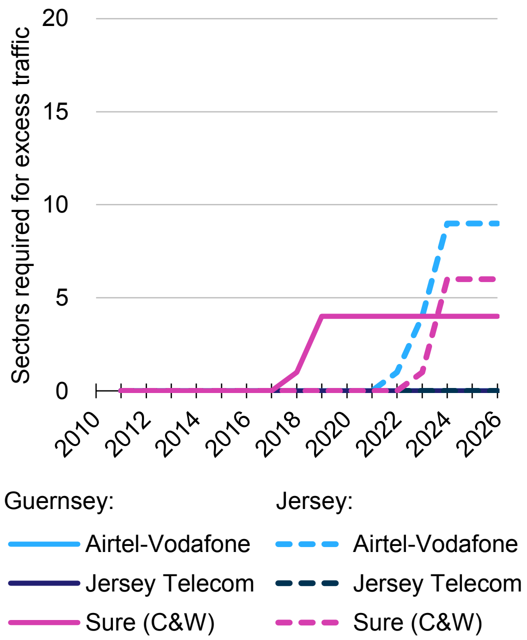


Figure 7.23: Additional sectors required to carry excess traffic beyond assigned spectrum assuming the new entrant ***reduces the site growth*** *[Source: Analysys Mason, 2013]*



As shown in Figure 7.21 and Figure 7.23, these results suggest that while the entrance of a new operator should be possible in both markets from a spectrum perspective, the risk of either Sure or Airtel needing more spectrum than is available is increased. We note however that the additional number of sectors required is not overly significant, and additional spectrum (for example 700MHz or TDD spectrum) could be used instead to increase the operator assignments. As such, the additional market efficiency gained by increased competition may still make a new entrant appropriate from a regulatory stand point, even given the additional risk.

7.1.5 Scenario 5: Assuming low natural site growth across both Bailiwicks

Our final scenario compares the spectrum requirements for our base case traffic levels, against the spectrum assignments for each operator, assuming that the level of site growth assumed in our base case is optimistic and that, in fact, a significantly lower site growth is achievable across all regions as discussed in Section 6.3.7, and detailed in Figure 7.24. Other than the level of site growth, all other model parameters including traffic and spectrum distributions remain as in Scenario 2.

	Urban site growth ratio (2011 vs. 2026)	Rural site growth ratio (2011 vs. 2026)	Compound annual growth rate
Jersey macro sites	125%	125%	1.5%
Guernsey macro sites	115%	115%	0.9%
Jersey / Guernsey small-cell sites	130%	130%	1.8%

Figure 7.24: Conservative case site growth across both Channel Islands [Source: Analysys Mason, 2013]

The spectrum demand results from this lower site growth scenario are shown below.

Figure 7.25: Spectrum analysis for ***Airtel-Vodafone*** *under Scenario 5 [Source: Analysys Mason, 2013]*

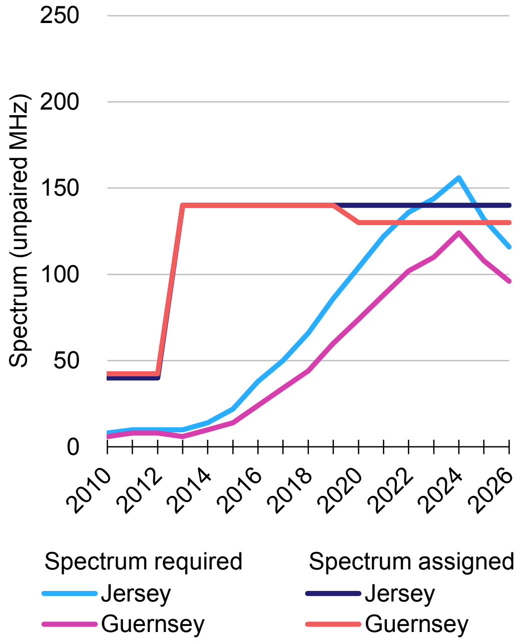


Figure 7.26: Spectrum analysis for ***Jersey Telecom*** *under Scenario 5 [Source: Analysys Mason, 2013]*

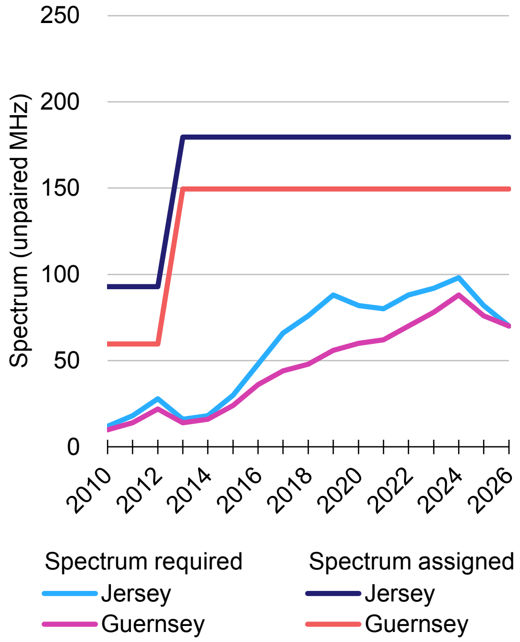


*Figure 7.27: Spectrum analysis for **Sure (C&W)** under Scenario 5 [Source: Analysys Mason, 2013]*

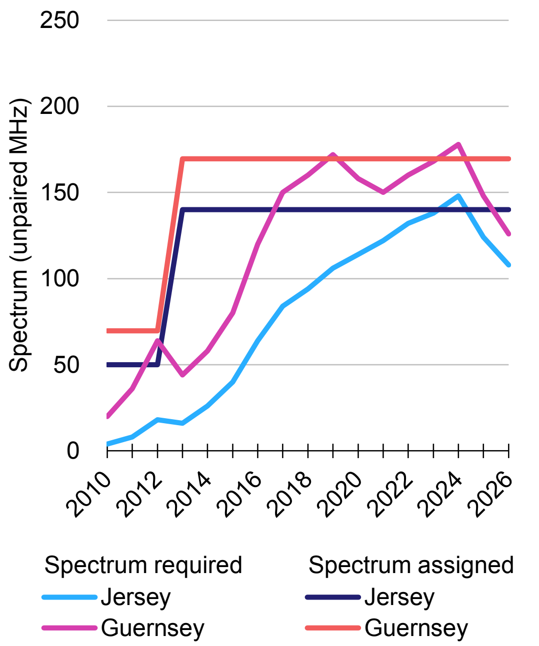
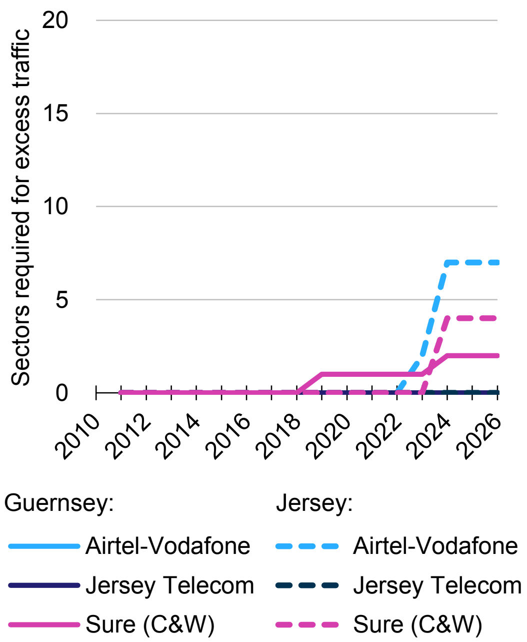


Figure 7.28: Additional sectors required to carry excess traffic beyond assigned spectrum [Source: Analysys Mason, 2013]



As can be seen in Figure 7.25, Figure 7.26 and Figure 7.27, the level of spectrum assigned to each operator is no longer sufficient given this conservative site growth, even with the 1800MHz redistribution step. This is even more obvious in the case of combined low site growth and high fixed traffic substitution (as considered in Scenario 3), as shown in Figure 7.29.

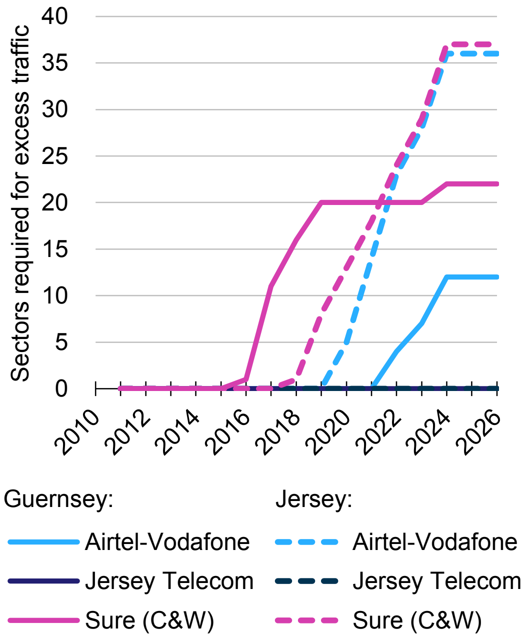


Figure 7.29: Additional sectors required to carry excess traffic beyond assigned spectrum assuming a 30% fixed traffic substitution [Source: Analysys Mason, 2013]

While the number of sectors required to deal with excess traffic in the base case traffic scenario is limited, the number of sectors required to address the traffic in the high fixed substitution test would likely be a significant extra cost to all three of the operators. Additionally, given that any reasons for limiting the overall natural level of site growth would likely also limit the level of additional sectors that operators could build (or certainly significantly increase the cost per sector), it is possible that in this situation operators would have no choice but to introduce traffic-reducing measures such as different tariffs, "fair usage" policies, or force customers to accept additional site congestion.

7.2 Sensitivity analysis

In order to test the impact of our modelling parameters on the output, we have undertaken a sensitivity analysis of key parameters. Sensitivity analysis is detailed for the following parameters and assumptions:

- the LTE-A spectral efficiency
- the level of mobile offloading onto WiFi
- the traffic forecasts used for both mobile and fixed subscriber data usage
- the long-term operator market share assumptions
- the difference in site growth between the Channel Islands, including the extreme of no site growth.

To simplify the analysis we have only applied the sensitivities to our base case (as detailed in Scenario 2), rather than adjusting each scenario. As the relative effects for sensitivity will be similar in other scenarios as it is in the base case, it is felt that that these do not need to be explicitly modelled.

Our base case scenario assumes that there are three infrastructure providers and base case traffic forecasts, with assumptions of 30% flat offloading over time and that the market's fixed broadband traffic substitution, by 4G services, reaches 15%. Additionally, both new and existing spectrum is redistributed evenly in the 1800MHz bands, while equal amounts of new spectrum are awarded to each operator in the 800MHz and 2.6GHz bands.

In the following diagrams, dotted lines show the spectrum demand under the base case, compared to the demand predicted by varying the assumptions in our sensitivity analysis shown in solid lines.

7.2.1 Sensitivity 1: Impact of different LTE-A spectral efficiency parameters

In order to test the influence of our LTE-A spectral efficiency parameters, and specifically the high impact assumption of increasing MIMO deployment, we have shown the total market spectrum demand and additional sector requirements assuming the LTE-Advanced spectral efficiency does not increase beyond Rel-10, SU-MIMO 2×2 (which is equivalent to our first LTE-A step, as discussed in Annex E).

Figure 7.30: The total market spectrum requirements under Sensitivity 1 (Dotted lines represent the base case spectrum requirement) [Source: Analysys Mason, 2013]

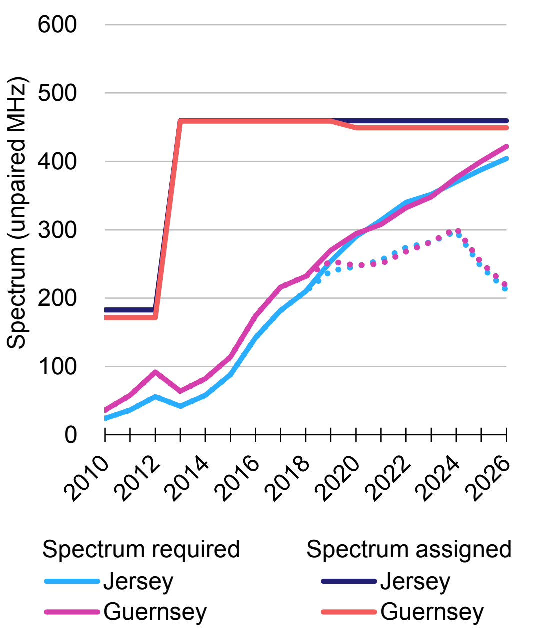
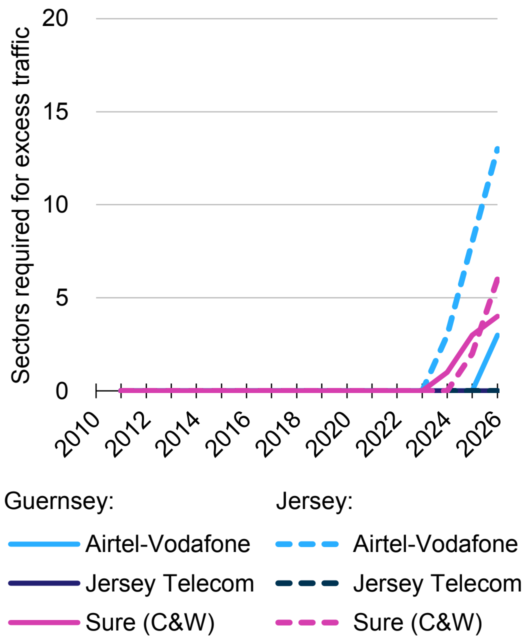


Figure 7.31: Additional sectors required to carry excess traffic beyond assigned spectrum under Sensitivity 1 [Source: Analysys Mason, 2013]



As this demonstrates, the influence of not having higher order MIMO can make a significant impact on the overall market spectrum demand. In practice, given the current trends in technology improvements, we expect spectrum efficiency to improve to at least some extent beyond our first step (forecast to be met by 2017) before the 2026 end of the model.

7.2.2 Sensitivity 2: Impact of different mobile offloading assumptions

In order to test the influence of different mobile to WiFi offloading assumptions, we have shown the spectrum requirements under both the Analysys Mason Research offloading forecast (Sensitivity 2a) and a flat 0% offloading (Sensitivity 2b).

The results using the two offloading case are shown below.

Figure 7.32: The total market spectrum requirements under Sensitivity 2a using Analysys Mason Research offloading assumptions (Dotted lines represent the base case spectrum requirement) [Source: Analysys Mason, 2013]

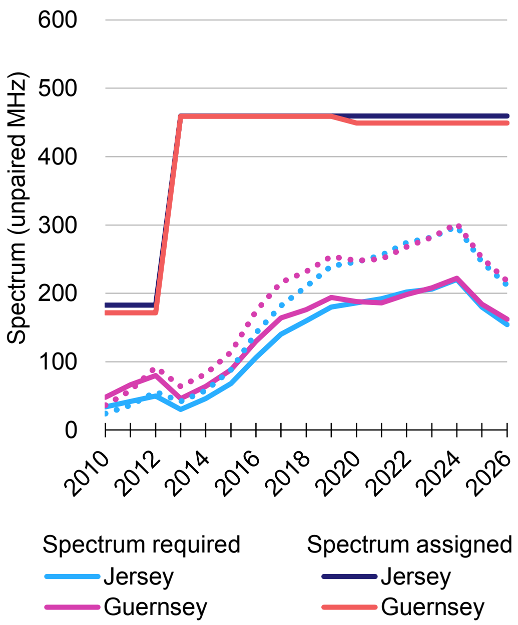


Figure 7.33: Additional sectors required to carry excess traffic beyond assigned spectrum under Sensitivity 2a [Source: Analysys Mason, 2013]

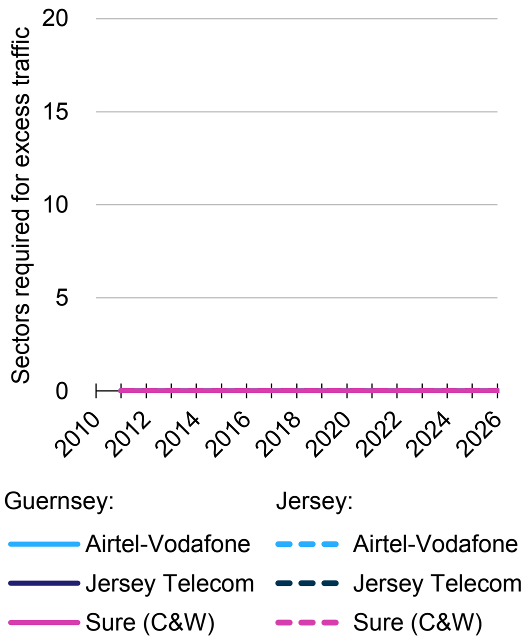


Figure 7.34: The total market spectrum requirements under Sensitivity 2b using a flat 0% offloading assumptions (Dotted lines represent the base case spectrum requirement) [Source: Analysys Mason, 2013]

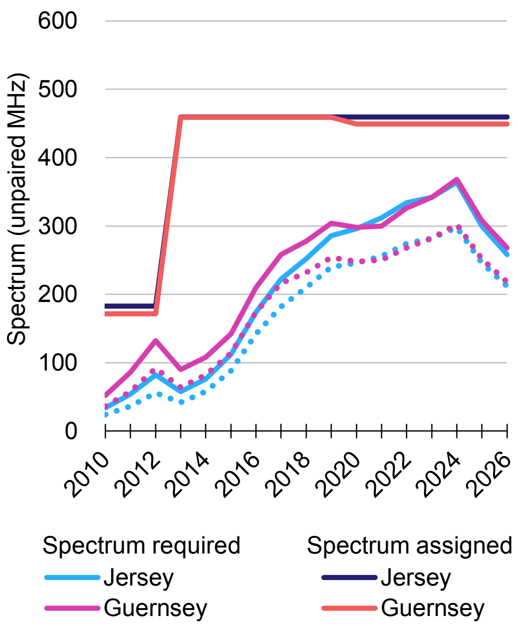
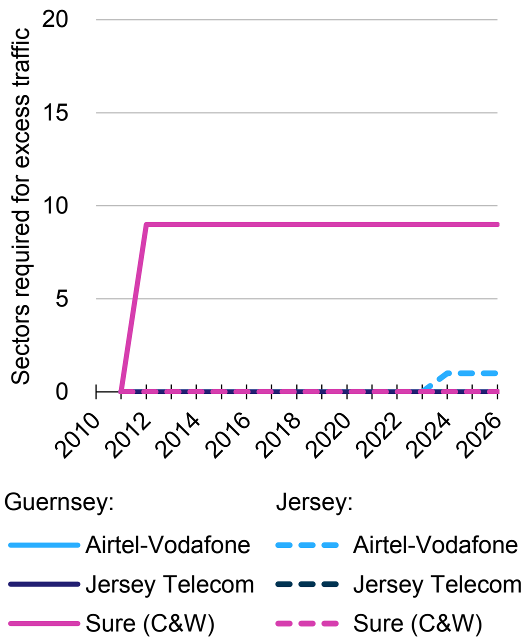


Figure 7.35: Additional sectors required to carry excess traffic beyond assigned spectrum under Sensitivity 2b [Source: Analysys Mason, 2013]



As this demonstrates, the influence of the specific offloading case can be significant; however, the two results here show the difference between two extremes, with the Analysys Mason Research forecast extending to 66% offloading over the long term compared to the 0% offloading in Scenario 2b. We note that, while our flat 30% base case offloading is slightly higher than the current Channel Islands' operator views, it is still slightly below Cisco's offloading forecast case (trending from 33% in 2012 to 46% offloading in the long term). Also our modelling shows that if the 0% offloading level was currently seen in the Channel Islands, Sure would already have become spectrum constrained from 2011 onwards.

7.2.3 Sensitivity 3: Impact of different data traffic forecasts

In order to test the influence of different data traffic forecast assumptions, we have shown the spectrum requirements under both the Cisco Western Europe (Sensitivity 3a) and Analysys Mason Research UK (Sensitivity 3b) data forecasts, as compared to the model base case, which uses an average forecast.

The results of the modelling for the higher traffic forecast from Cisco Western Europe, Scenario 3a, are shown below.

Figure 7.36: The total market spectrum requirements under Sensitivity 3a using Cisco traffic forecast (Dotted lines represent the base case spectrum requirement) [Source: Analysys Mason, 2013]

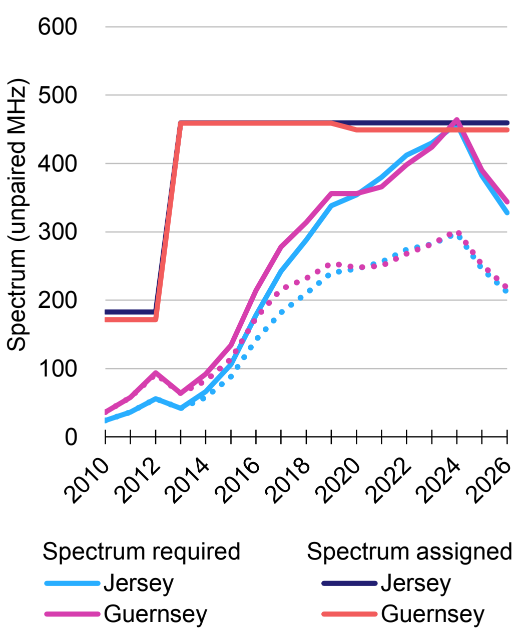
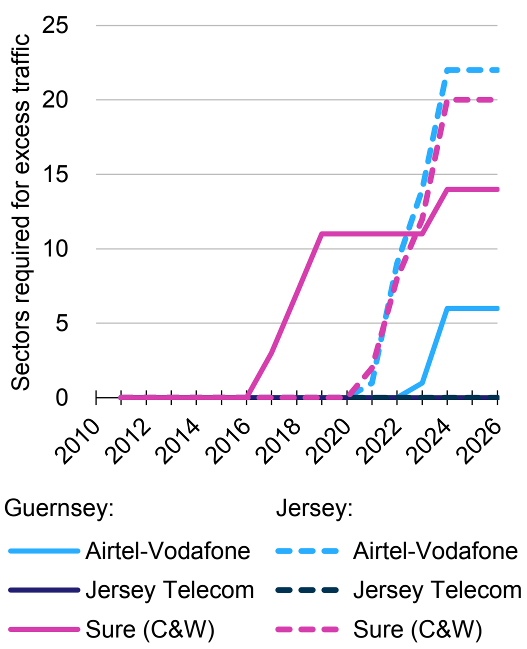


Figure 7.37: Additional sectors required to carry excess traffic beyond assigned spectrum under Sensitivity 3a [Source: Analysys Mason, 2013]



The results of the modelling for the lower traffic forecast from Analysys Mason Research UK, Scenario 3b, are shown below.

Figure 7.38: The total market spectrum requirements under Sensitivity 3b using Analysys Mason Research UK traffic forecast (Dotted lines represent the base spectrum requirement) [Source: Analysys Mason, 2013]

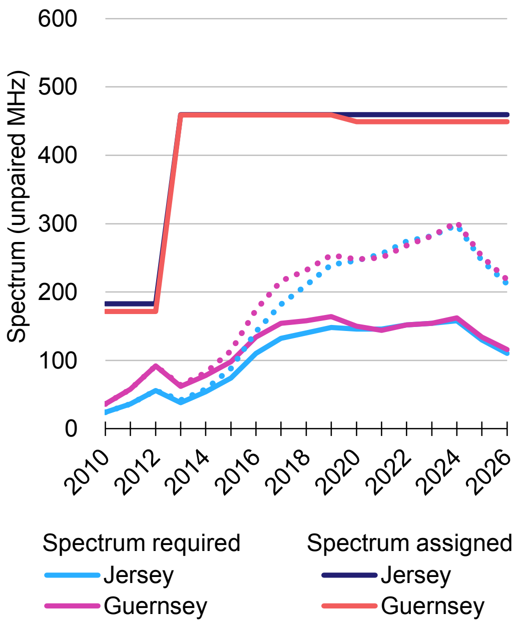
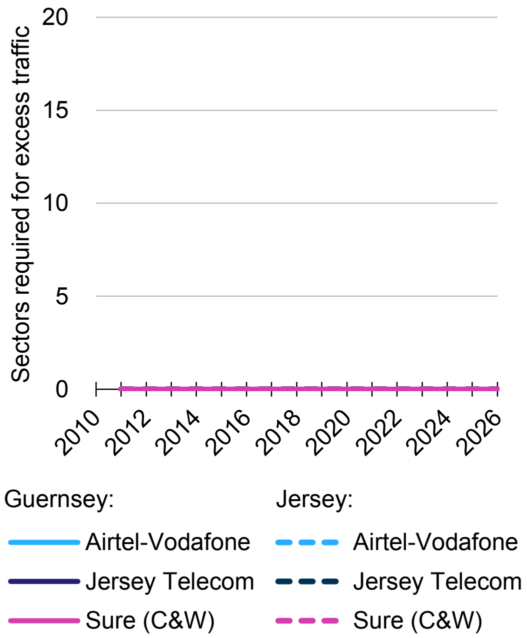


Figure 7.39: Additional sectors required to carry excess traffic beyond assigned spectrum under Sensitivity 3a [Source: Analysys Mason, 2013]



As this demonstrates, the influence of the traffic forecast used in the model can have a significant effect. We note that Cisco's forecasts are widely considered in the industry to be at the top end of potential growth, whereas the Analysys Mason Research forecasts tend to be more conservative.

Given the high levels of uncertainty in the future of traffic growth, especially in the long term, and the sometimes long timescales required to release new spectrum, it is prudent to plan using an average which includes the more aggressive Cisco forecast. We note that this also brings our traffic predictions close to other groups such as the UMTS Forum, whose forecasts of future traffic growth sit between the two levels shown here.[77]

7.2.4 Sensitivity 4: Impact of different long-term operator market share assumptions

In order to test the influence of our assumed levelling-out of market share (as shown in Annex D), we have shown the spectrum requirements under an assumption of the market shares remaining the same over time as the levels forecast by operators for 2017.

[77] 'UMTS Forum Report 44: Mobile traffic forecasts 2010-2020', IDATE on behalf of the UMTS Forum, January 2011.

Figure 7.40: The total market spectrum requirements under Sensitivity 4 assuming flat long-term market shares (Dotted lines represent the base case spectrum requirement) [Source: Analysys Mason, 2013]

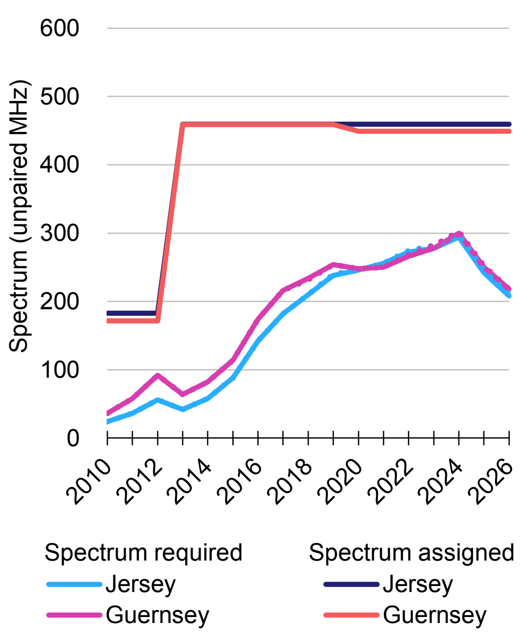
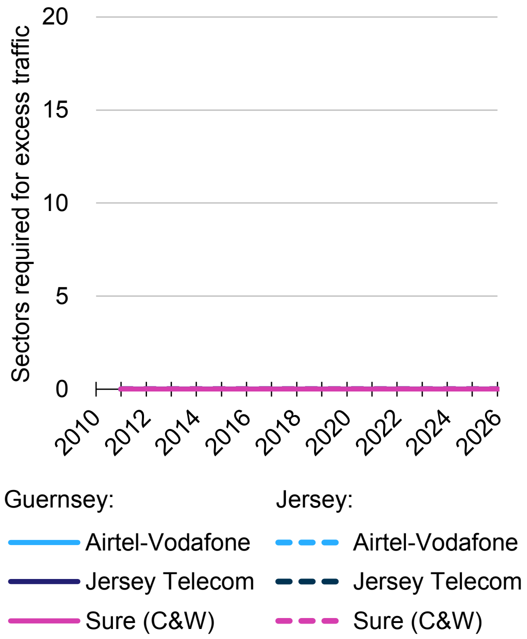


Figure 7.41: Additional sectors required to carry excess traffic beyond assigned spectrum under Sensitivity 4 [Source: Analysys Mason, 2013]



While total spectrum demand has not changed significantly, as there is still an equal level of traffic being carried across all the networks on each Bailiwick, the balance of traffic handled by each operator changes, as shown in Annex F.4. As can be seen, following the release of new spectrum and the redistribution of 1800MHz, no operator becomes spectrum constrained even if the operator market shares continue to show large disparities.

We note, however, that in the case of no redistribution of the existing 1800MHz holdings that Sure does actually become spectrum constrained. This further demonstrates the case for redistribution of 1800MHz spectrum, especially if Sure's market share should persist at such a high level as currently seen in Guernsey. We note though that deciding to give Sure even further spectrum beyond the allocations in Scenario 2 (and therefore likely having to limit the spectrum given to other operators) could be self-fulfilling in terms of fixing current market shares and thus limiting the benefits of competition.

7.2.5 Sensitivity 5: Impact of different site growth assumptions between the Channel Islands

In order to test the influence of our assumption of divergence in future site growth between Guernsey and Jersey, we have shown the spectrum requirements under the assumption of identical site growth across both islands modelled in the Scenario 2 base case site growth (Sensitivity 5a) and the Scenario 5 low case site growth (Sensitivity 5b).

Figure 7.42: The total spectrum requirements under Sensitivity 5a assuming equal base case site growth for both Bailiwicks (Dotted lines represent the Scenario 2 spectrum requirement) [Source: Analysys Mason, 2013]

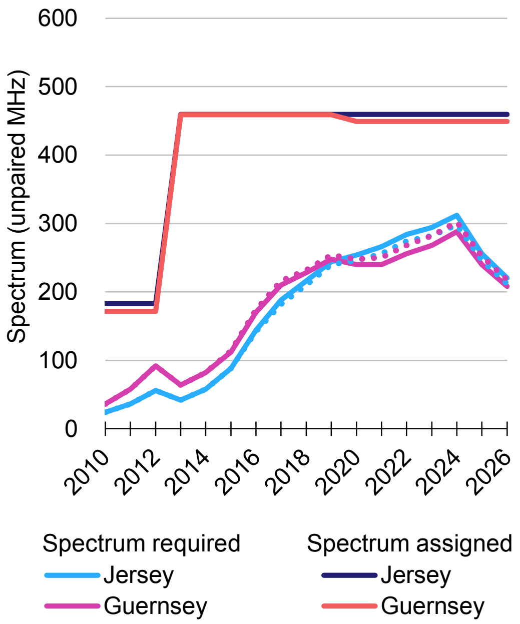


Figure 7.43: Additional sectors required to carry excess traffic beyond assigned spectrum under Sensitivity 5a [Source: Analysys Mason, 2013]

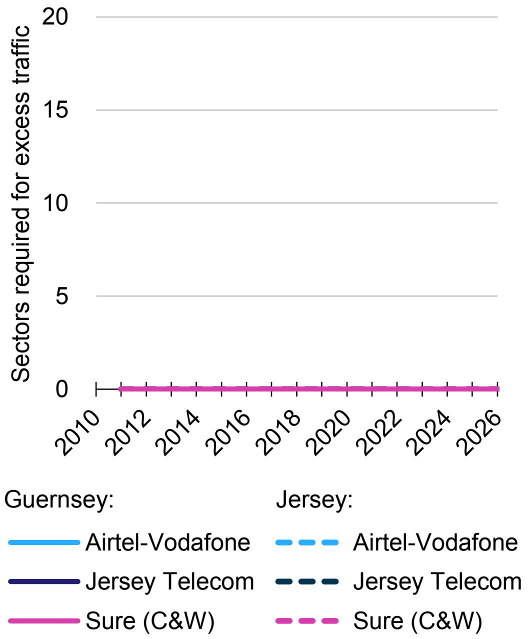


Figure 7.44: The total spectrum requirements under Sensitivity 5b assuming low site growth for both Bailiwicks (Dotted lines represent the Scenario 5 demand) [Source: Analysys Mason, 2013]

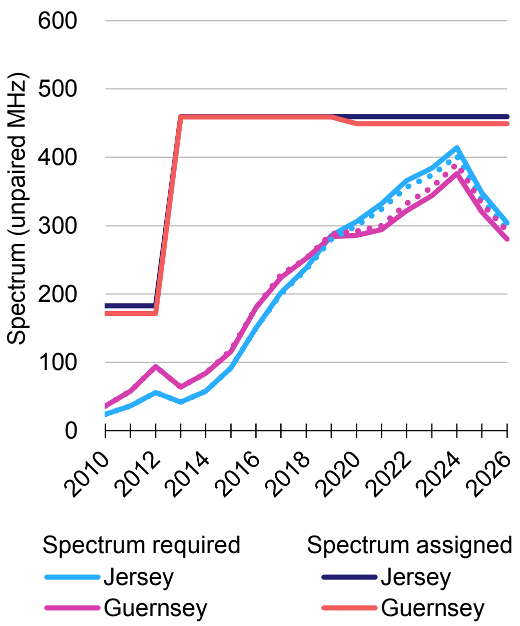
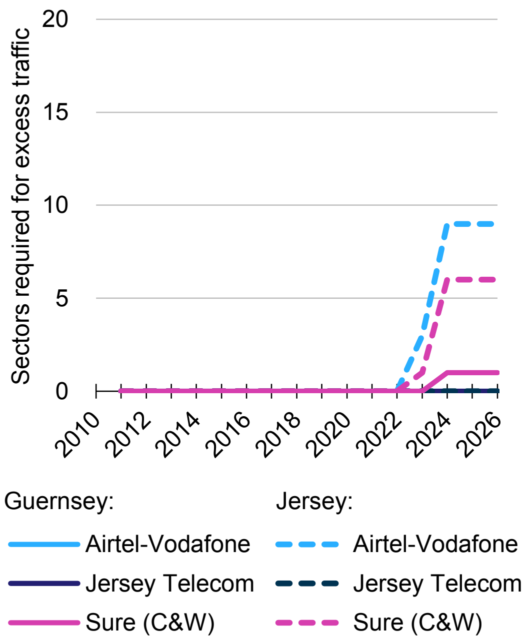


Figure 7.45: Additional sectors required to carry excess traffic beyond assigned spectrum under Sensitivity 5b [Source: Analysys Mason, 2013]



The results demonstrate that averaging site growth across both islands reduces the spectrum demand required in Guernsey but increases it in Jersey, as would be expected. Given Guernsey is more spectrum constrained, this tends to have the overall result of lowering the number of additional sectors required and pushing back the point in time at which the constraint occurs.

In order to demonstrate the extreme case, we have also modelled spectrum demand assuming no site growth (Sensitivity 5c) across both islands.

Figure 7.46: The total market spectrum requirements under Sensitivity 5c assuming no site growth in both Bailiwicks (Dotted lines represent the Scenario 2 base case) [Source: Analysys Mason, 2013]

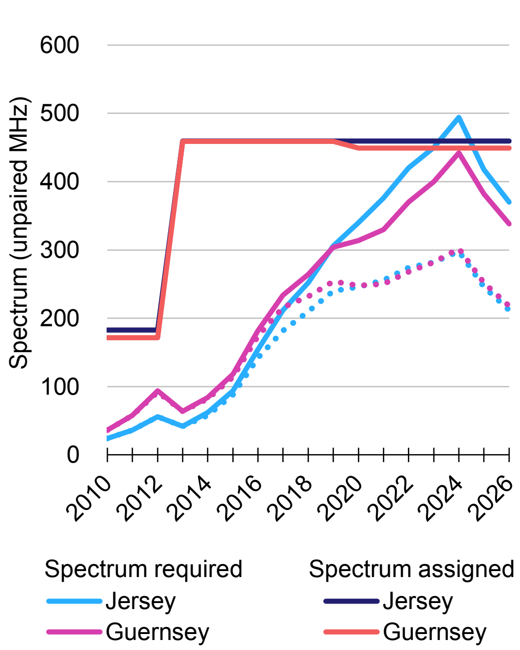
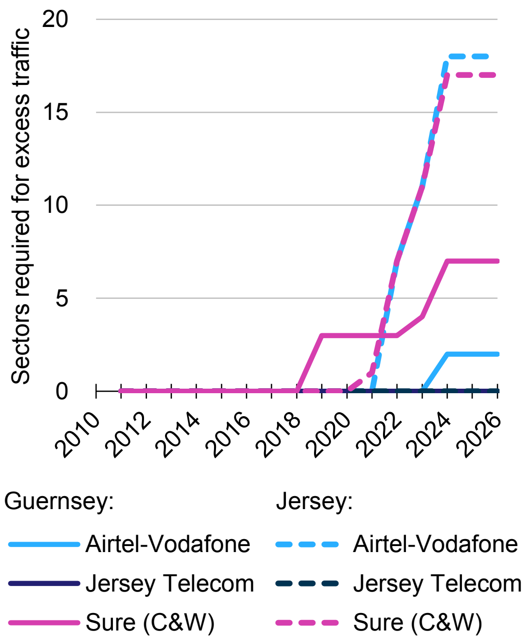


Figure 7.47: Additional sectors required to carry excess traffic beyond assigned spectrum under Sensitivity 5c [Source: Analysys Mason, 2013]



As can be seen from Figure 7.47, the assumption of no site growth dramatically increases the level of spectrum demand. Assuming that the limits on site growth would also limit the deployment of any additional sectors to carry the excess traffic, operators would be forced to consider methods to limit the traffic on their network, or acquire additional spectrum, for example 2.3GHz or 3.4GHz, within this timeframe.

The results also demonstrate that limiting site growth has a more immediate effect on Guernsey. This is due to the Bailiwick already having a low number of sites per population, and as shown by the modelling, becoming spectrum constrained quicker than Jersey. This shows that site growth on each island is an important consideration in the future development of the mobile market, as detailed below.

7.3 Conclusions

Overall our modelling shows that spectrum requirements do not exceed the available spectrum under our base case assumptions, as long as significant amounts of spectrum are made available in the next few years. However, the margin between the available and the required level of spectrum is sufficiently small that higher traffic demand, lower offloading, or lower site growth than assumed can lead the spectrum required to exceed the spectrum available.

Our modelling demonstrates that the full 800MHz, 1800MHz and 2.6GHz bands need to be swiftly made available in the next few years to meet the rapid increase in traffic in the short term. Following this release of spectrum, further large spectrum changes may not be necessary, though smaller improvements in allocation efficiency, such as realignment of the 1800MHz band, should be strived for.

Relative spectrum holding

The modelling shows that overall Jersey Telecom has sufficient spectrum to account for its traffic under even the highest traffic sensitivities, due in part to the larger site to traffic ratio seen on Jersey. Conversely, Sure frequently becomes spectrum constrained in Guernsey due to the limited number of sites and its significant share in the market traffic. Airtel tends to become equally constrained across both islands at a slightly higher traffic level than was needed for Sure, but needing similar levels of new sites due to the constraints it faces on both islands.

Redistribution of spectrum

The modelling showed that redistributing the 1800MHz spectrum, including the new award as in Scenario 2, increased the overall spectrum efficiency both by removing the issue with non-contiguous spectrum, which exists for both Airtel and Sure, as well as increasing the spectrum available for both operators, which as mentioned above tend to become spectrum constrained in our base case modelling. We note that a redistribution of the 1800MHz band, along with the award of the remaining 1800MHz spectrum, would still result in a net gain of spectrum by each operator, even under the case of a new entrant.

While we believe the market would also benefit from redistribution of the 900MHz band, as detailed in Section 9.1, this is likely to be difficult to implement in practice until after GSM is switched off. We note that in the case of a new operator entering the market, this inequality could be partially resolved by including a sub-1GHz spectrum cap, which would have the additional effect of allowing easy allocation of the 800MHz between the 2 non-incumbents and the new entrant on each island.

Site growth

One of the key factors which will influence the overall spectrum demand and which is controllable by the Bailiwick governments, is the allowed growth in the number of sites between now and 2026. As shown both in Scenario 5 and Sensitivity 5, the site growth has an especially significant effect in Guernsey, which already has a relatively high level of subscribers per site (780 subs/site) compared to Jersey (630 subs/site). In our base case we assume a lower level of site growth in Guernsey than Jersey, due in part to the more restrictive planning conditions. This leads the subscribers-per-site ratio to further diverge for the two Bailiwicks, as shown in Figure 7.48.

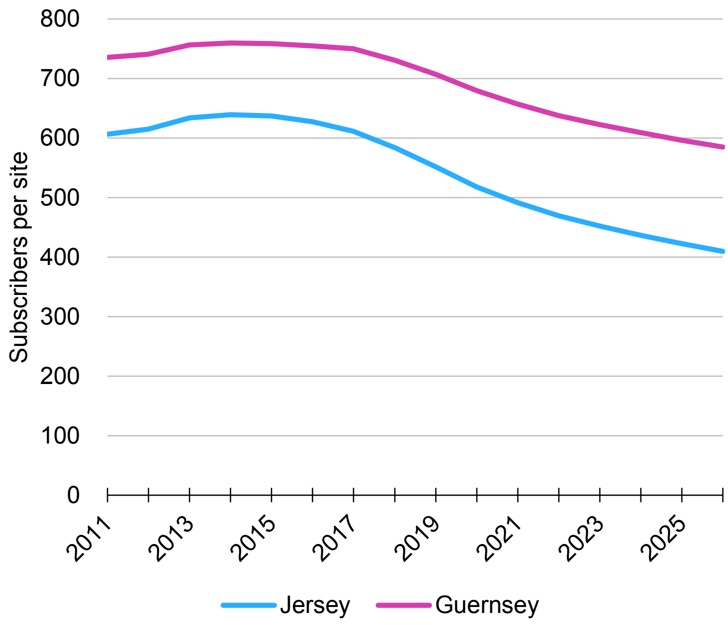


Figure 7.48: Comparison of the number of subscribers per site for both Bailiwicks [Source: Analysys Mason, 2013]

This highlights the importance of ensuring both Bailiwicks, and in particularly Guernsey, accept that future site growth will be needed. Therefore a streamlined planning process that allows flexibly of site growth, while remaining mindful of the environmental impact of new sites, would be highly advantageous for the Channel Islands' mobile market.

One possible solution to this issue that CICRA could consider, is to move to having one or more neutral network asset owners across the Channel Islands. This approach has been adopted on a voluntary basis in many countries worldwide, often for reasons of financing and management specialisation.[78] However, forcing operators to sell sites to a neutral body may seem overly intrusive given other possible solutions; and there is a risk of material competition concerns, with the site-sharing body potentially acting as a mechanism for a cartel, unless it is carefully set up.

New entrant

Our modelling has shown that the spectrum is sufficient to support a new entrant, although this does increase the risk of spectrum shortages for both Sure and Airtel. One key area of focus, if there was a new entrant, would be to ensure that potential site growth for the other operators was not limited, as discussed above. One method of achieving this could be to ensure an additional portion of new virgin sites is allowed for the new entrant on each Bailiwick. This would help to increase the possible site-sharing options for the other operators, at the same time as reducing the entry risk for the new operator.

78 Tower companies are asset-based companies with stable revenue streams, which can be largely debt funded

8 Benefits of LTE deployment in the Channel Islands

One of the issues raised by the Government of Guernsey when commissioning this study was the potential economic benefits of LTE deployment in the Channel Islands and the scope for 4G network deployment to improve the availability of Internet connectivity and broadband services to homes and businesses.

A considerable amount of literature has been written on the potential benefits accrued through the deployment of next-generation mobile/LTE networks.[79] Likewise, there have been extensive studies undertaken into the benefits of Internet and next-generation broadband access to homes and businesses, both via fibre networks and via wireless broadband.[80] It is noted that LTE technology can be used to provide both broadband connection wirelessly to mobile devices on the move, as well as to receivers at fixed locations ('fixed wireless access').

In the following section, we consider some of the likely benefits from LTE roll-out for the Channel Islands, focusing on the benefits gained by consumers and by each island, both in terms of mobile broadband services delivered while on the move, and wireless broadband services within the home.

8.1 Potential benefits

Economic benefits arising from the availability of communications services are typically described in terms of consumer benefits and value to the wider economy (e.g. island-wide advantages).

Examples of each of these benefits as they apply to 4G deployment in the Channel Islands are summarised below.

Consumer benefits

The likely consumer benefits resulting from better availability of mobile broadband services would include:

- An improved user experience. LTE generally offers consumers faster data speeds and reduced network congestion, which would be particularly beneficial in the Channel Islands around the main urban areas (St Peter Port, St Sampson, St Clement, St Helier and St Saviour) and the airports, significantly improving the user experience for data-heavy content and applications.

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79 For example: 'The benefits of using LTE in digital dividend spectrum', 4G Americas, 2011; 'Getting the most out of the Digital Dividend', Spectrum Value Partners, 2008; 'Mobile Broadband and the UK Economy', Capital Economics, 2012; 'Estimating the cost to UK businesses of slow mobile broadband' Open Digital Policy Organisation, 2011.

80 For example, see http://www.gfirstbroadband.co.uk/Portals/11/Broadband%20Files/Useful%20Documents/EconomicImpactofNGABroadbandinHerefordshireGlos.pdf and http://www.irg.eu/streaming/ERG_(09)_17_Report_on_NGA_Economic_Analysis_and_Regulatory_Principles.pdf?contentId=546059&field=ATTACHED_FILE.

- The addition of voice-over-LTE (VoLTE), which network operators may plan in conjunction with rolling out 4G data services, will allow for innovative new services such as 'HD-voice', offering users higher-quality, in addition to increasing the quality and usability of mobile videoconferencing services.

- The availability, through LTE, of a wider range of data services and the potential to integrate these with services delivered via other platforms. For example, the mobile operator 'EE' in the UK is offering a movie service targeting consumers with 4G mobile and fibre connectivity, such that film downloads can be integrated and viewed on multiple platforms.

- Another choice for consumers to consider when looking at data usage within their home. LTE offers high-speed connectivity in the home, with the additional benefit of being truly mobile, by giving WiFi level connectivity without being limited to specific hotspots. In Guernsey, where fixed broadband is currently only offered at download speeds of 16Mbit/s and 40Mbit/s (see Annex B), the introduction of LTE could significantly increase the options available to consumers.

- A potential reduction in prices – as discussed in Annex B, consumers in the Channel Islands face relatively high fixed broadband prices. The additional competition in the market brought by LTE could be particularly beneficial, potentially driving a fall in broadband prices for low usage customers in particular. Additionally, the level of substitutability between fixed broadband offers and LTE may result in service consolidation by some consumers, increasing cost efficiency.

In more general terms, consumer benefits for next-generation access (NGA) broadband services including those delivered via wireless connection are likely to include:

- Improved productivity/time savings for businesses and home workers (for example, being able to access faster services to enable tasks to be completed more quickly).

- Increased equality between different areas of each island in terms of access to services via the Internet.

- Reduced transport congestion through flexible/home working.

- Better availability and delivery of virtual learning and other e-Government services, including e-Health.

- Improved access to applications and content. NGA broadband services, including LTE, allow users to access new content, which can include communications services such as VoIP and video calling, as well as more functional content including e-commerce and booking services.

Island benefits

Benefits of mobile broadband network roll-out for each island can be summarised as follows:

- Infrastructure investment. Assignment of 4G spectrum to existing mobile operators (and potential new operators) will result in a large capital investment across the two islands, potentially leading towards island-wide LTE networks over the next few years, if operators move ahead with immediate network deployments. This investment will be good for jobs in the short term, and should increase the efficiency of the mobile sector in the long term. The roll-outs may additionally provide wider availability of high-speed data connectivity in areas where the 4G network is available, depending on the operators' roll-out strategies.
  - This helps to demonstrate that the Channel Islands' commitment to infrastructure, including increasing mobile services, will help to improve the work environment for other key businesses sectors such as banking, manufacturing, and tourism.
  - The infrastructure will position residents and businesses on the island to benefit from mobile broadband services as an alternative to fixed broadband (depending on operators' coverage strategies for LTE), providing greater competition, choice and availability of services.
- In the long term, migration of existing users to LTE will enable the switch-off of either the older, less efficient 2G networks on the islands, or the higher-frequency 3G networks, with associated opportunities for cost savings.
  - In addition, investment in LTE is likely to encourage operators to upgrade networks to single-RAN solutions,[81] which, once fully implemented, are more energy-efficient than multi-network solutions.
- The Channel Islands will become more open to innovation and will gain access to new wireless services, including potential e-Government and e-Health services, as well as positioning the Islands at the forefront of next-generation mobile development.
- Increased efficiency. Mobile broadband brings with it an element of immediacy for its users, and its ability to provide flexibility on where to process data can result in efficiency gains, saving time for other tasks, which may boost the economy. Additionally, mobile access to information can have a direct economic benefit, for example in the case of an investor who can receive news via a mobile device and react to it immediately.

81 Single-RAN solutions allow operators to support multiple mobile standards and services on a single network.

— Recent (conservative) estimates place the increase in GDP from LTE deployment to be approximately 0.5%,[82] which for the Channel Islands would be an increase in Jersey of approximately GBP175 per capita per annum and in Guernsey of approximately GBP150 per capita per annum.

In terms of broadband connectivity within the home and to businesses, island-wide benefits include:

- Positive GDP uplift and jobs creation, similar to LTE.
- Improved competitiveness of businesses located on the island, and increased innovation. This can be particularly beneficial for SMEs and start-ups, which are able to use NGA technologies to reduce their costs and improve their business processes.
- Capital investment in infrastructure.
- Cross-technology competition.
- Reducing broadband prices and making services more accessible.
- Access to e-Government services, including, for example, e-Voting and e-Health services.
- Benefits to public-sector workers, such as those in the emergency services, through better connectivity.
- Environmental benefits in the form of emissions reductions. While ICT is in itself a relatively green technology, it can also enable other industries to reduce their carbon emissions by using M2M technology to power ‘smart solutions’, such as smart meters and logistics solutions.

[82] ‘Mobile Broadband and the UK Economy’, Capital Economics, 2012.

9 Assessment of alternative approaches to 4G spectrum release

As part of this study, we have been asked to recommend the right method for assignment of 4G spectrum in the Channel Islands. In this section, we compare various 4G assignment processes taken in selected EU countries, as well as the approaches that those countries have taken to liberalise the use of 2G frequencies (900MHz and 1800MHz) for LTE.

The following countries have been considered, representing a selection of different approaches to 4G assignment across the EU:

- UK
- France
- Ireland
- Sweden
- Denmark
- Netherlands
- Italy
- Belgium.

A summary of the approaches taken by individual countries is provided in Annex G.

A comparison of approaches and implications for the Channel Islands is summarised below.

9.1 Comparison of approaches

Analysis of how different EU countries have approached 4G licensing in Annex G indicates a variety of approaches are being taken to assign new 4G spectrum (mainly in the 800MHz and 2.6GHz bands), as well as reassigning 900MHz and 1800MHz spectrum from 2G to 3G/4G use. It is noted that in a number of cases, the regulator's approach has included redistributing existing 900MHz and/or 1800MHz spectrum among existing operators. In a few countries, for example, Ireland, the regulator has opted to re-award all available mobile bands in a combined award process upon expiry of 2G licences. The practice of a number of other European regulators choosing to realign 2G spectrum assignments ahead of liberalising 900MHz spectrum for 4G use is relevant to the decisions that the Governments of Guernsey and Jersey, along with CICRA, need to take in relation to possible reorganisation of 900MHz and 1800MHz spectrum in Guernsey and Jersey.

Ofcom has indicated to us, as part of this study, that for both the 900MHz and 1800MHz bands, a re-alignment of spectrum holdings to align operators' spectrum packages between Guernsey and Jersey could result in more efficient distribution of spectrum and could allow for increased spectrum usability. However, the need to divide the channels fairly, allowing for preferential and non-preferential channels for GSM frequency coordination with France, may limit the overall potential for this in the short term, particularly at 900MHz. We note though that preferential and non-preferential channels are not expected to be used for coordination of UMTS or LTE use of

900MHz and 1800MHz bands, and so this is a short-term restriction only. Frequency coordination is further considered in Section 11.3.

Our analysis suggests that, in most cases, new spectrum bands for 4G (that is, 800MHz and 2.6GHz) have been awarded through an auction process. This reflects that in most European countries, the regulator has determined that likely 4G spectrum demand may exceed the amount of spectrum available, and hence an auction process is the most transparent way to assign spectrum. As noted in this report, this is not necessarily the case in the Channel Islands however, and our modelling suggests sufficient spectrum exists to meet demand in most of our scenarios (including those involving a new entrant to the market).

In terms of liberalising 900MHz and 1800MHz spectrum for 4G use, a summary of the different approaches taken in Europe is provided below.

Figure 9.1: Summary of different approaches to reassigning 2G spectrum, and awarding 4G spectrum [Source: Analysys Mason, 2012]

Country	Summary
UK	900MHz and 1800MHz spectrum licences held by existing 2G operators have been liberalised for 3G/4G use. The 3G-only operator, Three, has acquired 2×15MHz of 1800MHz spectrum as a result of an existing operator (EE) relinquishing some of its spectrum. 4G spectrum will be awarded in the 800MHz and 2.6GHz bands by auction in 2013. Existing 900MHz licences have population coverage targets associated with them for 2G services, and 2.1GHz licences obtained coverage obligations for 3G. One 800MHz licence will include a coverage obligation for 4G.
France	In France, the approach to liberalising 900MHz spectrum was linked to the Government's objective to introduce a new entrant to the mobile market. Existing 900MHz licences were liberalised but existing operators had to reorganise spectrum in order to release a 2×5MHz block, which was subsequently assigned to the new 3G market entrant, Free. 1800MHz assignments were not affected. The 900MHz re-organisation was designed to release a contiguous 2×5MHz block for the new entrant, suitable for either 3G or 4G deployment. 4G licences in the 800MHz and 2.6GHz bands were subsequently offered by auction with all players, including the new 3G entrant, participating in this process.
Ireland	In Ireland, 2G licences were originally awarded to operators at different times and so had different licence expiry dates. Following a series of industry consultations, ComReg opted to re-award all 2G spectrum, along with the 800MHz band for 4G, in a combined auction, which was completed in November 2012. This enabled the 3G-only operator, Hi3G, to gain spectrum in the 900MHz and 1800MHz bands, whereas it previously only held spectrum in the 2.1GHz band. The other three operators all gained new spectrum in the 800MHz band as well as retaining some spectrum in 900MHz and 1800MHz for continuation of their 2G services, and subsequently refarming to 4G.
Sweden	The 900MHz band was re-licensed by direct award to existing players, with 2×5MHz spectrum being assigned to the 3G-only operator, H3G. Licences were issued by direct award to each operator, due to pre-agreement between the five operators. 1800MHz assignments were also redistributed through a combination of direct award plus auction of 4x10MHz blocks. Auctions were held to award 4G licences in the 800MHz and 2.6GHz bands. One 800MHz licence includes a coverage obligation to provide 4G services to areas of low population density.

Country	Summary
Denmark	Before auctioning 4G spectrum in the 800MHz and 2.6GHz bands, the Danish regulator negotiated a redistribution of 900MHz and 1800MHz spectrum with existing mobile operators. As a result, existing operators had their 900MHz licence durations extended and the terms of the licences liberalised. As part of the process, the 900MHz band was reorganised so that all operators would have contiguous spectrum. A 2×5MHz block of 900MHz spectrum was also released and auctioned, which was acquired by the 3G-only operator, Hi3G. The existing operators also released 2×10MHz of 1800MHz spectrum, which was also awarded to Hi3G. Separate auctions were held to award 800MHz and 2.6GHz licences respectively. All licences were won by the existing operators (including Hi3G).
Netherlands	The Dutch regulator followed a similar approach to the Irish regulator and rather than reassigning 2G licences administratively, decided to auction 900MHz and 1800MHz assignments for 4G use, along with spectrum in the 800MHz and 2.6GHz bands. The combined auction was completed recently (although an earlier auction had previously awarded some 2.6GHz spectrum). As part of the auction, the regulator re-planned 900MHz and 1800MHz spectrum into contiguous blocks suitable for 3G/4G use. Existing operators KPN, Vodafone and T-Mobile all acquired new 900MHz and 1800MHz licences. In addition, a fourth operator, Tele2, won spectrum in the 800MHz band, along with KPN and Vodafone.
Italy	The Italian regulator reassigned 900MHz spectrum amongst existing players before awarding new 4G spectrum in the 800MHz and 2.6GHz bands. As part of the 900MHz spectrum reassignment, the band was reorganised so that each operator obtained contiguous assignments. A 2×5MHz block was released for award to a fourth operator and subsequently assigned to Hi3G, which previously only held 2.1GHz spectrum in Italy. 4G licences to operate in the 800MHz and 2.6GHz band were subsequently auctioned along with some previously unassigned 1800MHz spectrum. The remaining 1800MHz spectrum (originally assigned for 2G) is still held by existing 2G operators, although those licences are due to expire in 2015.
Belgium	The regulator in Belgium has liberalised 900MHz and 1800MHz spectrum in a number of stages. Initially, existing operators have been allowed to use existing assignments for 3G and 4G services. However, licences will expire in 2015. The regulator has indicated that when this happens, the 900MHz and 1800MHz bands will be reorganised with a view to spectrum being released for the 3G-only operator, Telenet. Meanwhile, the regulator has auctioned 2.6GHz licences for 4G use, with spectrum being won by the three 2G operators plus BUCD, a new entrant to the mobile market. Preparations are underway to auction 800MHz licences.

10 Approaches to setting licence fees for mobile spectrum

The choice of award mechanism for mobile spectrum (for example, beauty contest or auction) influences the way that spectrum fees are charged, as does the relevant telecommunications and radio frequency legislation in place in different countries.

As noted in the previous section, many European regulators have chosen to award new 4G spectrum by auction. Auctioned licences are typically valid for 15-20 years, and operators pay either an upfront fee for the duration of the licence, as determined by the auction, or sometimes an upfront fee followed by annual or other periodic payments during the licence period.

If spectrum is not auctioned, a method of setting annual fees is required. Nowadays the trend in Europe is to set spectrum fees based upon the market value of the spectrum or its 'opportunity cost'. Traditionally, fees were set based on recovering the regulator's cost to administer the licence.

While there are many arguments and approaches for the imposition of charges on users of spectrum, the aim behind spectrum charges that are applied can broadly be split into two categories:

- use of fees to cover the costs of licensing and regulating a particular sector of the telecommunications market relevant to the spectrum being used by that sector
- use of fees to incentivise spectrum users to maximise their efficiency, often based on the value assigned by operators (or alternative users who are being precluded from using the spectrum).

It is important in the first instance for the States of Jersey and Guernsey, in conjunction with CICRA, to decide (as policy) which of these outcomes they believe is most suitable for the Islands and, as such, which outcome they hope to achieve in the setting of licences fees. While a well-designed fee system will achieve both of these objectives to some extent, an understanding of the overall aim will help decide the level of fee to be charged.

While fees can be charged based on a one-time upfront payment at the start of a licence period, it can also be beneficial to have annual or recurrent payments payable by licensees throughout the entire licence period. A discussion of different approaches to setting fees, for the case where spectrum has not been auctioned to determine its price, is provided below.

10.1 Discussion of approaches to spectrum fees

As noted above, spectrum fees can be imposed either as a lump-sum or on a recurrent basis. Many regulators use both methods of fee imposition. However, the weighting between the two approaches can have some impact: high upfront fees might work against parties who are not well funded or who have difficulty in forecasting future revenue flows. This may become especially important in smaller markets into which new entrants are looking to enter, such as the Channel Islands, given the additional uncertainty provided by these two factors.

Annual charges can be calculated in various ways, including fees calculated on the basis of an operator's annual profit, revenue from wireless services, or on a per-use basis (for example, based on the amount of spectrum used, or the geographical area covered). Calculating fees which scale with economic activity is seen in some jurisdictions as advantageous in that it relates the use of the spectrum to its cost, therefore minimising the risk/cost to new entrants while maximising revenue from more established players.

One-off fixed fees are most frequently determined using a market-based approach, such as by assigning spectrum via an auction, or setting an upfront fee based upon benchmarks of the price paid for similar spectrum in other countries through an auction or other market-based award process. It is noted that licence fees may also need to be used to recover the cost of reimbursing the previous users of the spectrum for any spectrum clearance that is necessary to enable new services to use a particular band. This is sometimes the case with the 800MHz band for example, which was previously used for television broadcasting in Europe before being reallocated for mobile use.

Fees implemented on a recurrent basis can be designed to cover the long-term costs to the regulator of licensing and administering the spectrum ('cost recovery'), or alternatively can be based on the value or opportunity cost of spectrum (for example, administered incentive pricing (AIP), which Ofcom applies to 2G spectrum in the UK) or other metrics. In the case of fees being charged above the regulatory cost of the spectrum, any additional value is returned to the countries' respective treasuries for the wider benefit of the taxpayer.

Recurrent fee methodologies used by regulators, i.e. administratively set fees, can broadly be grouped into the following categories:

- revenue-based fees or royalties
- fixed annual recurring fees
- administrative incentive pricing (AIP)
- fees based on population and audience size
- profit-based fees.

10.1.1 Revenue-based fees or royalties

A possible way to charge recurrent administratively set fees is based on charging a proportion of the licence holder's gross revenue or turnover as an annual fee. European countries in which administrative fees are charged on the basis of revenue include:

- Austria
- Greece
- Ireland
- Luxembourg
- Spain
- Sweden.

Additionally, Italy sets its spectrum management fees based on the annual operator revenue.

These fees would normally be charged on an annual basis throughout the duration of the licence. A possible benefit of using a revenue-based fee is that it reduces risk by ensuring costs scale for network operators over long licence terms. However, fees based only on revenue tend not to be linked to the bandwidth of spectrum that the operator is using, and so do not incentivise operators to use spectrum efficiently. Some measure of fees based upon spectrum utilisation (e.g. bandwidth used) is therefore appropriate alongside a revenue-based fee (that is, licensees using more spectrum are charged more for their use).

One of the key challenges with this approach would be for the Channel Islands to determine the appropriate proportion of revenue to charge. This would likely require a specific analysis of the relevant revenue streams of each operator and then a comparison of either the regulatory costs that need to be recovered, or the value/opportunity cost of the spectrum to the operators, depending on the selected rationale.

10.1.2 Fixed annually recurring fees

A flat-rate charge across all operators, levied on an annual basis, is often cited as the simplest way to implement an administrative fee. In such a case, an overall fee level is decided, either on a year-by-year basis or as a fixed amount over the licence duration, and divided by the number of operators in the market. This fee level can be derived from benchmarks of prices paid for similar spectrum in other countries (a value based fee, if the other countries have used market mechanisms) or simply calculated at a level of regulatory cost recovery (a cost based fee), depending on whether there is scarcity.[83] However, while the costs for some regulatory activities can be seen as originating equally across all operators, this is not always the case and imposing the same fee burden on small operators as on larger incumbents can be viewed as being disproportionate.

Fixed fees applied to all operators in a given market sector also fail to take account of the amount of spectrum each operator is using and so do not offer an incentive to use spectrum efficiently, unless linked to the bandwidth used in some way, as noted above. Further variations may also be required depending on the precise spectrum used by each operator – for example, if technical restrictions apply in a certain part of a frequency band assigned to one operator, implying that the spectrum is less useful than spectrum in other parts of the band assigned to other operators.

10.1.3 Administrative incentive pricing (AIP)

One way to ensure that recurrent fees incentivise efficient spectrum use is to set fees that reflect the opportunity cost to the spectrum, i.e. the maximum cost to the operator of not using the spectrum, and the value of the spectrum to alternative users whose use of the spectrum the operator

[83] We note that the lack of mobile spectrum demand in our model does not necessarily indicate a lack of spectrum scarcity. Scarcity could exist in the situation where more than one new mobile entrant wants spectrum or where another non-mobile user wants access to the mobile spectrum (i.e. DTT wanted to use the 800MHz band).

is precluding. If the fees can accurately represent this opportunity cost then this should theoretically incentivise operators to use only the amount of spectrum for which they have an economic value that exceeds the level of the AIP. As a result, any unused spectrum or spectrum valued below the AIP may be returned to the regulator for reassignment.

AIP is the current method of annual spectrum fee calculation used by Ofcom in the UK. Ofcom has implemented AIP fees across a wide range of spectrum users, including for 2G mobile.[84]

Regulators may calculate a 'baseline' AIP figure (for example, per MHz of spectrum used), which can then be modified using factors such as the coverage area, the interference environment, the addressable population within the coverage area and total bandwidth used. However, the calculation of the optimal level of AIP is complex, especially given the complications of non-aligned spectrum and possible alternative users across the two Bailiwicks.

Given the size of the Channel Islands' markets, we believe the two most appropriate options would therefore be either to undertake a first order estimate of the opportunity cost, or to use Ofcom's newly calculated annual licence fees as detailed below.

We note that when using a first order estimate to set spectrum fees it is important to be conservative, because if the fee level is incorrectly judged and set above the operators' (or alternative users') spectrum value, then efficiency will be harmed through spectrum being left idle. Pricing the spectrum above the existing users' value will incentivise an operator to relinquish the spectrum and instead build additional sites (or use other methods) to cope with any excess traffic. However, if the spectrum is also priced above any alternative users' value, then no new user would move in to use the vacant spectrum, so it will remain idle and the valuable resource will be wasted.

10.1.4 Fees based on population or addressable market

Fees for spectrum can be based on the population potentially served by the licensee or other parameters defining the addressable market for the service, for example the audience reached, in the case of television and/or radio broadcasting. We have found evidence of such an approach being used for the one-off Italian spectrum management fees, where half of the amount to be paid by each operator is allocated on the basis of the amount of spectrum assigned and, where appropriate, the proportion of national population served by the spectrum concerned. The other half is apportioned according to the revenue of the operator. Similarly, Germany bases its fees for WLL spectrum on factors including the population in the coverage area.

However, such methodologies are not typically considered to be suitable for fee charging to mobile operators, since it might act as a disincentive to provide services over a wider population. This method is normally more suited to networks that are obliged to cover a certain proportion of population, as a result of universal or other obligations such as terrestrial television broadcasting and radio.

84 3G licences in the UK were auctioned and so an upfront fee was paid by operators for a 20-year term based upon the auction outcome.

10.1.5 Profit-based fees

Fees based on operator profit can be considered similar to those derived from revenue and enables a link between the value of the licence to the operator and the fee charge to be made. However, due to the potential for volatility of operator profit, it would result in erratic revenues being received by the regulator. Additionally, this method suffers from the difficulty of separating spectrum and non-spectrum-related profit in tightly integrated mobile/fixed operators. While the fee could be based on operators' accounting business units, it would be necessary to ensure that each operator reported these in a consistent method, in line with the government's intentions.

As noted for previous methods, this also does not incentivise spectrum efficiency, unless linked to the bandwidth of spectrum used.

10.1.6 Additional factors used in the calculation of spectrum usage fees

Other factors that might be taken into account when setting licence fees include:

- the frequency band
- the amount of spectrum (channels)
- the number of subscribers
- the amount of equipment owned or operated by the operator (for example, the number of base stations).

10.2 Comparison of approaches

Most new 4G spectrum has been awarded through auctions, with the fees that individual operators pay for 4G spectrum determined by the auction and the relative operator values for the spectrum. As noted previously, auctions are typically used where demand for spectrum exceeds supply, which our modelling suggests may not be the case in the Channel Islands (though it may require a public consultation to fully determine this). Therefore, if an auction process is not used to assign 4G licences, the Governments of Guernsey and Jersey, and CICRA, should use an administrative process to set fee levels. The fees to be paid by operators that are awarded 4G spectrum need to be determined as part of this process.

To guide thinking on the exact approach to use once the cost recovery versus spectrum policy decision has been made, we have investigated the approach to 2G spectrum and administrative fee calculations used in Europe and specifically by European Union (EU) member states (since 2G spectrum has typically been awarded administratively, whereas 3G and 4G has been awarded by auction). A more detailed view of different approaches used in Europe can be found in Annex C

Recurrent fees charged as a proportion of revenue is a particularly prevalent approach used by a number of regulators. The proportion of revenue that is charged can be reduced over the term of the licence, such that the European countries that use this methodology often use proportions of less than 0.2% of annual revenues charged at the end of the period, using the most recently completed financial year's accounting revenue.[85] Alternatively, a base percentage could be determined, which would then be scaled by the amount of spectrum used by the operator, though it should be noted that this could over-penalise operators with larger subscriber bases, as they will both require larger amounts of spectrum and have higher revenues.

Other factors relevant to setting recurrent spectrum fees are:

- the propagation characteristics of the frequency band (e.g. 900MHz spectrum propagates further than 1800MHz, and provides better in-building penetration)
- amount of spectrum (channels)
- number of base stations
- licensing and/or frequency management costs to the regulator i.e. cost recovery.

It is also possible to set recurrent licence fees by benchmarking against the market value of similar spectrum used in other European countries, based on the prices paid in other markets. Some countries use different calculation methodologies in comparison to the more popular methods described above. Of particular note is the Italian spectrum fee methodology, in which a cost is set by the government across all 2G operators; half of this overall cost is split among the operators on the basis of their spectrum holdings, while the other half is divided proportionally based on each operator's income. This Italian spectrum fee is to be paid across a five-year period.

We note that operators sometimes suggest that lower operator cost bases, through lower spectrum fees, will lead to lower prices for subscribers and increased consumer and producer surplus. However, it is generally agreed by economists that traditional spectrum costs (i.e. from auctions) are like any other sunk cost, and therefore would not be transferred through to subscriber costs, assuming effective market competition.[86]In the case of annually variable spectrum fees (such as AIP) though, the cost may not truly be sunk, as the cost can be flexed to some extent by reducing (or, in rare cases, increasing) spectrum holdings – which is not the case for traditional upfront fixed auction revenues. As such, actual behaviour in the case of an administrative fee may fit between these two theories.

Additionally, we note that it is important to be conservative when setting the level of the fees, because if the fee level is incorrectly judged so that the fee is set above the operators (or alternative users) spectrum value, then efficiency will be harmed as valuable spectrum would be left idle. Instead, operators would be incentivised to build additional sites (or use other methods) to cope with traffic.

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85 For example in Ireland, the fees are charged at the end of the financial year of the regulator based on the revenues for the operator for the year that ends within the regulatory year; http://www.irishstatutebook.ie/1998/en/si/0043.html.

86 For example, see http://wireless.fcc.gov/auctions/data/papersAndStudies/SpectrumAuctionsDoNotRaisePrices.pdf.

10.3 Current background of WTA fees in the Channel Islands

Currently in the Channel Islands, the 900MHz, 1800MHz and 2.1GHz bands spectrum fees are based on Ofcom's Wireless Telegraphy Act (WTA).[87] These fees are set at "GBP320 for each 2×200kHz channel or slot. GBP4000 for each 1×5MHz channel or slot. GBP8000 for each 2×5MHz channel or slot" for a 12-month period. For FWA usage, in the 3.5GHz and 3.6GHz bands, there is just one single fixed five-year fee of GBP5000. This fee is paid directly to Ofcom, which returns part of the fee to the Channel Islands. We have not been able to fully clarify with Ofcom how much of the licence fee is actually returned.

The Channel Islands WTA fees are based on the UK 2G licence fees for 900MHz and 1800MHz spectrum used in the UK, adjusted for the populations of the Bailiwicks. The UK 2G licence fees are currently based on administered incentive prices (AIP), calculated theoretically for GSM licences about ten years ago and adjusted to take account of any restrictions on use (e.g. cross border or other interference).

Ofcom plans to change both the 900MHz and 1800MHz old AIP fees for the UK to newly calculated 'annual licence fees' (ALF)[88] at some point within the next year, following the recent UK 4G auction. The intention is to use the UK auctions of the 800MHz and 2.6GHz bands as a benchmark of prices paid by the mobile operators for 4G spectrum, and to calculate the appropriate fee for the 900MHz and 1800MHz bands. AIP/ALF will also need to be determined at some point in the future for the 2.1GHz band, to apply after the initial 20-year licence term expires.

For the 900MHz and 1800MHz bands, adjusting fee levels to reflect the UK's 4G auction outcome is likely to result in the operators paying slightly more for 900MHz and 1800 MHz spectrum (since the current 2G AIP levels are considered to be low, despite the relatively low spectrum prices seen in the 4G auction). This will be confirmed once Ofcom states exactly how it intends to use the 4G results to calculate ALF and, therefore, what effect that will have on the WTA fees.

The implication of this is that the Channel Islands' 900MHz and 1800MHz licence fees will be outdated once Ofcom calculates ALFs for the UK; the Islands' fees are based on the current GSM-based AIP and so will need to be updated, ideally in a consistent fashion with the 800MHz and 2.6GHz bands fees (which are yet to be determined).

[REDACTED]

87 http://www.legislation.gov.uk/uksi/2011/1128/pdfs/uksi_20111128_en.pdf

88 ALF is similar to AIP but calculated in a slightly different technical method, however we use these terms interchangeable in reference to the Channel Islands fees as it is not certain yet which will apply to the WTA

10.4 Conclusions

As detailed above, the initial decision to be made by the States of Jersey and Guernsey, in conjunction with CICRA, is whether the administrative fees' main aim is to recover the regulatory costs of the spectrum or the operators' value of the spectrum:

- In the case of cost recovery being the Channel Islands' primary aim, the fee should not fall below total costs of licensing and regulating the telecommunications sector across the Channel Islands, including, if necessary, Ofcom's relevant costs.
- In the case of value or opportunity cost recovery to promote spectrum efficiency being the Channel Islands' primary aim, the fee should not go above the value ascribed to the spectrum by at least one party (either the operator or an alternative user).

Assuming the value of the spectrum is larger than the regulatory costs, the choice of just cost recovery will generally result in a lower fee for operators, whereas a value-based fee will result in a higher fee. We also note that the value-based fee in this case would have the additional benefit of recovering the regulatory cost, while any remaining fee would provide additional revenue for the respective Bailiwick's treasuries.

Theoretically, in the case of there being no spectrum scarcity in the Channel Islands there is no need to use the spectrum more efficiently than is currently seen up to the point where scarcity ensures. As such, it could be argued that once CICRA has rearranged the spectrum and distributed enough to cover future demand, then all that is required for a fee is regulatory cost recovery.

However, a potential concern with this approach would be that spectrum will become less efficiently used in the future, and that any existing users who generate less value than new, emerging users will not be incentivised to leave the spectrum. Using value-based pricing would also ensure operators use spectrum efficiently in the long run, which could be useful in the future if spectrum demand does exceed supply, as shown in some of the modelled scenarios and sensitivities. However, we note that this check on relative spectrum user values and efficiencies could also be ensured by fully enabling spectrum trading between operators and other spectrum users.

We note that if Ofcom does adjust its WTA fees in the future to fully reflect the value of the spectrum, then the Channel Islands would not be able to charge a further fee on top of this without a strong possibility of leading to inefficient, empty spectrum. If operators were charged beyond Ofcom's value-based fee, it could result in operators relinquishing more spectrum than necessary, which may not be appropriate for the situation where spectrum demand does not (currently) exceed supply in the Channel Islands, as was shown in Section 7.

As such, if Channel Islands wish to set a fee, it may be worth considering negotiating with Ofcom so that:

- either the WTA fees are kept constant (if below value),

- or set only to recover Ofcom's regulatory costs relative to the licences (an alternative would be to deduct the WTA fees from the Channel Islands' fee levels).

In addition, for simplicity, we would recommend that operators only pay a single fee to a single party, as is currently the case. This could be achieved if:

- the WTA fees are reduced to zero, with CICRA potentially covering Ofcom's licence costs,
- or if the WTA fees are set as Ofcom and CICRA agree and the Channel Islands recover any fees from Ofcom (e.g. either in full or the remainder after Ofcom's costs are covered, depending on the nature of the agreement with Ofcom).

11 Frequency coordination and interference issues

Of relevance to the decisions that the Governments of Guernsey and Jersey need to take in relation to the assignment of 4G spectrum are any interference issues affecting the use of different bands, which may mean that some bands are more suitable than others, or that special conditions may need to be included in operator licences to overcome certain issues.

This section considers the following frequency coordination and interference issues relevant to licensing of 4G spectrum in the Channel Islands:

- interference from LTE networks in the 800MHz band to digital terrestrial television (DTT)
- interference from LTE networks in the 2.6GHz band to airport radar
- cross-border frequency coordination for each of the primary considered bands for 4G use (800MHz, 900MHz, 1800MHz, 2.1GHz and 2.6GHz).[89]

To assess what interference issues might exist, we have assessed information published on similar interference issues arising in the UK, which are described in Ofcom's Information Memorandum (IM) for the upcoming 4G auction.[90]

11.1 800MHz interference issues

The main issue affecting the use of the 800MHz band for LTE is the potential for interference to DTT services, which use the adjacent UHF spectrum (470–790MHz) in the Channel Islands, in the UK, in France, and in the rest of Europe.

In the UK, Ofcom has identified two issues arising as a result of the requirements for DTT. Firstly, there are some restrictions on the availability of the 800MHz band for use by LTE in certain locations across the UK until the migration of DTT services from the 800MHz band to spectrum below 790MHz is completed (because DTT was using channels in the 800MHz band before it was re-assigned for mobile use). Secondly, there are obligations on LTE licensees in the 800MHz band to mitigate interference to DTT services in adjacent spectrum.[91]

In terms of the migration of DTT services from the 800MHz band, Ofcom's IM states that the original timetable was for DTT clearance to be completed by the end of 2012 for Northern Ireland, May 2013 for Wales, and October 2013 for England and Scotland. Availability of the 800MHz band for LTE use depends not only on the relocation of DTT services from the old DTT channels

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89 We have not considered cross-border frequency coordination for the 2.3GHz and 3.4GHz bands since neither of those bands are currently included in the proposed consolidated MoU between the UK and France.

90 http://stakeholders.ofcom.org.uk/binaries/consultations/award-800mhz/statement/IM.pdf.

91 Terrestrial television broadcasting formerly used spectrum from 470–862MHz, which includes the 800MHz band. Ofcom had originally planned to clear DTT channels 63 to 68 as part of the 'digital dividend' but extended this to clear channels 61, 62 and 69 in order to harmonise with the rest of Europe, where the 800MHz band uses DTT channels 61 to 69. As well as migrating DTT services out of the 800MHz band, PMSE services that previously used 'interleaved' spectrum within the 800MHz band also need to be moved to adjacent channels.

61 and 62 (790–806MHz), but also on relocation of programme making and special events (PMSE, i.e. wireless microphones) from channel 69 (854–862MHz). Ofcom put in place a compensation scheme for wireless microphone users with channel 69 equipment, to help fund equipment replacement to use a newly identified channel elsewhere in the UHF band (in the UK, the new wireless microphone channel is UHF channel 38).

Following the publication of the IM, however, Ofcom published a further statement on 2 October 2012 indicating that clearance of DTT services had progressed at a faster pace than originally envisaged, and that, as a result, the 800MHz band will be available for LTE use across 'much of the UK' by Spring 2013, rather than October 2013.[92] This means that operators acquiring 800MHz spectrum in Ofcom's 4G auction in January 2013 can begin network roll-out from Spring 2013, only a few months after the auction has ended.

However, this roll-out must still be planned to mitigate interference from LTE base stations into DTT services using the spectrum below the 800MHz band. To manage this, Ofcom developed a series of proposals, based upon detailed technical modelling to estimate the potential scale of the interference issue, and the funding requirements.

The potential scale of interference to DTT in the UK arising from the use of each 2×10MHz block of 800MHz spectrum was estimated by Ofcom in technical analysis reports released in June 2011[93] and February 2012,[94] as shown in Figure 11.2 (with Block A being the lowest 2×10MHz block in the 800MHz band and Block C being the highest).

Figure 11.1: Estimated total number of households (HH) affected by LTE interference within the UK [Source: Ofcom, 2012]

Aerial type	Total households	Blocks A+B+C (HH)	Blocks B+C (HH)	Block C (HH)	Block B (HH)	Block A (HH)
Standard installations	12 969 605	389 677	267 503	141 424	145 173	170 154
Domestic installations with amplifiers	9 000 000	952 648	745 906	464 826	470 472	503 403
Communal aerial systems	5 609 491	945 238	693 790	373 769	371 906	389 515
Total	**27 579 096**	**2 287 563**	**1 707 199**	**980 019**	**987 551**	**1 063 072**

The mitigation procedure (now being implemented) is based upon the creation of a legal entity, originally referred to as the UK MitCo but since named Digital Mobile Spectrum Limited

92 http://media.ofcom.org.uk/2012/10/02/delivering-4g-mobile-for-consumers/.

93 'Technical analysis of interference from mobile network base stations in the 800 MHz band to digital terrestrial television', Section 8, Ofcom, June 2011.

94 'Technical analysis of interference from mobile network base stations in the 800 MHz band to digital terrestrial television', Technical report, Ofcom, February 2012.

(DMSL), the purpose of which is to deliver a consumer help scheme to DTT households that might potentially be affected by interference. The help scheme involves distribution of consumer information (e.g. informing households located within 2km of a planned 800MHz base station of the potential for interference) as well as the funding of both proactive and reactive engineering measures to mitigate interference.

DMSL is being funded through payments made by the mobile operators which are awarded 800MHz spectrum in the 4G auction. The funding arrangements for DMSL are set out by Ofcom in the IM, as follows:

- Each 800MHz licensee is to pay GBP20 million per 2×5MHz block of spectrum to DMSL, shortly after 800MHz licences are awarded.
- A second payment of GBP5 million per 2×5MHz block of spectrum is to be paid by each licensee to DMSL one year after the first payment.
- A third payment of GBP5 million per 2×5MHz block of spectrum is to be paid by each licensee to DMSL two years after the first payment (i.e. a year after the second payment).

DMSL is responsible for distributing this funding throughout the lifetime of the organisation. Ofcom has stipulated that the organisation should remain in place until twelve months after each licensee's network is fully rolled out, or until 31 December 2018.

The UK government has confirmed the creation of a board to oversee DMSL's operation, established by the Department for Culture, Media and Sports.[95]

We note that the Governments of Guernsey and Jersey, and CICRA, have recently talked to Ofcom regarding modelling of the DTT interference within the Islands and it is expected that provisional costs of DTT interference mitigation in the Channel Islands may be calculated assuming a similar approach to mitigation as per the UK. In the UK, this led to an estimation of costs as shown in Figure 11.2, excluding any additional costs due to the need for LTE network mitigation that may be borne by individual operators.

Figure 11.2: Summary of UK DTT interference cost modelling [Source: Ofcom, 2012]

	UK cost range (GBP million)	Relevant UK households
Information for all households	23	27,579,096
Distribution of filters to affected households	65–88	2,287,563
Filter installation for vulnerable consumers	18–28	2,287,563
Platform change where filters are ineffective	8–11	3,313
Total cost	**114–150**	**27,579,096**

95 http://www.culture.gov.uk/news/news_stories/9376.aspx.

Our view is that similar modelling of the situation in the Channel Islands is required in order to confirm possible interference mitigation costs, and to determine a suitable approach to implementing interference mitigation on DTT installations (and within LTE networks, as required). We consider that while detailed extrapolation from Ofcom's work could provide a first estimate, more detailed modelling would be necessary given the difference in geography seen in the Channel Islands and the relatively low height and low power of DTT transmitters on the Bailiwicks when compared to the majority of the UK.

In relation to PMSE, Ofcom has planned a clearance process in consultation with the PMSE industry, such that the use of channel 69 for wireless microphones[96], as well as the use of the interleaved spectrum within the old DTT channels 61 to 68 (now part of the 800MHz band) will cease in the UK from 31 December 2012. Ofcom has not investigated what PMSE use might remain in the 800MHz band in the Channel Islands, which were not subject to the clearance exercise of the UK-wide process, as described above. There is, therefore, a need for CICRA to establish whether there are any relevant wireless microphone assignments/use in either Guernsey or Jersey and, if so, to implement a clearance process potentially similar to that of the UK. Our understanding from Ofcom is that this would be for the Governments of Guernsey and Jersey to implement. Key decisions to be taken would be whether a period of notice is to be given to PMSE users (and, if so, what that notice period might be), and whether funding or other assistance is to be provided to incentivise clearance to alternative spectrum.

11.2 2.6GHz interference issues

In relation to the use of the 2.6GHz band for LTE, the main interference constraint (applying both in the UK and in France) arises from the use of adjacent 'S-Band' (2.7–3.1GHz) for aeronautical, maritime and military radars. In France, the French military also used to use spectrum within the 2.6GHz band for military fixed links; however, our understanding from Ofcom is that this usage is being cleared and the band will be fully vacated by July 2013 (ahead of this time, coordination limits apply within a UK/France Memorandum of Understanding, described in the following section).

The lower part of the S-Band, 2.7–2.9GHz, is used for civil and military ATC by the National Air Traffic Service (NATS) and the MOD in the UK, respectively. Under UK spectrum management arrangements, the lower part of the S-band is managed jointly between the CAA and the MOD. The upper part, 2.9–3.1GHz, is also used by maritime radar, in addition to civil and military ATC. The Maritime Coastguard Agency (MCA) in the UK therefore has a role in managing the upper band, along with the CAA and the MOD.

96 Channel 69 use was licence-exempt in the UK and many cheap wireless microphones were using this range (e.g. in churches).

Because of the poor selectivity performance of some radar systems that use the S-Band, studies have indicated that there is potential for LTE emissions in the 2.6GHz band to interfere with radar reception.[97]

To mitigate this, Ofcom and the UK government established a programme of work to modify susceptible radar systems and make them more resilient to interference. Details of this are set out in Ofcom's IM for the 4G auction. The detail provided in the IM suggests that the first prototype modification was approved in June 2012 and the last prototype modification was due to be delivered in September 2012. These prototype modifications have confirmed the feasibility of the proposed design changes; and, these modifications need to be rolled out across all affected radar systems in the UK.

Since 2012, a radar modification programme has been on-going in order to coordinate modification to individual radars, with modifications scheduled to be complete by the first quarter of 2014. However, even after this date, the IM indicates it is possible that some residual interference might remain. The costs of these modifications are being partially funded by the UK government, under a scheme administered by the Department for Transport (DfT), which covers 80% of the remediation costs (up to a limit of GBP300 000 per 'air navigation service provider').[98]

Ofcom has proposed a condition in the 2.6GHz licences such that licensees must comply with the following coordination procedure:

> "When planning its network deployment, the 2.6GHz licensee must check whether the protection thresholds set out in this document would be exceeded as a result of any proposed 2.6GHz deployment. To do so, the 2.6GHz licensee will need to calculate the communication signal and the out of band noise at the relevant protected radar locations. If these calculations show that the relevant threshold(s) will not be exceeded as a result of the planned deployment, then deployment can go ahead. If the calculations show that the relevant threshold(s) would be exceeded as a result of the planned deployment, the 2.6GHz licensee may consider adjusting the deployment. If it is not possible to adjust the deployment so that the threshold(s) are not exceeded, the 2.6GHz licensee may only proceed to deployment if agreement is reached with the operator(s) of the relevant radar."[99]

It is noted that air traffic services in the Channel Islands also use the S-band. We understand that replacement of currently deployed radars is being planned, and that the radar in Jersey Airport has recently been replaced[100]. Guernsey Airport is following a similar process at present. Confirmation

97 Selectivity in a radio system refers to the performance of filters that are used to ensure that a receiver is able to select the wanted signal (i.e. the signal intended for its reception) and to reject unwanted signals. In radar systems, poor selectivity can mean that when subjected to emissions from adjacent bands, radars might be unable to distinguish their wanted targets (i.e. aeroplanes) from other signal sources e.g. arising from LTE base stations.

98 See http://www.caa.co.uk/docs/33/InformationNotice2012173a.pdf

99 See http://stakeholders.ofcom.org.uk/binaries/consultations/award-800mhz/statement/IM2.pdf.

100 Though we understand that the recently replaced Jersey radar has not necessarily been fitted with the relevant filter to reject 2.6GHz LTE, we understand that it could be so modified.

will be needed from both airports that the new systems have sufficient immunity from the effects of mobile services using the adjacent 2.6GHz band. Based on the UK coordination process, it is noted that some coordination at affected installations will still be required even after the UK radars have been upgraded. Ofcom has therefore proposed different protection thresholds before and after radars are modified (with thresholds after modification being less restrictive).[101] The Governments of Guernsey and Jersey should therefore confirm with each airport (and potentially the manufacturer of the radars used in Guernsey and Jersey) if the post-modification threshold proposed in the UK is required in the Channel Islands, and if it is sufficient to avoid interference. Our current understanding is that Guernsey's radar once replaced should be fine, but that Jersey's radar will require the installation of additional filters.

Unlike for the 800MHz band, we do not believe it would be appropriate for an organisation involving commercial companies to manage the radar mitigation for the 2.6GHz band. This is due to the strong 'safety of life' implications surrounding airport radar operation. Rather, we believe that a similar process should be undertaken as in the UK, where a government-led programme comprising relevant government bodies[102], supported by Ofcom, assists radar operators in modifying their radars.

Given our understanding that there are differences in past costs between the two Bailiwicks, with Jersey only requiring a filter upgrade and Guernsey requiring a full radar modification, we note that it is not necessary that both Bailiwicks need to follow the same approach to organising mitigation in addressing the radar interference issues, although on administrative efficiency grounds parity may be seen as sensible.

The 'polluter pays' principle, would suggest that it is appropriate for radar interference mitigations costs to be recovered from the users of the paired 2.6GHz bands as a whole, as we have suggested for DTT services and the 800MHz band users. This principle only applies, though, in the case that the radars were within their original spec, i.e. if the upgrade is necessary because the radars ought to have been immune to 2.6GHz but are not, otherwise it would not be fair to demand that any changes were funded by the 2.6GHz users.

However, despite the above principle, our understanding is that the cost of mitigation of radar is likely to be significant across the Bailiwicks, especially compared to the relevant value of the spectrum when scaled from recent UK 4G auction prices.[103] As such, it may be necessary for the government to cover the modification costs in the first instance, and then recover costs later through the spectrum fee. Whichever method the Governments and CICRA decide, it is important that any mitigation funding process, levied from either the government or operators, needs to be communicated to any potential 2.6GHz spectrum applicants at the point of the 2.6GHz consultation.

[101] See annexes to Ofcom's 4G IM for details.

[102] This consists of Department of Culture Media and Sport (DCMS), Department for Transport (DfT), the MOD and the Civil Aviation Authority (CAA).

[103] As detailed above, assuming UK benchmarks, the whole 2.6GHz spectrum band is valued at GBP79 000 per year across the Channel Islands, compared to the UK mitigation limit of GBP300 000 per radar provider.

11.3 Cross-border coordination

There is a need to coordinate mobile network deployment in the Channel Islands with networks deployed in both the UK and France, to avoid interference. Coordination agreements usually take the form of a Memorandum of Understanding (MoU), negotiated between the regulators in each country, which mobile operators must comply with. Ofcom manages the coordination process on behalf of the UK and the Channel Islands, and the Agence Nationale des Fréquences manages the process in France.

For GSM services, coordination is typically based on agreeing a division of channels into preferential/non-preferential, with different field strength coordination levels applying to each (with the thresholds applying to preferential channels being less restrictive). For UMTS and LTE, coordination is based only on field strength coordination levels applying across the band, without division into preferential or non-preferential frequencies.

Until recently, separate MoUs were negotiated between the UK and France applying to each individual mobile frequency band in use for 2G and 3G services (i.e. 900MHz, 1800MHz and 2.1GHz). We understand from discussions with Ofcom, however, that a process is now underway to consolidate all existing MoUs into a single agreement. This would mean that for both the UK and France, and separately for the Channel Islands, all previous MoUs for mobile bands between 800MHz and 2.6GHz will be consolidated. Coordination methods and thresholds will also be standardised, taking account of the propagation differences between bands. This should not change the actual coordination levels or selection of preferential or non-preferential channels for current GSM use, but will extend the scope of the coordination to the potential use of LTE in all bands. As noted above, coordination of bands used for LTE does not involve division of bands into preferred and non-preferred channels but is based on field strength limits applying across each band (which is further described below).

The process of consolidating agreements into a single MoU for the UK and for the Channel Islands is underway at present, and we understand from Ofcom that the Governments of Guernsey and Jersey, and CICRA, will be notified when this process is completed.

Ofcom has indicated to us, as part of this study, that the consolidated MoUs will be based as far as possible on pan-European coordination recommendations established by the European Communications Committee (ECC) of the Conference of Postal and Telecommunications Administrations (CEPT).

The field strength limits proposed by the ECC are described in a series of ECC recommendations, which are presented below.

11.3.1 800MHz coordination

Coordination thresholds for mobile use of the 800MHz band have been published by the ECC in ECC Recommendation 11(04).[104] The recommended limits contained in this recommendation are as follows: [105]

- FDD systems may be established, operated or modified without coordination with the neighbouring country, provided that the predicted field strength produced by a cell (all transmitters within the sector) does not exceed the threshold of 55dBμV/m in a bandwidth of 5MHz at a height of 3 metres above ground level at the coast or border line of the neighbouring country, and 29dBμV/m in a bandwidth of 5MHz at a height of 3 metres above ground level at a distance of 9km inside the neighbouring country.

- In the case that LTE is deployed on both sides of the border, the field strength levels may be increased to 59dBμV/m at the border, and 41dBμV/m at a distance of 6km within the border.

An MoU covering the 800MHz band has not been finalised between the UK and France as yet, but we understand from Ofcom this will be captured by the consolidated MoU. As noted, a separate consolidated MoU governing frequency use in the Channel Islands will also be required.

11.3.2 900MHz and 1800MHz coordination

ECC Recommendation (08)02 has been established to describe frequency planning and frequency coordination for UMTS/LTE use of the 900MHz and 1800MHz bands.[106] The following coordination thresholds are recommended:

- Between UMTS systems using either the 900MHz or the 1800MHz bands, using *non-preferential codes*, [107] a field strength of up to 35dBμV/m is permitted in the 900MHz band and 41dBμV/m in the 1800MHz band, at 3 metres above ground level at the border line between the two countries, without coordination.

- For all other cases (e.g. GSM to UMTS/LTE), a threshold of 59dBμV/m is specified at the border for 900MHz networks, and 65dBμV/m for 1800MHz networks, at the border line between the two countries.

Ofcom has informed us that the consolidated MoU between the UK and France updates the current GSM-based coordination arrangements for the 900MHz and 1800MHz bands with new arrangements for the UMTS/LTE use of both bands. This will remove the current preferred/non-

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104 Frequency planning and frequency coordination for terrestrial systems for mobile/fixed communication networks (MFCN) capable of providing electronic communication services in the 790–862MHz frequency band, http://www.erodocdb.dk/docs/doc98/official/pdf/Rec1104.pdf.

105 See Annex 7 of Ofcom's IM for the 800MHz and 2.6GHz award.

106 http://www.erodocdb.dk/docs/doc98/official/pdf/Rec0802.pdf.

107 This refers to distribution of CDMA code groups into preferred and non-preferred groupings, which can be divided between networks operating on either side of a border, as described in Annex 3 of the ECC recommendation.

preferred channel divisions and is expected to be based on the above coordination limits. As noted above, Ofcom will inform the Governments of Guernsey and Jersey, and CICRA, when the consolidated MoU with France is established.

11.3.3 2.6GHz coordination

Frequency coordination for mobile use of the 2.6GHz band is described in ECC recommendation ECC/(Rec)/(11)05.[108]

This establishes the following limits:

- In general, FDD systems may be used without coordination with a neighbouring country if the mean field strength produced by a cell (i.e. all transmitters in a sector) does not exceed the value of 65dBμV/m in a bandwidth of 5MHz at a height of 3 metres above ground level at the coast or border line of the neighbouring country, and 37dBμV/m in a bandwidth of 5MHz at a height of 3 metres above ground level at a distance of 6km inside the neighbouring country.
- In the case that LTE is deployed on both sides of the border, the field strength level at 6km may be increased to 49dBμV/m in a 5MHz channel.
- TDD base stations can be established without coordination if the mean field strength produced by a cell (i.e. all transmitters in a sector) does not exceed a level of 21dBμV/m in a bandwidth of 5MHz at a height of 3 metres above ground level at the borderline.
- If TDD systems are in operation on both sides of the border and are synchronised, then the same field strengths as for FDD systems may be applicable.

The IM for Ofcom's 4G auction states that the UK/France MoU includes French military radar systems that currently use spectrum below 2.5GHz, as well as operating within the 2.6GHz band. However, it is stated that systems within the 2.6GHz band are to be switched off by summer 2012, although systems using the adjacent spectrum below 2500MHz may continue to operate beyond this date. The MoU states that the emissions from these radar systems falling on the UK coastline have been studied, and that none of the radar using the 2500–2690MHz band has emissions that exceed the stated LTE coordination field strength of 21dBμV/m on the UK coastline. The MoU indicates that some radars operating below 2500MHz may emit signals in excess of this threshold on the UK coastline however. It is noted that field strengths measured in the Channel Islands will be higher than those on the UK coastline, however. The Governments of Guernsey and Jersey, and CICRA, may therefore wish to check this with Ofcom.

Once a draft of the consolidated MoU for the Channel Islands is available, it may be necessary for the Channel Islands operators to validate the impact of the proposed thresholds on their existing sites, in order to confirm that the new agreement is suitable. It is noted that this may also impact the feasibility of reorganising existing 900MHz and 1800MHz spectrum between the operators,

108 http://www.erodocdb.dk/docs/doc98/official/pdf/Rec1105.pdf.

since operators will wish to ensure that any constraints imposed by the MoU thresholds do not unduly affect one operator over another.

The potential for redistributing existing 900MHz and 1800MHz assignments is further discussed in the following section.

12 Conclusions and recommendations

As described in this report, the purpose of this study has been to assess various factors relevant to making recommendations in respect of 4G spectrum usage and assignment in the Channel Islands.

Our findings are as described below.

12.1 Conclusions

The conclusions from our analysis are described below.

Demand for 4G spectrum in Guernsey and Jersey

The roll-out of 4G services is expected to deliver benefits to mobile consumers in the Channel Islands, as well as to the economies of Guernsey and Jersey.

Published studies suggest that consumer benefits from mobile LTE services will be created through access to much higher speeds for mobile data transmission than is currently available, which will support wider availability of new mobile services and generate an improved user experience compared to earlier generations of mobile telecommunications. Wider availability of mobile broadband services using LTE could also offer consumers an alternative method of accessing broadband services, rather than using a fixed connection. This may be beneficial in areas where fibre broadband is not available or in instances where consumers prefer a mobile rather than a fixed connection, and might improve the competitiveness of the broadband market.

Direct and indirect benefits to the economies in Guernsey and Jersey will arise as a result of the capital investments being made in LTE infrastructure by existing operators, and by a new entrant should this emerge. This will contribute to employment and the creation of new jobs. Availability of new high-speed infrastructure will also provide a platform for development of new and innovative high-speed mobile data services including a range of business and consumer applications, also contributing to employment and job creation. Provision of public services in the Channel Islands could also be facilitated through having access to better mobile infrastructure, including better access to e-health and other e-services.

To fully access the benefits of these 4G services, however, will lead to a significantly increased level of spectrum demand compared to the status quo. Our modelling of the mobile market and corresponding spectrum demand suggests that there will likely be sufficient spectrum availability to meet the level of spectrum demand in both a three- and a four-player market under our base case assumptions, with 800MHz, 1800MHz, and 2.6GHz bands being made available for mobile use in Jersey and Guernsey. We note, however, that under even marginally more aggressive spectrum demand forecasts, for example increased levels of FWA traffic or reduced levels of site growth, certain operators' spectrum demand begins to exceed their individual spectrum availability.

Any excess spectrum demand could be addressed either by the deployment of additional sectors, or the release of additional spectrum beyond that modelled, for example in the 700MHz band or in one of the TDD bands.

Opportunities for re-organising existing mobile spectrum

Spectrum in the 900MHz and 1800MHz bands is currently used for second-generation (2G/GSM900 and GSM1800) services by mobile operators in Guernsey and Jersey. This is in line with most other countries across Europe. Both bands are suitable for LTE deployment, having both been incorporated into equipment specifications for LTE developed by 3GPP. The 900MHz band has similar properties to 800MHz in terms of wide-area coverage and depth of signal penetration. However, there are currently device availability constraints affecting LTE use of the 900MHz band, since many 900MHz operators have opted to refarm 900MHz frequencies to UMTS/HSPA900 initially, rather than to LTE. The 1800MHz band, by contrast, is currently one of the most popular LTE bands from a device perspective and has been incorporated into multiple new smartphone models such as the iPhone5. The propagation characteristics of 1800MHz spectrum are less favourable than those of 900MHz spectrum, but the band can still be usefully deployed to provide wide-area and indoor coverage. A key benefit of the 1800MHz band is the total bandwidth available (2×75MHz, compared to 2×35MHz in the 900MHz band).

In both Guernsey and Jersey, existing 900MHz and 1800MHz spectrum is split unevenly between operators, with one operator (Airtel-Vodafone) having only around 2×5MHz of spectrum in each band. Spectrum is also non-contiguous in some cases, meaning that it cannot be used for UMTS or LTE, which requires a contiguous 2×5MHz channel to operate.

We have considered the scope to re-organise the existing 900MHz and 1800MHz spectrum assignments such that operators have access to spectrum in contiguous 2×5MHz blocks for future use, which is the block size required for LTE. Our conclusion is that there is merit in re-organising 1800MHz spectrum in the short term, such that operators have contiguous blocks and also have access to the same blocks in Guernsey and Jersey.

We believe the 900MHz band may be harder to re-organise in the short term, as a result of:

- the more limited bandwidth available in that band
- the fact that the available bandwidth is currently fully assigned to the existing operators
- markedly different allocations for Sure and Jersey Telecom in their 'home' markets
- the coordination constraints with the UK and France, as noted in Section 11.3. This is because there is a need to take account of existing 2G frequency coordination MoUs between the UK, Channel Islands and France when assessing the scope to re-align existing 900MHz and 1800MHz assignments, until such time as 2G services are switched off. The current 2G/GSM-based MoUs divide the available spectrum into preferred and non-preferred channels (with more restrictive coordination limits applying to the non-preferred channels).

This may make re-alignment of the 900MHz band difficult in the short term. There may be greater scope to re-align the 1800MHz band however, noting that there is nearly 2×50MHz of spectrum in each Bailiwick in the 1800MHz band that is currently unassigned.

It may be possible to re-align 900MHz spectrum if existing operators with larger spectrum holdings in that band are willing to relinquish some 900MHz spectrum, possibly in return for being assigned new 800MHz spectrum. This is further explained below, when we describe mechanisms for awarding 4G spectrum.

Based on advice from Ofcom, it is noted that there is nothing in the Wireless Telegraphy Act (WTA) licences held by the Channel Islands operators that would enable Ofcom to direct a return or change in the current spectrum assignments. Also, without spectrum trading, it is not possible to transfer amounts of spectrum directly between operators. Therefore, any re-planning of the 900MHz and/or 1800MHz band would potentially need to be consulted on by the Governments of Guernsey and Jersey, and CICRA, possibly as part of a larger consultation. Once agreed with all stakeholders, Ofcom can be notified of the amendments to be made.

It is also noted that Ofcom is currently developing new consolidated MoUs with its counterpart in France covering 3G/4G use of the 900MHz and 1800MHz bands. Coordination of 3G and 4G networks will not be based on division of spectrum into preferred and non-preferred channels. Therefore, the difficulties of re-aligning in accordance with existing MoUs is a short-term problem only and should be resolved once new MoUs are in place.

Use of the 2.3GHz and 3.4GHz bands

As part of this study, we were asked to comment on the suitability of 2.3GHz spectrum to provide wireless broadband connectivity between the Channel Islands and the UK/France.

The UK Frequency Allocation Table (FAT), which covers the UK mainland and coastal waters including the Channel Islands and the Isle of Man, designates the 2.3GHz band in the UK as being managed by MOD. . Therefore, any use of the 2.3GHz band either in the Channel Islands or between the Channel Islands and the UK would require the Governments of Guernsey and Jersey, and CICRA, to liaise with the UK MOD in the first instance regarding use of the spectrum to provide a link to the UK. A similar process would need to be followed in France, since the 2.3GHz band is used by the French military.

As described in this report, the 2.3GHz band is being standardised for LTE use, and a number of countries in Asia have awarded 2.3GHz spectrum to mobile operators for TD-LTE deployments. Work is underway in Europe within CEPT to develop a harmonised decision on mobile use of the 2.3GHz band. Therefore, whilst providing wireless connectivity between the Channel Islands and the UK/France is a possible use of the 2.3GHz band, it may be that a preferred use of this band is for mobile broadband services, using LTE, once a European decision is in place. The 2.3GHz band could be considered as a band to meet possible future 4G spectrum demand for mobile or FWA traffic (noting that our demand modelling suggests scope for demand to exceed the currently available spectrum from around 2020 under certain assumptions).

Similarly, the 3.4–3.6GHz band has been identified internationally for use by 4G systems and work is also underway within CEPT to update an earlier ECC Decision regarding harmonised use of this band for LTE. We recommend that the Governments of Guernsey and Jersey, and CICRA, consider this when assessing possible future use of the 3.4GHz band, since it is possible that mobile operators may identify potential uses of this band for future 'small- cell' LTE deployments.

Mechanism for efficient assignment of 4G spectrum

As noted in this report, co-channel frequency coordination with the UK and France will be needed for all bands assigned for 4G use in the Channel Islands. In addition, various adjacent channel interference issues exist, which are discussed below.

It is likely that the efficient use of spectrum use will be maximised if each of the bands are planned in the Channel Islands in a similar way to that of the UK and France. This will reduce the severity of cross-border interference issues, and will also benefit mobile operators in the Channel Islands through having access to harmonised equipment markets – which is particularly important for 4G devices. Accordingly, our conclusion is that the Governments of Guernsey and Jersey should use similar spectrum for 4G services to that of the UK and France – which is the 800MHz, 900MHz, 1800MHz and 2.6GHz bands. The 900MHz band, in particular, can only be used for 4G once existing 2G usage has been migrated – and possibly once existing 2G assignments have been re-planned into contiguous blocks suitable for 4G, as noted above.

As described in this report, 4G devices are becoming widely available for use in 800MHz, 1800MHz and 2.6GHz bands in Europe. The 900MHz band is currently lagging in terms of 4G device availability, with many operators opting to deploy HSPA+ rather than LTE in this band. There is a more limited LTE device availability for use in the 2.3GHz band, and very few devices available to use the 3.4GHz band at present.

Our demand analysis suggests that the currently available 4G spectrum (800MHz, 900MHz, 1800MHz, 2.1GHz and 2.6GHz) should be sufficient to meet spectrum demand for either three or four mobile operators under the majority of scenarios. This provides scope for the Governments of Guernsey and Jersey, and CICRA, to assign 4G spectrum to a new market entrant if this emerges. It also suggests that assignment of 4G spectrum via an auction may not be required if demand does not exceed supply (since auctions are most commonly used where excess demand exists), and a simpler process, either by direct award or using a beauty contest (e.g. if spectrum is to be awarded to a new entrant), could be adopted.

One area where demand could possibly exceed supply relates to the use of the available spectrum below 1GHz. Below 1GHz, there are two bands that can be used for 4G services – 800MHz and 900MHz. As described in this report, the 800MHz band is a new band for mobile use (created through switchover from analogue to digital terrestrial television), whereas the 900MHz band is used for 2G mobile services and hence can be used for 4G once 2G usage has declined/been migrated.

The total bandwidth available in the 800MHz band is 2×30MHz, and in the 900MHz band it is 2×35MHz. The entire 900MHz band is currently assigned for 2G use in Guernsey. There is an uneven distribution of 900MHz spectrum between Airtel-Vodafone, Jersey Telecom and Sure, and Airtel-Vodafone has less spectrum overall, which is also not assigned in a contiguous block in Guernsey.

If three 4G operators are to be licensed in Guernsey and Jersey, there is sufficient new spectrum in the 800MHz band for each operator to be awarded an equal 2×10MHz block. Assigning the 800MHz band in 2×10MHz blocks is the most common outcome of European 4G award processes, and a 2×10MHz assignment per operator enables each operator to deploy an LTE service. However, if four operators are to be licensed (e.g. three existing operators and a new entrant), there will be insufficient spectrum available in the 800MHz band for each operator to be awarded a 2×10MHz block.

In the case of four operators, the options would be to divide the band into unequal packages (e.g. two blocks of 2×10MHz and two blocks of 2×5MHz), or to link access to 800MHz spectrum to spectrum currently assigned in the 900MHz band, which would avoid any one existing operator gaining a dominant share of spectrum below 1GHz. For example, a number of regulators in Europe have implemented sub-1GHz spectrum caps to avoid any one operator gaining a large share of spectrum in both the 800MHz and 900MHz bands. A suitable cap might be 2×20MHz, which would mean that existing operators with 900MHz spectrum cannot acquire new 800MHz spectrum unless the total holding in both bands does not exceed 2×20MHz. The effect of this may be to encourage existing operators with larger 900MHz assignments to consider relinquishing some 900MHz spectrum if they want to acquire new 800MHz spectrum. The relinquished 900MHz spectrum could then be used either to even out the distribution of 900MHz spectrum between existing operators (i.e. to provide Airtel-Vodafone with more bandwidth), or alternatively could be assigned to a new entrant.

However, without spectrum trading in the Channel Islands, it is noted that it is not possible to transfer amounts of spectrum directly between operators, and thus any re-planning of the 900MHz band (including relinquishment of 900MHz spectrum by existing operators and re-award of that spectrum) would need to be consulted on by the Governments of Guernsey and Jersey, and CICRA.

Interference mitigation

As noted, various adjacent channel interference issues exist in relation to the use of the 800MHz and 2.6GHz bands for 4G or LTE.

With regard to the assignment of spectrum in the 800MHz band, we have noted that modelling of the potential for LTE to interfere with DTT in the Channel Islands (similar to the studies conducted in the UK) is potentially required in order to confirm possible interference mitigation costs, and to determine a suitable approach to implementing interference mitigation on DTT installations (and within LTE networks, as required).

Ofcom has indicated that this would be a matter for the Governments of Guernsey and Jersey, with CICRA, to resolve. It may be possible to estimate costs by extrapolating the UK results to reflect the number of DTT households in the Channel Islands, however a more accurate approach would be to model the potential for interference using radio planning tools.

In a similar fashion it is essential for the Governments of Guernsey and Jersey, with CICRA, to determine the mitigation costs required to protect radar from interference caused by the 2.6GHz band.

We note that if cost recovery of the relevant mitigation costs (DTT respectively and radar) is taken from all users of each band (800MHz and 2.6GHz respectively), then the cost of mitigation is spread across a larger number of operators and evened out within each band. This will have the advantage of ensuring that different allocations within the band are all of relatively equal value (which makes spectrum allocation through an administrative process easier), and ensures that all of the relevant blocks in each band have the same chance of being utilised. However, we note that due to the relative sizes of the 2.6GHz mitigation cost when compared to the spectrum value of the 2.6GHz, the government may wish to fund modifications as in the UK.

For the 800MHz band, a combined mitigation fund run by the operators, similar to UK MitCo, would be appropriate as long as costs could be kept sufficiently low. However for the 2.6GHz band, we do not believe it would be appropriate for an organisation involving commercial companies to manage the radar mitigation, given the ‘safety of life’ implications surrounding airport radar operation. Rather, we believe any mitigation funds should be managed by the airport authorities and their respective radar manufacturers and safety certification authorities. CICRA should oversee as a neutral party and would be able to distribute any collected funds.

Spectrum fees

As described in this report, the method of setting spectrum fees for mobile spectrum depends on the method of spectrum award. If spectrum is awarded via an auction then prices are determined through the auction. If direct award or a beauty contest is used then regulators have a range of different approaches at their disposal in terms of setting fees. Annual charges can be calculated on the basis of an operator’s annual profit or revenues from wireless services (thus enabling fees to be applied proportionally across all operators, minimising the risk to new entrants), or on a per-use basis (e.g. based on the amount of spectrum used, or the geographic area covered.

At present in the UK, 2G licence fees for 900MHz and 1800MHz spectrum are based on adjusted administered incentive prices (AIP), calculated theoretically for GSM licences around a decade ago. The AIP fee per channel is adjusted to take account of any restrictions on use (e.g. cross-border or other interference). For the Channel Islands, a proportion of the current UK AIP rate is currently charged, historically adjusted approximately by head of population in Guernsey/Jersey compared to the UK.

For 3G spectrum fees in the Channel Islands, it was decided to use the same fee per channel as determined for 2G. This differs from the UK where 3G spectrum fees were determined by the 3G auction in 2000, at which point UK 3G operators purchased 20-year licences.

It is noted that Ofcom plans to change 900MHz and 1800MHz fees applying in the UK next year to newly calculated 'annual licence fees' (ALF), to reflect the value of both bands if used for 3G/4G. The intention is to use benchmarks of prices paid by the mobile operators for 4G spectrum in the 800MHz and 2.6GHz bands following the UK 4G auction, to re-set fees for the 900MHz and 1800MHz bands. AIP fees are also being proposed for the 2.1GHz band, to apply after the initial 20-year licence term set by the 3G auction expires. A similar change (to reflect 3G/4G use of 900MHz and 1800MHz bands) may also be required in the Channel Islands, noting as above that current fees are based on UK GSM-based fees.

The decision to liberalise 900MHz and 1800MHz spectrum (i.e. to enable mobile operators to use either band for 3G/4G rather than 2G) is a decision that the Governments of Guernsey and Jersey, and CICRA, need to take, rather than Ofcom. That decision should be taken in the context of overall 4G assignment, as we have noted above.

Fees for liberalised 900MHz and 1800MHz assignments could be set in one of two ways:

- By adopting the new UK 900/1800MHz fees once Ofcom determines those, divided per head of population for the Channel Islands, as per the current method.
- By devising a new approach to fee setting, such as based upon revenue per operator (this could possibly be implemented by using telecoms legislation in the Channel Islands, since this approach is not possible via the WTA). To reduce complexity, it may be worth considering that the WTA fees are reduced to zero at the same time (or covered by CICRA) so that the operators only pay a single fee to a single party.

This decision will be based in part on a policy decision as to whether the administratively set fee's main aim is to recover the regulatory costs of the spectrum or the operators' value/opportunity cost of the spectrum. The method of selecting an administrative fee should also be considered in the context of the size of the Channel Islands' market, and as such, the cost of calculating an appropriate Channel Islands-specific value-based administrative fee (such as AIP) may be too expensive – and, therefore, using (or adjusting) Ofcom's fee may be seen as a more appropriate method.

12.2 Recommendations

Our recommendation is that the Governments of the Channel Islands use similar spectrum for 4G services to the UK, and make available spectrum in the 800MHz, 1800MHz and 2.6GHz bands for 4G use, as well as reviewing frequency usage rights in the existing 900MHz and 1800MHz bands with a view to reorganising existing assignments to be better suited for 3G/4G use. As indicated in this report, a total of 2×30MHz of spectrum is available for 4G use in the 800MHz band, and 2×70MHz of paired spectrum (with 50MHz unpaired) available in the 2.6GHz band. There is also 2×48.5MHz of spectrum in the 1800MHz band in Jersey and 2×53.5MHz in Guernsey currently not used for 2G services that could be made available for 4G use.

We recommend that the Governments of Guernsey and Jersey and CICRA should proceed with design of a process to award new 4G spectrum in the 800MHz, 1800MHz and 2.6GHz bands, and to consider options for redistributing 900MHz and 1800MHz spectrum as soon as practical. The award process should be designed to determine the spectrum assignment to each existing operator. Given that a possible new entrant has already been identified through the earlier expression of interest on 2.6GHz spectrum issued in Jersey, the process should also allow for a possible fourth operator.

With regard to the assignment of spectrum in the 800MHz band, we have noted that modelling of the potential for LTE to interfere with DTT in the Channel Islands is potentially required. It will be up to the Governments of Guernsey and Jersey and/or CICRA to decide whether it feels the costs of more accurate modelling of interference (i.e. using radio planning tools) are necessary, given the relative costs compared to the market, or whether it feels that an estimate of the costs by extrapolating the UK results would be appropriate, given the number of DTT households in the Channel Islands. We have noted, however, that given the difference in height and power of DTT transmitters on the Bailiwicks compared to the majority of the UK, that extrapolation may not be very accurate.

In a similar fashion, it will be necessary for the Governments of Guernsey and Jersey, together with CICRA, to determine the mitigation costs required to protect radar from interference caused by the 2.6GHz band and to inform the operators of the method of mitigation at the point of the 2.6GHz consultation, given the relative size of the likely mitigation costs to the value of spectrum.

Given that our analysis suggests there is potentially sufficient 4G-spectrum available to support four operators (although noting this of itself does not mean that a four operator market is economically viable), and given the small size of the Channel Islands markets, a simple direct award or a comparative selection (e.g. beauty-contest) based process could be used, rather than an auction. To establish requirements for a beauty contest, we recommend that a consultation document is issued first of all, to establish demand for 4G spectrum in general and for a new entrant(s) in particular. If results of the consultation suggest that the only interest in 4G spectrum is from the existing mobile operators, then it may be appropriate to proceed with a direct assignment of spectrum to each operator. This could be done on the basis of assigning equal amounts of spectrum to each existing operator in each of the available 4G bands (i.e. 800MHz, 1800MHz and 2.6GHz). If one or multiple new players were to emerge as a result of the consultation process, then a process of comparative selection (e.g. a beauty contest) may be the most appropriate way to assign spectrum to existing and new players.

Our analysis of the demand for 4G-spectrum also suggests there could be merit in re-aligning 2G spectrum so that each operator is able to refarm its existing 2G spectrum for 3G/4G use. However, this is likely to be easier to implement in the 1800MHz band, where there is greater scope for re-organisation. Re-planning in the 900MHz band could be encouraged through use of a sub-1GHz spectrum cap on 4G spectrum, such that existing operators with large blocks of 900MHz spectrum are ineligible to obtain new 800MHz spectrum unless they relinquish an equivalent amount of spectrum in the 900MHz band. A suitable sub-1GHz cap may be 2×20MHz per operator.

We also recommend that unassigned 1800MHz spectrum is offered to the market for 4G use, along with new 800MHz and 2.6GHz spectrum, but noting the proposed cap on sub-1GHz holdings, as above.

Ofcom has indicated that any net gain in spectrum in existing bands by any existing operator would need to be the subject of a consultation exercise to ensure that all stakeholders agree to the approach and have the opportunity to comment. Similarly, assignment of unused 1800MHz spectrum would also need to be consulted on. We recommend that this process is approached in two stages:

- Firstly, that the Governments of Guernsey and Jersey, along with CICRA, invite existing operators to meet to discuss voluntary re-alignment of existing 900MHz and 1800MHz assignments. The purpose of this should be to design a method by which current assignments of spectrum can be moved to form contiguous blocks of spectrum, ideally aligned for each operator between Guernsey and Jersey, with suitable space left for the allocation of additional 1800MHz spectrum in the next phase. If agreement cannot be reached between operators, we suggest that the Governments of Guernsey and Jersey, along with CICRA, intervene to propose a solution upon existing operators. This might involve enforcing a sub-1GHz spectrum cap on existing operators (preventing operators with large 900MHz assignments from being assigned 800MHz spectrum unless some 900MHz spectrum is relinquished), as well as proposing a re-alignment of 1800MHz spectrum into contiguous 2×5MHz blocks across each island (likely to require each operator to move some existing GSM channels to other parts of the band). However, it is noted that it would be highly desirable for a voluntary agreement to be negotiated with the existing operators, since the operators themselves are best placed to advise on what re-alignment is possible and what is not, based upon current 2G spectrum usage.

- Once a potential method to re-align existing assignments has been agreed, the second stage would be a consultation document, describing the proposed re-alignment of existing spectrum and inviting expressions of interest to acquire further 4G spectrum (in the 800MHz, 1800MHz and 2.6GHz bands). If demand for 4G spectrum in any band exceeds the available bandwidth, a process of comparative selection (e.g. a beauty contest) may then be required.

While it is possible that the 2.3GHz band could be used to provide wireless connectivity between the Channel Islands and the UK/France (more likely France, given the propagation characteristics), we do not propose that this option is pursued at the current time. This is both because the 2.3GHz band is currently the subject of European harmonisation studies for future LTE use, so the band's exact development is uncertain, and because the band is currently owned and operated by the

MOD in the Channel Islands, with current regulation not allowing the MOD to trade it with operators, unlike in the UK.[109] Therefore, while it is possible in the future that parts of the 2.3GHz band could be used to accommodate growth in demand for 4G services, we consider the development of this band in the Channel Islands to be still very uncertain.

Similarly, the 3.4GHz band is also being considered for 4G use in Europe, with a heavy emphasis on use by FWA services, and we recommend that the Governments of Guernsey and Jersey, and CICRA, consider this when proposing any further assignment of 3.4GHz spectrum, given the possible benefits for competition in the fixed market as detailed above.

[109] One way to achieve distribution of this spectrum would be for the MOD to return it to civil control for distribution. However, without detailed discussions with the MOD it is difficult to say whether this would be a course of action the MOD would consider.

Annex A Glossary of abbreviations and terms used

Abbreviation	Meaning
AIP	Administered incentive pricing, a method of charging for spectrum based on the opportunity cost of denying the spectrum for other usages.
ARPU	Average revenue per user.
ATC	Air traffic control.
Batelco	Bahrain Telecommunications Company.
Beauty contest	Process of comparative selection to award spectrum between operators, where companies are ranked based on a series of qualities and spectrum awarded in order. Comparators can include metrics such as financial stability, market experience, business plans, and/or proposed coverage targets.
CA	Carrier aggregation, the ability to combine several radio frequency carriers in the uplink and downlink.
CAA	Civil Aviation Authority.
CDMA	Code division multiple access, the 3G transmission multiplexing technology that allows more than one user to operate in a cell at once.
Cell	Geographical area covered by a single mobile transmitter, i.e. one sector.
CEPT	Conference of Postal and Telecommunications Administrations.
CICRA	Channel Islands Competition and Regulatory Authorities.
CoMP	Coordinated multipoint transmission and reception, designed to improve cell edge performance.
Contiguous blocks	Neighbouring frequency holdings.
CWC	Cable and Wireless Communications.
DC-HSPA	Dual carrier high-speed packet access technology, an advance 3G technology (marketed as 4G in the USA).
DMSL	Digital Mobile Spectrum Limited, previously referred to as the UK MitCo. DMSL is a UK organisation created by UK operators to carry out interference mitigation to protect DTT services from issues caused by LTE operation in the 800MHz band.
Downlink channel	Transmission path from a base station (cell site) to a mobile phone. This is the opposite path direction to an uplink channel.
DTT	Digital terrestrial television.
EC	European Commission.
ECC	European Communications Committee, a committee of the CEPT.
EDGE	Enhanced data GSM environment, an enhanced form of 2G technology.
E-GSM	Extended GSM frequencies.
EV-DO	Evolution data optimised, a 3G wireless radio broadband data standard.
FAT	Frequency allocation table, used to assign different frequencies to various high level uses within the UK.
FDD	Frequency division duplex, where the uplink and downlink channels are differentiated by the frequency of transmission.
FD-LTE	Frequency division long-term evolution, LTE technology which uses FDD transmission.

Abbreviation	Meaning
FWA	Fixed wireless access, a non-mobile wireless technology that can be used to substitute a fixed broadband connection.
GAMBOD	Global Suppliers Association analyser for mobile broadband devices.
GDP	Gross domestic product.
GPRS	General packed radio services, an enhanced form 2G technology.
GSA	Global Suppliers Association.
GSM	Global System for Mobile, the second-generation standard for mobile telecommunications.
HD-voice	High-definition mobile voice.
HSDPA	High-speed downlink packet access, an evolved form of WCDMA used for 3G technology.
HSPA	High-speed packet access, an overlay to third generation (UMTS) networks providing higher cell throughputs.
HSPA+	Enhanced 3G high-speed packet access technology.
IMT	International mobile telecommunications.
ISM	Industrial scientific and medical spectrum.
ITU	International Telecommunications Union.
LLU	Local loop unbundling.
LTE	Long-term evolution, while officially classified as a pre-4G technology, LTE is normally considered by operators as a 4G transmission technology.
LTE-A	Long-term evolution Advanced, the development of the LTE standard which gives better speeds and performance.
M2M	Machine-to-machine communications.
MBB	Mobile broadband.
MFCN	Mobile or fixed communications network.
MiFi	Portable broadband wireless device functions of a modem, router and access point; also referred to as a personal hotspot.
MIMO	Multiple in-multiple out, a method of using multiple antennas to increase data rates and transmission resilience.
MitCo	Interference mitigation company, in the UK this company has been named DMSL.
MOD	UK Ministry of Defence.
MoU	Memorandum of Understanding.
NATS	National Air Traffic Services.
NGA	Next-generation access.
NITA	National Information Technology and Telecom Agency, the Danish telecommunications regulator which has now become part of the Danish Business Authority.
OFDMA	Orthogonal frequency division multiple access.
Offloading	The move of mobile traffic to a fixed-line transmission source, often via WiFi, which reduces the amount of traffic required to be carried on typical mobile operator spectrum.
P-GSM	Primary GSM frequencies.

Abbreviation	Meaning
PMSE	Program Making and Special Events equipment, including wireless microphones, mobile.
QAM	Quadrature Amplitude Modulation, an enhanced modulation scheme, providing faster speeds over shorter distances.
S-band	Spectrum neighbouring the 2.6GHz bandwidth and currently used for air traffic control.
Sector	The active electronics found in a site.
Single-RAN solution	Single radio access network, refers to the mobile base station equipment that supports multiple mobile standards and services on a single infrastructure.
Site	Transmitter facility, such as a tower or monopole, containing both active electronics and antennas.
Small cell	Localised small mobile transmitters covering a limited geographical area. This can include micro-, pico- and/or femto-cells.
Spectral efficiency	A measure of the amount of data transferred across a known bandwidth of spectrum, hence determining spectrum availability and quality of service.
TDD	Time division duplex, where the uplink and downlink channels are differentiated by individual time slots across the same frequency.
TD-LTE	Time division long-term evolution, LTE technology which uses TDD transmission.
UHF	Ultra-high frequency, the range of frequencies between 300MHz and 3GHz.
UMTS	Universal mobile telecommunications system, the third generation (3G) standard for mobile telecommunications.
Uplink	Transmission path from a mobile phone to a base station (cell site). This is the opposite path direction to a downlink channel.
VoIP	Voice-over-Internet protocol, a method of transmitting voice data encoded as packet-switched data.
WCDMA	Wideband code division multiple access.
WiMAX	Worldwide interoperability for microwave access, a 4G transmission technology popular for FWA purposes.
WRC	International Telecommunications Union World Radio Conference.
WTA	Wireless Telegraphy Act, the UK issued licences which cover spectrum use across the Channel Islands.
2G	Second-generation mobile telephony standards, including GSM
3G	Third-generation mobile telephony standards, including UMTS and HSPA.
3GPP	Third-generation Partnership Project.
4G	Fourth-generation mobile telephony standards, including WiMAX and LTE.

Annex B Cost of fixed broadband services to consumers in the Channel Islands versus other European countries

B.1 Introduction

In this section, we provide an analysis of the cost of fixed broadband services in the Channel Islands compared to other European countries. This may influence decisions that the Governments of Guernsey and Jersey take in relation to 4G spectrum assignment, particularly if 4G is viewed as a possible competitor to fixed broadband services to influence the price of broadband services.

B.2 Methodology

We started the process by collecting price data for all of the home broadband packages available on the following Channel Islands operator websites:

- Jersey Telecom[110] – this operator is active in both Jersey and Guernsey (where it used to operate under the name Wave)
- Sure[111] – this operator is active in both Jersey and Guernsey
- Newtel[112] – this operator is active only in Jersey
- Y:tel[113] – this operator is active only in Jersey.

When it came to choosing the benchmark data set, we considered broadband package prices for operators in Western Europe. We have specifically chosen to benchmark prices for those countries which we consider in Section 9:

- UK
- France
- Ireland
- Sweden
- Denmark
- Netherlands
- Italy
- Belgium.

110 http://www.jtglobal.com/Jersey/Personal/Broadband/Products/Home-broadband-tariffs/
http://www.jtglobal.com/Guernsey/Personal/Broadband/Products/Home-broadband-plan/

111 http://shop.surecw.com/jersey/sure-price-plans/internet
http://shop.surecw.com/guernsey/internet/sure/broadband

112 http://www.newtelsolutions.com/

113 http://www.ytel.je/#!Broadband/c18do

In the case of the broadband prices for the operators in these countries, we used a publicly available dataset: *International Broadband Pricing Study: Dataset for public use*.[114] This dataset includes pricing information for operators in all of our reviewed countries except for Ireland, taken from August 2012.

The price data collected for the operators in both the Channel Islands and the benchmark countries is exclusively for the monthly cost to a subscriber. Any costs related to equipment or connections have been ignored.

B.3 Results

We have analysed the results of this benchmarking exercise within three categories related to the downlink speed of the service:

- low-speed broadband – broadband packages with download speeds between 0Mbit/s and 10Mbit/s
- mid-speed broadband – broadband packages with download speeds between 10Mbit/s and 30Mbit/s
- high-speed broadband – broadband packages with download speeds greater than 30Mbit/s.

It appears from the comparison between prices in the Channel Islands and those in the benchmark countries shown below that the prices in the low-speed and mid-speed broadband categories are higher in the Channel Islands than elsewhere in our Western European benchmark. However, prices for high-speed broadband packages in the Channel Islands appear to be more consistent with those in the benchmark countries.

B.3.1 Low-speed broadband

Within the low-speed broadband category, all Channel Islands prices available to be analysed have come from Jersey, with no Guernsey operators offering broadband with downlink speeds below 16Mbit/s.

As shown in Figure B.1 below, the majority of the Jersey low-speed broadband prices fall above the trend line for benchmark prices.

114 http://policybythenumbers.blogspot.co.uk/2012/08/international-broadband-pricing-study.html.

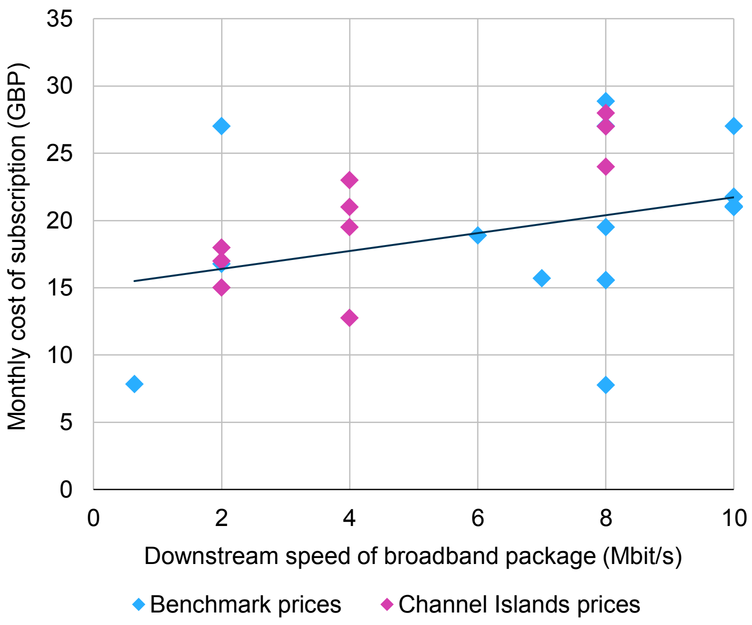


Figure B.1: Comparison of low-speed broadband pricing for operators in the Channel Islands and in benchmark countries [Source: operator websites, Google international broadband pricing study, 2012]

B.3.2 Mid-speed broadband packages

As can be seen in Figure B.2, all broadband packages in the Channel Islands are priced above the level of the corresponding packages in benchmark countries. In some cases, the price differential is quite significant with prices for packages with downlink speeds of 20Mbit/s being up to 155% more expensive than packages in benchmark countries.

Within the Channel Islands broadband packages that fall within this speed category, we have disregarded the “Pay-as-you-go” package offered by Sure in Guernsey due to the variation in price based on usage.

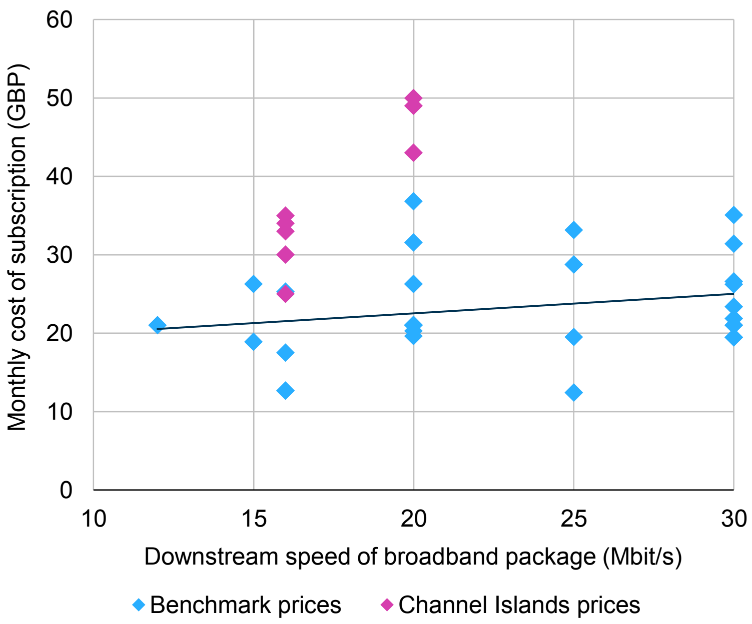


Figure B.2: Comparison of mid-speed broadband pricing for operators in the Channel Islands and in benchmark countries [Source: operator websites, Google international broadband pricing study, 2012]

B.3.3 High-speed broadband packages

As shown in Figure B.3, prices for high-speed broadband packages in the Channel Islands are more in line with those in the benchmark countries. However, the limited number of high-speed broadband packages available in the Channel Islands makes drawing any firm conclusions in this category difficult.

Additionally, Jersey Telecom offers a fibre broadband package with downlink speeds of up to 1Gbit/s, which is not shown in Figure B.3 as its high speed made it difficult to compare with the benchmark packages. This package has a monthly price of GBP59.99, which is not too far beyond the prices for benchmark packages offering speeds of 100Mbit/s or higher.

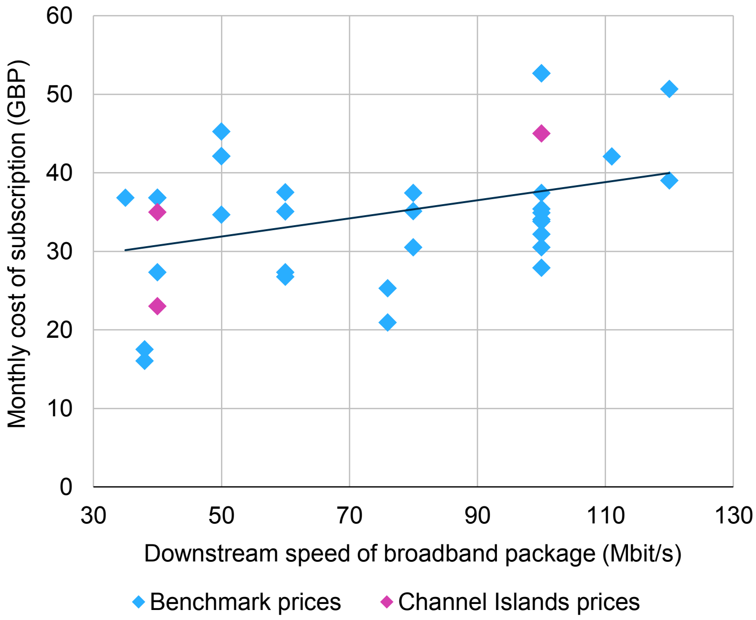


Figure B.3: Comparison of high-speed broadband pricing for operators in the Channel Islands and in benchmark countries [Source: operator websites, Google international broadband pricing study, 2012]

Annex C Comparison of approaches to the calculation of spectrum and non-spectrum mobile fees

Below we have compared European recurrent and one-off fee types, demonstrating various alternative approaches in the calculation of both non-spectrum and 2G spectrum-related charges. We are especially interested in 2G fees, as compared to 3G and 4G fees they are more frequently set administratively, whereas the later 3G/4G fees have tended to be auction-derived instead.

We have defined **non-spectrum related fees** as those imposed on network operators that are unrelated to spectrum, including the costs of verifying compliance service or network conditions (i.e. service or network licences) or for examining licence applications. Fees faced by the operators that are incurred on the basis of spectrum licences are referred to as **spectrum-related fees**. Spectrum fees can be divided into two categories (detailed in Section 10), namely regulatory- and value-based spectrum fees:

- **Regulatory-based** spectrum fees are those designed to cover the costs of licensing and regulating a particular sector of the telecommunications market relevant to the spectrum being used by that sector and are scaled in line with the operator's spectrum holdings.
- **Value-based** spectrum fees are those implemented in order to reflect the opportunity cost of the spectrum to the network operators and other potential users of the spectrum. Their goal is to incentivise spectrum holders to maximise their efficiency.

The benchmarks below, as seen in Figure C.1, include approaches used in selected European countries for 2G recurrent fees, frequently set administratively.

Figure C.1: Structure of recurring GSM spectrum and non-spectrum related fees [Source: Study on administrative and frequency fees related to the licensing of networks involving the use of frequencies, 2001,[115] ITU Trends in Telecommunication reform, 2004,[116] GSMA Licensing to support the mobile broadband revolution, 2012[117]]

Country	Non-spectrum related fees	Spectrum-related fees (covering both regulatory cost and spectrum value-based fees)
Austria	Between 0.1%–0.2% of annual revenues	Annually recurring fixed fee per channel used, covering regulatory costs as well as reflecting the value
Belgium	Fixed annually recurring fee	Fixed annually recurring fee per channel, reflecting the opportunity cost of the spectrum

115 AEGIS Study on administrative and frequency fees related to the licensing of networks involving the use of frequencies Report to the European Commission Directorate General Information Society, 14th November 2001; http://ec.europa.eu/information_society/policy/ecomm/doc/library/ext_studies/frequencies.pdf.

116 ITU Trends in telecommunications reform 2004/2005 Licensing in an era of convergence; http://www.itu.int/pub/D-REG-TTR.7-2004.

117 GSMA Licensing to support the mobile broadband revolution, May 2012; http://www.gsma.com/publicpolicy/wp-content/uploads/2012/03/gsma_licensing_report.pdf.

Country	Non-spectrum related fees	Spectrum-related fees (covering both regulatory cost and spectrum value-based fees)
Denmark	No fee	Annually recurring fixed fee per 200kHz spectrum lot designed to cover the regulatory costs
Finland	No fee	Diminishing annual fee covering regulatory costs only
France	Annually recurring fixed fee	Annually recurring fixed fee per MHz implemented on the basis of spectrum value
Germany	Frequency use contribution	Fixed annually recurring fee per licence reflecting the regulatory costs
Greece	Between 0.025% and 0.5% of annual revenues	Fixed annually recurring fee set off against the original licence fee
Ireland	0.2% of annual revenues	Fixed annually recurring fee per channel weighted by spectrum band, thereby reflecting the value of the spectrum
Italy	Fixed annually recurring fee	1.5% of annual turnover,[118] this is a value-based charge but does not scale with spectrum holdings and is not specific to GSM, as the operator turnover is based on operations using all spectrum holdings
Luxembourg	0.2% of gross turnover	Fixed annually recurring fee per channel, these cover the costs to the regulator
Netherlands	Fixed annually recurring fee	Fixed annually recurring fee per paired MHz, this fee does not cover the costs of regulation, but it implemented to reflect the value of the spectrum
Portugal	Fixed annually recurring fee	Fixed annually recurring fee per base station, plus fixed annually recurring fee per mobile terminal, these fees cover regulatory costs only
Spain	Up to 0.2% of annual revenues	Fixed annually recurring fee per kHz of spectrum, reflecting its opportunity cost
Sweden	Fixed annually recurring fee plus 0.15% of annual revenue	Fixed annually recurring fee per base station transmitter, this covers the regulatory costs of spectrum management
UK	Up to 0.08% of annual revenues	Fixed annually recurring fee per channel, differentiated by frequency band,[119] these fees are implemented on the basis of spectrum value

A summary of factors used in the 2G spectrum fee calculations in various EU Member States is shown in Figure C.2 below.

118 The percentage turnover used in the calculation of the Italian spectrum fees fell annually from when it was first charged in 1999 as follows: 1999, 3%; 2000, 2.7%; 2001, 2.5%; 2002, 2%; 2003, 1.5%.

119 This fee acted as a form of AIP, with early licences having a low fee rate per channel set on the year of issue, increasing at each anniversary of the licence. This ensured that later entrants to the market would benefit from the same relatively low initial fees as the early entrants. However, as a result of a fall in the number of potential new entrants, a single fee per channel per year was later introduced. See http://stakeholders.ofcom.org.uk/binaries/research/spectrum-research/evaluation_report_AIP.pdf.

Figure C.2: Inputs to spectrum usage fee calculations in selected EU Member States [Source: Study on administrative and frequency fees related to the licensing of networks involving the use of frequencies, 2001]

	BE	DK	FR	IE	IT	NL	SE	UK
Frequency band				✓				✓
Spectrum amount	✓	✓	✓	✓		✓		✓
Number of base stations							✓	
Spectrum market value	✓		✓			✓		✓
Licensing costs						✓	✓	
Frequency management costs			✓			✓	✓	
Revenues					✓			

Similarly, we have collected a set of data on the calculation methodologies used in the setting of one-off spectrum fees. This can be seen below in Figure C.3.

Figure C.3: Structure of one-off GSM spectrum and non-spectrum-related fees [Source: Study on administrative and frequency fees related to the licensing of networks involving the use of frequencies, 2001; ITU Trends in Telecommunication reform, 2004]

Country	Non-spectrum related fees	Spectrum-related fees covering both regulatory cost and spectrum value-based fees)
Austria	Fixed fee set by the government	Based on the auction results, thereby reflecting the operator's value of the spectrum
Belgium	Fixed fee referred to as a 'filing fee'	Based on the auction results, thereby reflecting the operator's value of the spectrum
Denmark	None	None
Finland	None	None
France	Based on the geographical coverage of the licence	None
Germany	Fee based on the administrative spending in each case	Fixed cost per channel reflecting the costs to the regulator of spectrum management
Greece	Unknown	Based on the auction results, thereby reflecting the operator's value of the spectrum
Ireland	Fixed fee charged on the third licence only	Fixed by band
Italy	Fixed fee	Overall cost set and split amongst the operators, half of the split based on their spectrum holdings and half on their income[120]
Luxembourg	Fixed fee	None
Netherlands	Fixed, but only charged if operator designated with SMP	None
Portugal	Fixed fee	Fixed cost per base station to cover the regulatory costs of spectrum assignment and management
Spain	None	None
Sweden	Fixed fee	None
UK	Fixed fee	None

As discussed in Section 10.1, the dominant methodologies for the calculation of one-off fees are to derive them from auction results or have the government set them in advance. The above benchmark shows that the majority of non-spectrum-related fees are administratively set (i.e. fixed by the government), while spectrum-related fees are often based on the auction results.

120 This is to be paid over a period of five years.

Annex D REDACTED: Detailed spectrum demand modelling inputs (including operator data)

This annex contains details of the spectrum demand modelling inputs, including figures derived from operator data, and as such has not been released in the final public version of the report.

[REDACTED]

Annex E Modelled spectral efficiencies

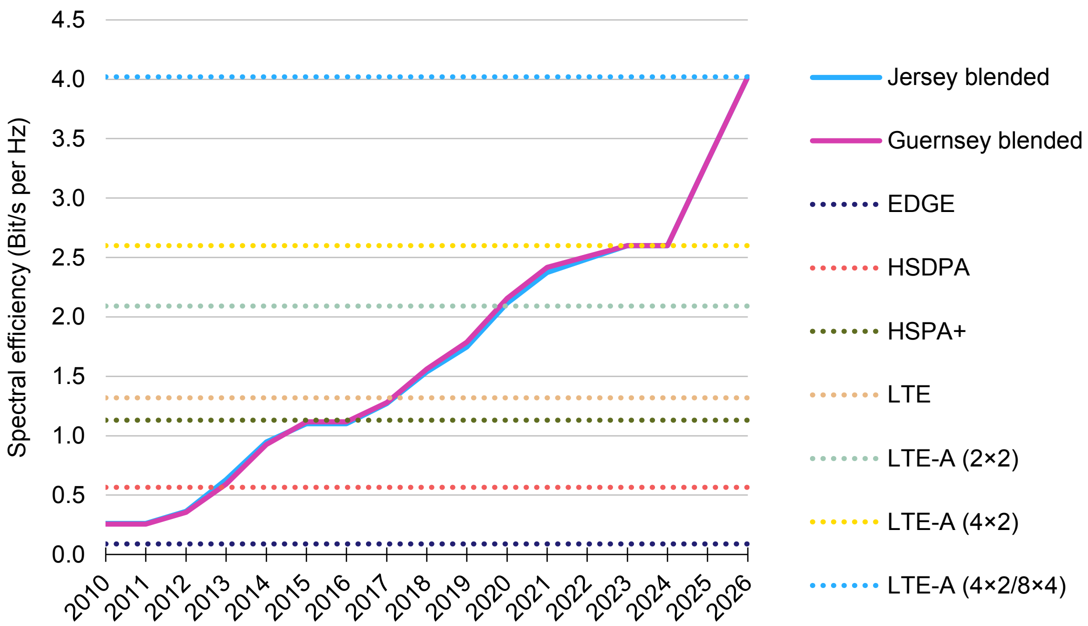
The spectral efficiencies chosen for the modelling were taken from the Real Wireless '4G Capacity Gains' report as detailed in Section 3.4.

Figure E.1: Spectral efficiency assumptions for modelled technologies [Source: Analysys Mason, 2013]

Technology	Spectral efficiency (bit/s per Hz)	Equivalent Real Wireless configuration	Technology assumptions
EDGE	0.09	N/A	N/A
HSDPA	0.57	Average of 'HSPA Rel-5' and 'HSPA Rel-6', Typical expected roll-out	Rx diversity 1×2, 15 codes, 16QAM
HSPA+	1.13	HSPA+ Rel-7/8, High-end	MIMO 2×2, 15 codes, 64QAM
LTE (20MHz)	1.32	LTE Rel-8, Typical expected roll-out	SU-MIMO 2×2, 20MHz
LTE-A (2×2)	2.09	LTE-A Rel-10, Low-end	SU-MIMO 2×2
LTE-A (4×2)	2.60	LTE-A Rel-10, Typical expected roll-out	MU-MIMO 4×2
LTE-A (4×2,8×4)	4.02	Average of LTE-A Rel-10, Typical expected roll-out and High-end	MU-MIMO 4×2 JP-CoMP 8×4

Using these efficiencies and the technology timeline described in Section 6.3.6, the blended spectral efficiency was calculated as shown in Figure E.2.

Figure E.2: Blended spectral efficiency used to calculate spectrum demand assuming an even split of all available spectrum in each band [Source: Analysys Mason, 2013]



Annex F Spectrum demand sensitivities by operator

Below we provide the detailed operator-by-operator spectrum demand, modelling results for each of our sensitivities summarised in Section 7.2. These sensitivities are used to test the impact of specific parameters on the results of the modelling, and the operator-by-operator results allow for a more detailed understanding of how the parameters would affect each operator in each market.

As detailed in Section 7.2 the following parameters and assumptions have been sensitivity-tested:

- the LTE-A spectral efficiency
- the level of mobile offloading onto WiFi
- the traffic forecasts used for both mobile and fixed subscriber data usage
- the long-term operator market share assumptions
- the difference in site growth between the Channel Islands, including the extreme of no site growth.

F.1 Sensitivity 1: Impact of different LTE-A spectral efficiency parameters

In Sensitivity 1, below, we assume the LTE-A spectral efficiency does not increase beyond Rel-10, SU-MIMO 2×2.

Figure F.1: Spectrum requirements for ***Airtel-Vodafone*** *under Sensitivity 1 [Source: Analysys Mason, 2013]*

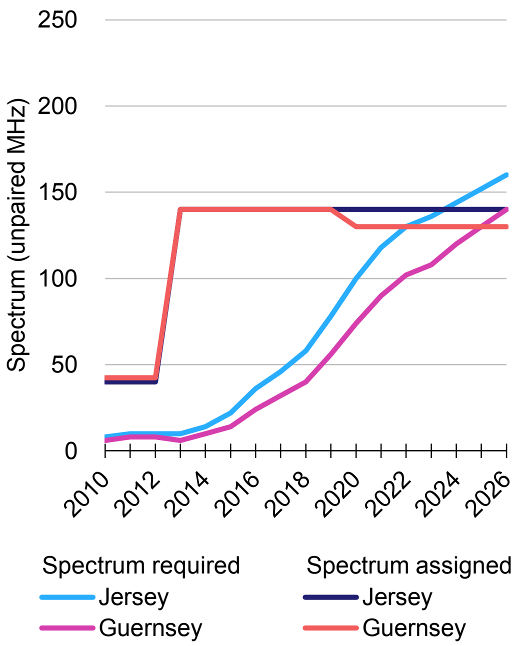


Figure F.2: Spectrum requirements for ***Jersey Telecom*** *under Sensitivity 1 [Source: Analysys Mason, 2013]*

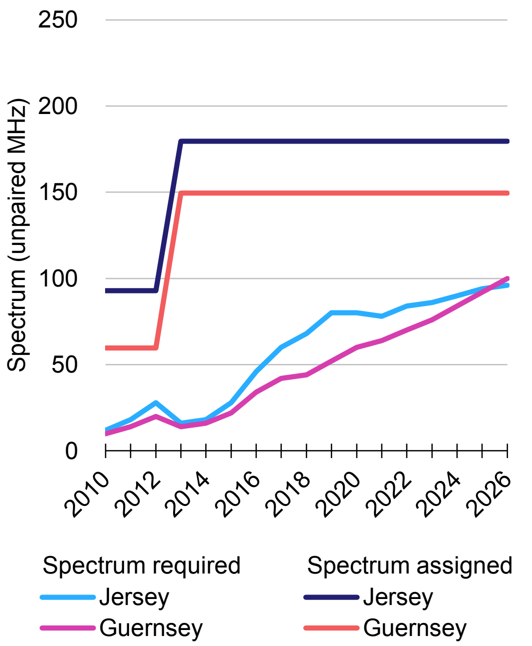
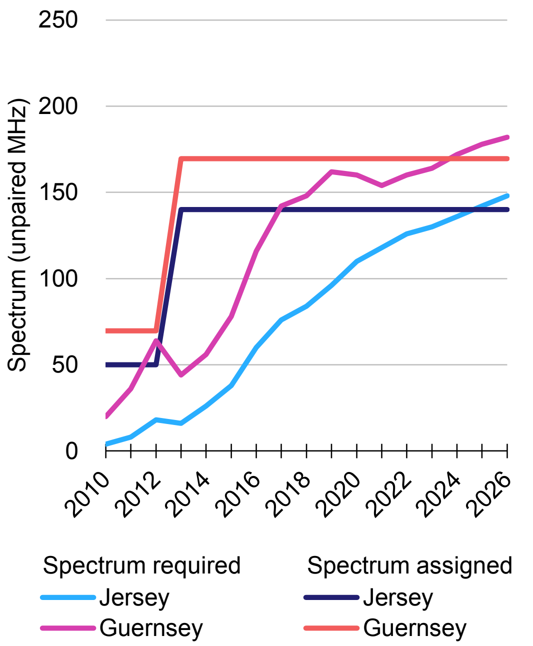


Figure F.3: Spectrum requirements for ***Sure (C&W)*** *under Sensitivity 1 [Source: Analysys Mason, 2013]*



F.2 Sensitivity 2: Impact of different mobile offloading assumptions

In Sensitivity 2a, below, we assume the Analysys Mason Research level of offloading of mobile traffic on to WiFi.

*Figure F.4: Spectrum requirements for **Airtel-Vodafone** under Sensitivity 2a [Source: Analysys Mason, 2013]*

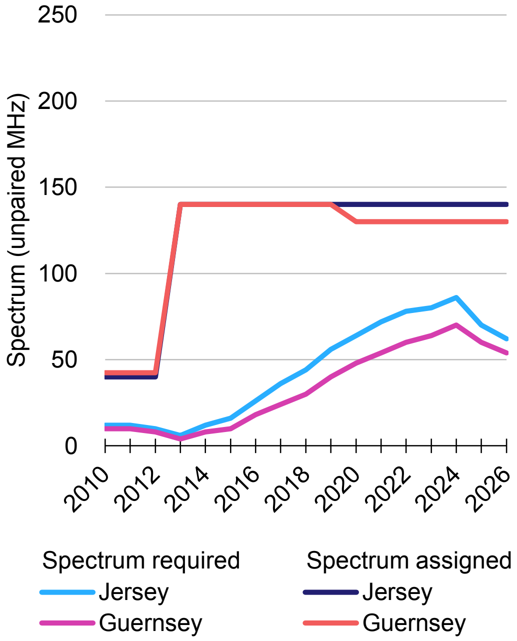


*Figure F.5: Spectrum requirements for **Jersey Telecom** under Sensitivity 2a [Source: Analysys Mason, 2013]*

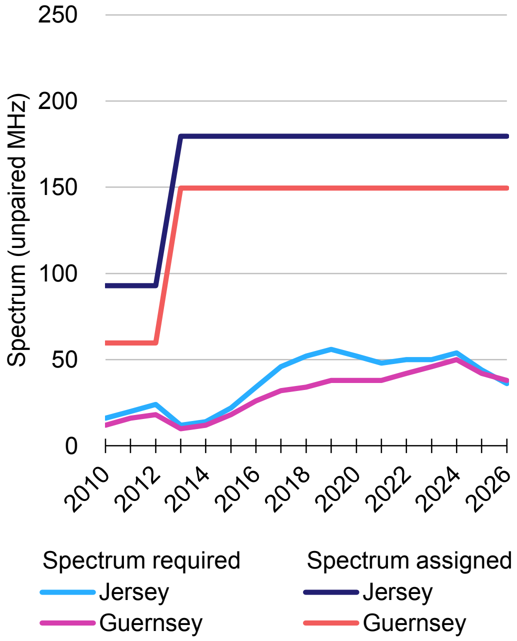
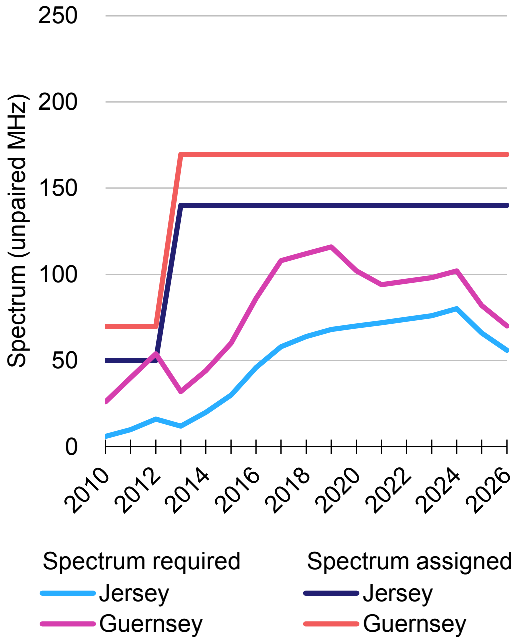


*Figure F.6: Spectrum requirements for **Sure (C&W)** under Sensitivity 2a [Source: Analysys Mason, 2013]*



In Sensitivity 2b, below, we assume 0% offloading of mobile traffic on to WiFi.

*Figure F.7: Spectrum requirements for **Airtel-Vodafone** under Sensitivity 2b [Source: Analysys Mason, 2013]*

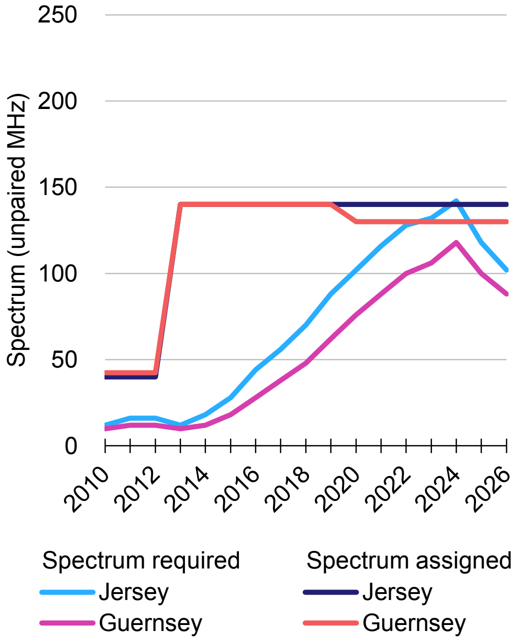


*Figure F.8: Spectrum requirements for **Jersey Telecom** under Sensitivity 2b [Source: Analysys Mason, 2013]*

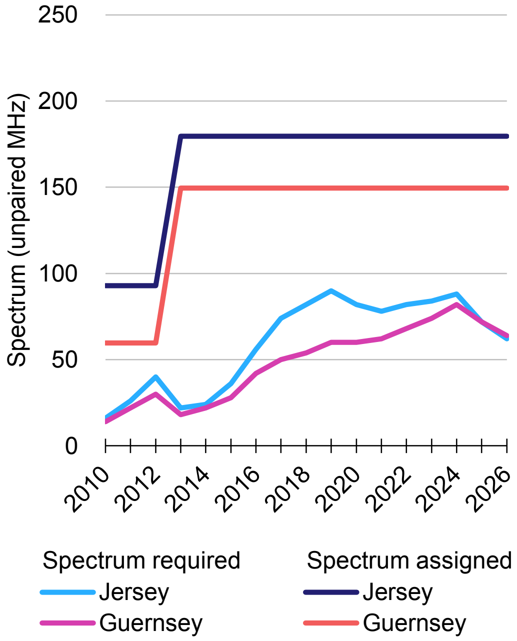
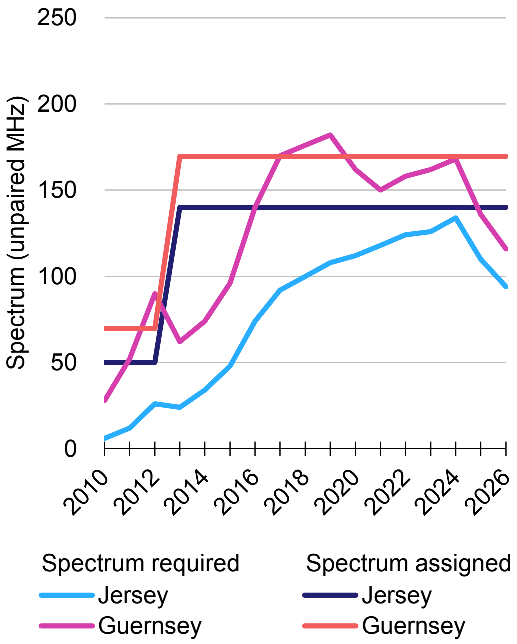


*Figure F.9: Spectrum requirements for **Sure (C&W)** under Sensitivity 2b [Source: Analysys Mason, 2013]*



F.3 Sensitivity 3: Impact of different data traffic forecasts

In Sensitivity 3a, below, we change both the mobile and fixed data per subscriber forecast to match Cisco's Western European forecast.

*Figure F.10: Spectrum requirements for **Airtel-Vodafone** under Sensitivity 3a [Source: Analysys Mason, 2013]*

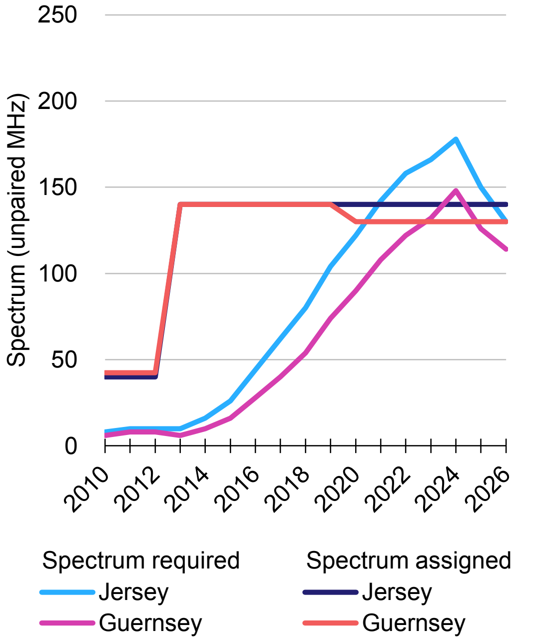


*Figure F.11: Spectrum requirements for **Jersey Telecom** under Sensitivity 3a [Source: Analysys Mason, 2013]*

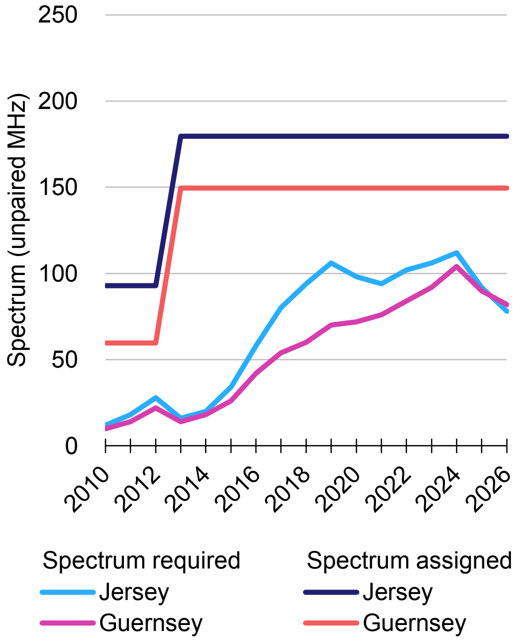
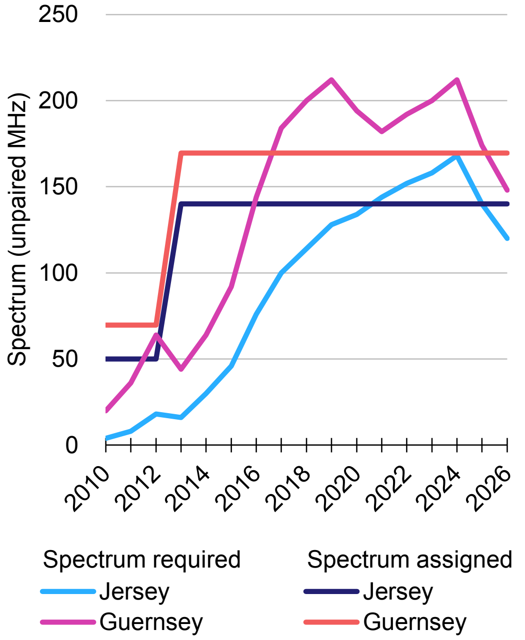


*Figure F.12: Spectrum requirements for **Sure (C&W)** under Sensitivity 3a [Source: Analysys Mason, 2013]*



In Sensitivity 3b, below, we change both the mobile and fixed data per subscriber forecast to match Analysys Mason Research's UK traffic forecast.

Figure F.13: Spectrum requirements for ***Airtel-Vodafone*** *under Sensitivity 3b [Source: Analysys Mason, 2013]*

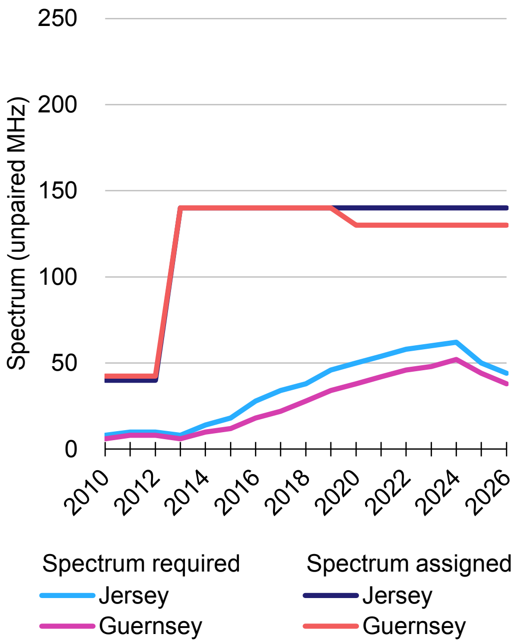


Figure F.14: Spectrum requirements for ***Jersey Telecom*** *under Sensitivity 3b [Source: Analysys Mason, 2013]*

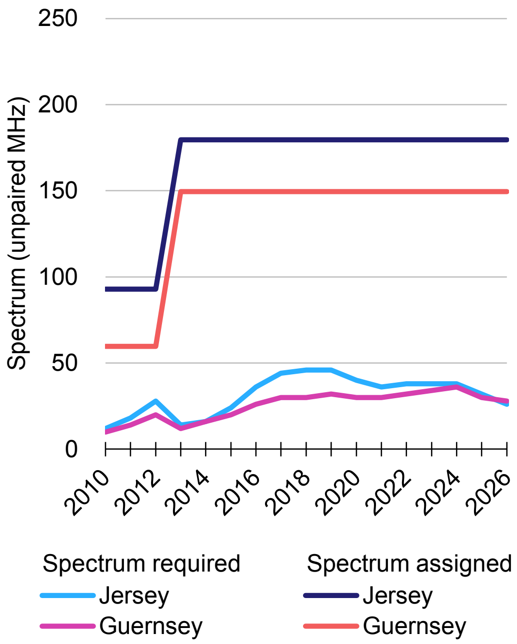
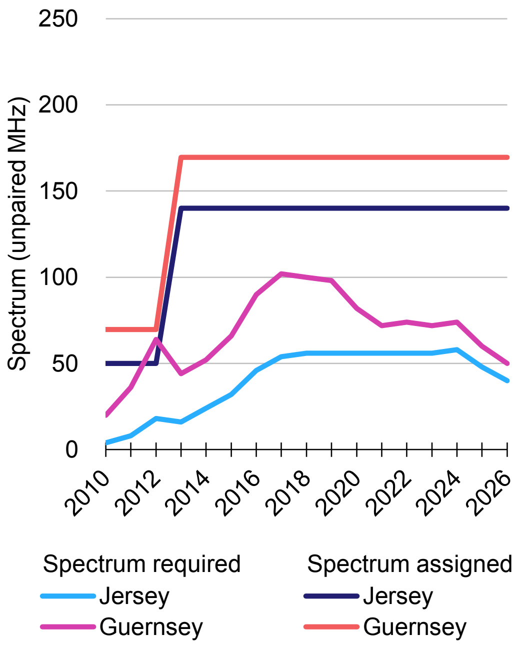


Figure F.15: Spectrum requirements for ***Sure (C&W)*** *under Sensitivity 3b [Source: Analysys Mason, 2013]*



F.4 Sensitivity 4: Impact of different long-term operator market share assumptions

In Sensitivity 4, below, we change the long-term market share assumptions, with operators' market shares assumed to remain flat beyond 2017.

*Figure F.16: Spectrum requirements for **Airtel-Vodafone** under Sensitivity 4 [Source: Analysys Mason, 2013]*

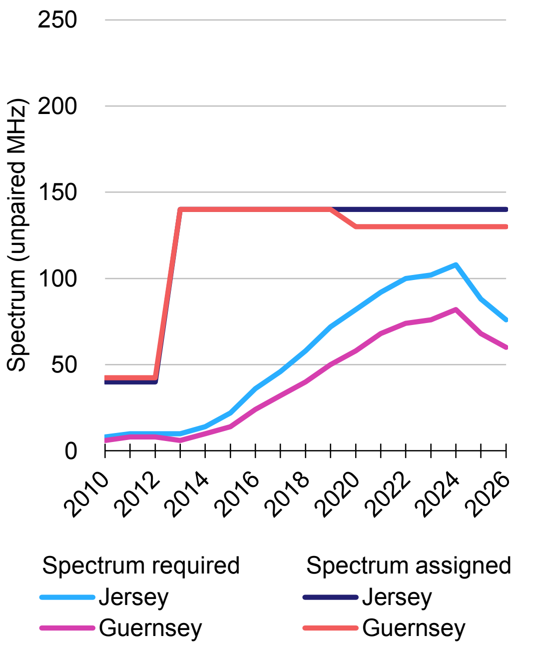


*Figure F.17: Spectrum requirements for **Jersey Telecom** under Sensitivity 4 [Source: Analysys Mason, 2013]*

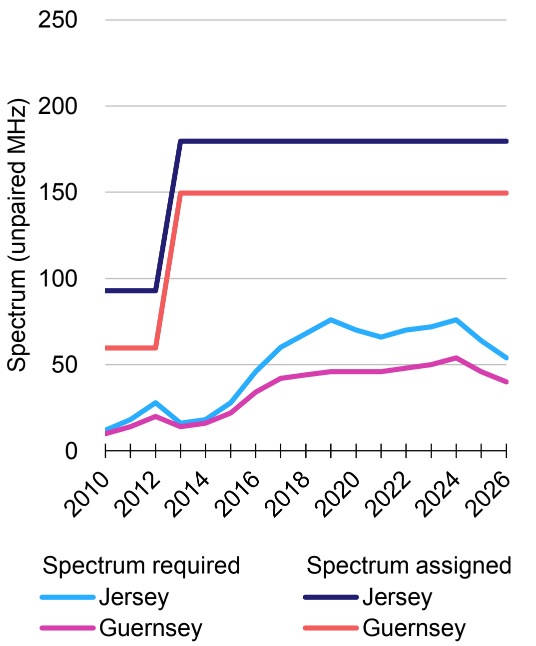
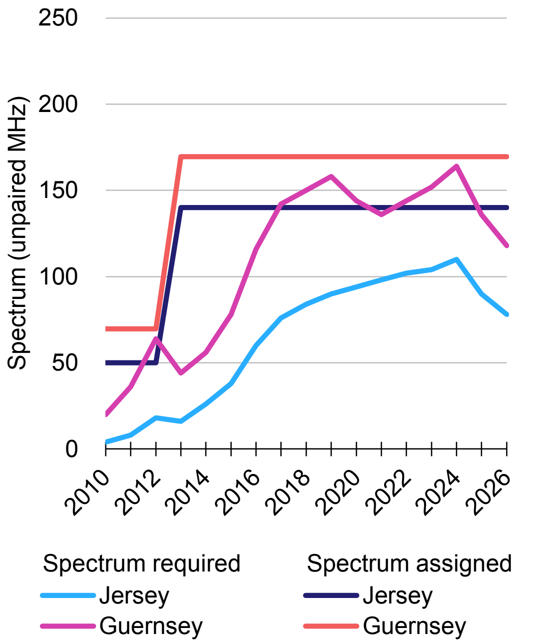


*Figure F.18: Spectrum requirements for **Sure (C&W)** under Sensitivity 4 [Source: Analysys Mason, 2013]*



F.5 Sensitivity 5: Impact of different site growth assumptions between the Channel Islands

In Sensitivity 5a, below, we remove the difference in site growth between Jersey and Guernsey, assuming the Scenario 2 (base case) site growth across the Channel Islands.

*Figure F.19: Spectrum requirements for **Airtel-Vodafone** under Sensitivity 5a [Source: Analysys Mason, 2013]*

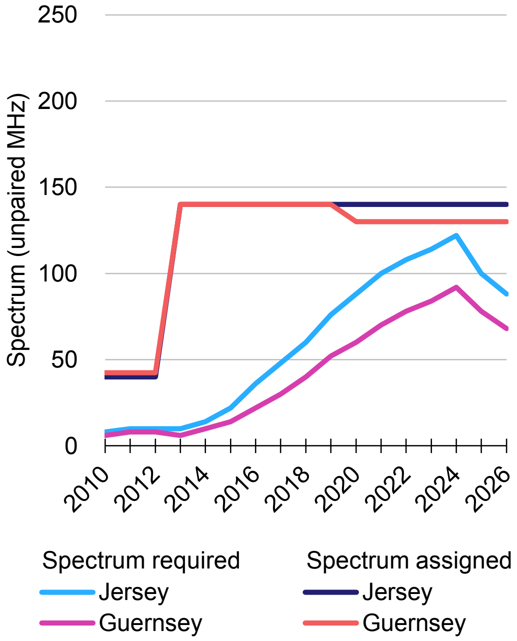


*Figure F.20: Spectrum requirements for **Jersey Telecom** under Sensitivity 5a [Source: Analysys Mason, 2013]*

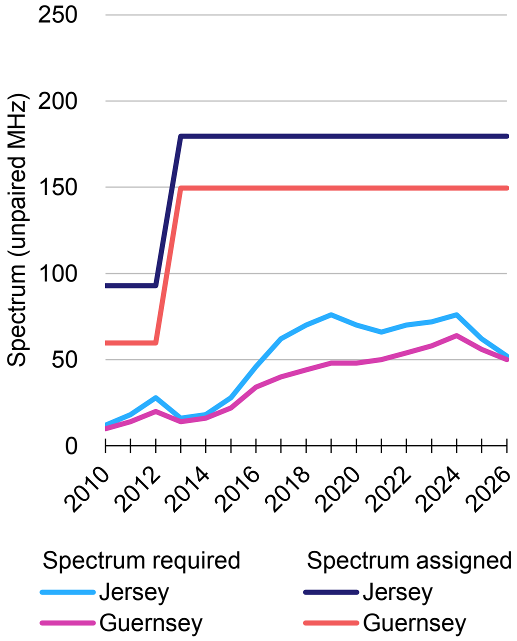
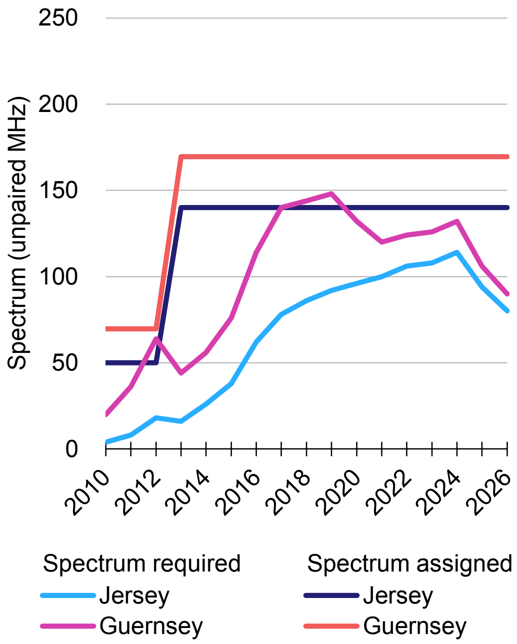


*Figure F.21: Spectrum requirements for **Sure (C&W)** under Sensitivity 5a [Source: Analysys Mason, 2013]*



In Sensitivity 5b, below, we remove the difference in site growth between Jersey and Guernsey, assuming the Scenario 5 (low case) site growth across the Channel Islands.

*Figure F.22: Spectrum requirements for **Airtel-Vodafone** under Sensitivity 5b [Source: Analysys Mason, 2013]*

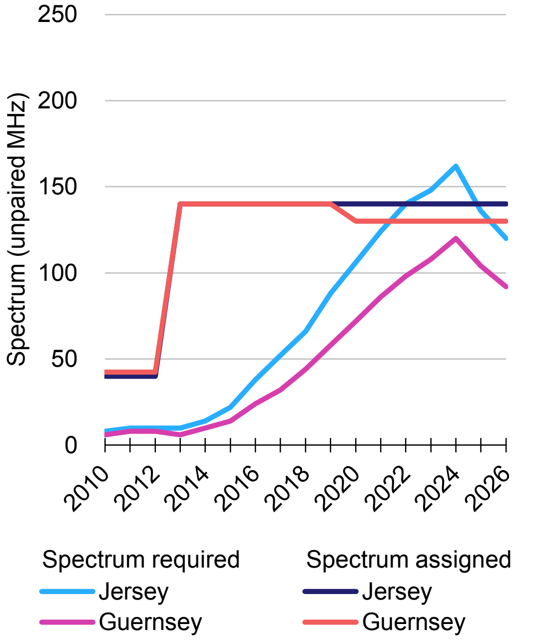


*Figure F.23: Spectrum requirements for **Jersey Telecom** under Sensitivity 5b [Source: Analysys Mason, 2013]*

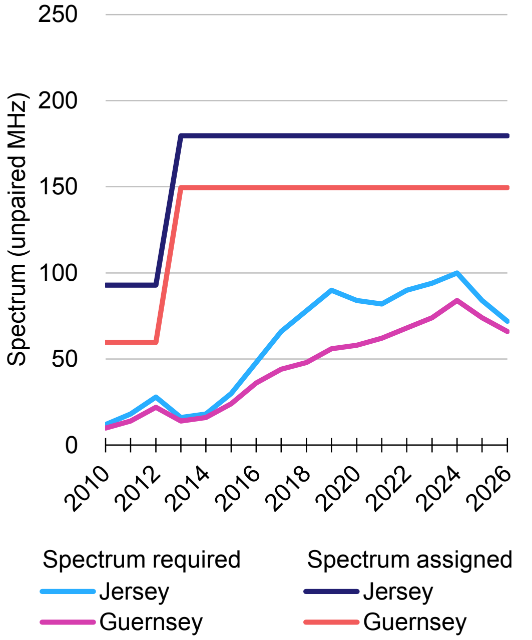
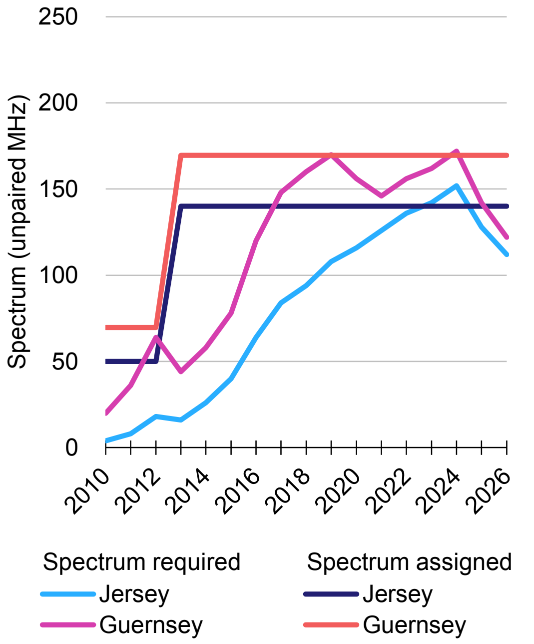


*Figure F.24: Spectrum requirements for **Sure (C&W)** under Sensitivity 5b [Source: Analysys Mason, 2013]*



In Sensitivity 5c, below, we assume 0% growth across both of the Channel Islands.

Figure F.25: Spectrum requirements for ***Airtel-Vodafone*** *under Sensitivity 5c [Source: Analysys Mason, 2013]*

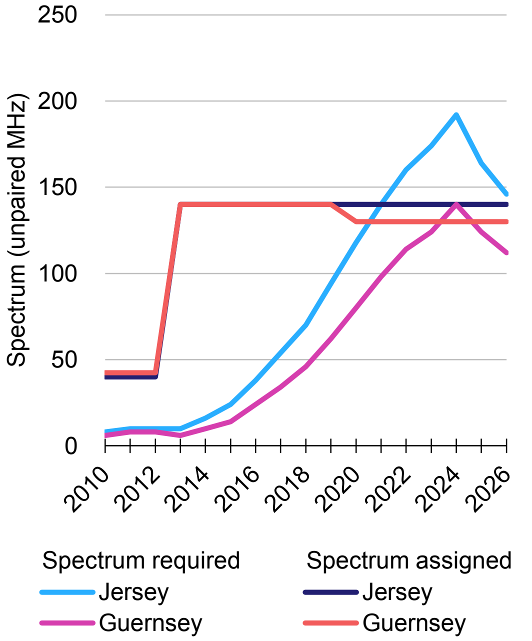


Figure F.26: Spectrum requirements for ***Jersey Telecom*** *under Sensitivity 5c [Source: Analysys Mason, 2013]*

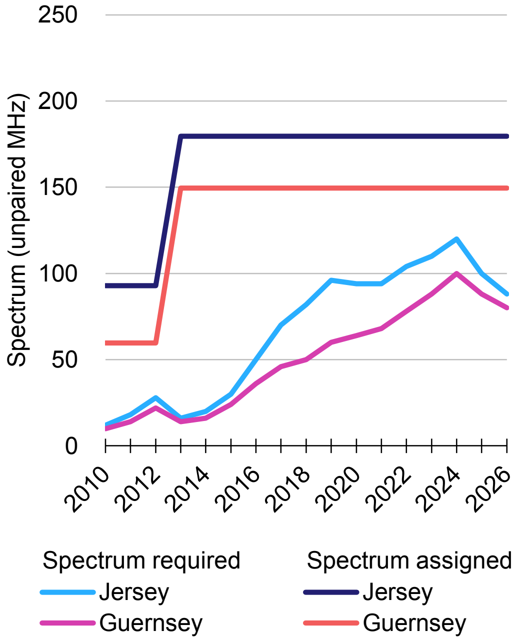
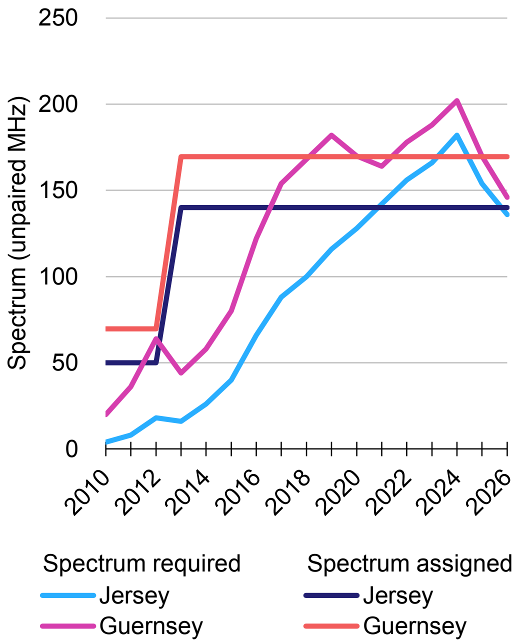


Figure F.27: Spectrum requirements for ***Sure (C&W)*** *under Sensitivity 5c [Source: Analysys Mason, 2013]*



Annex G Approaches to 4G spectrum release within selected EU countries

G.1 UK

In the UK, as noted previously, Ofcom is proposing to meet future demand for spectrum for mobile broadband services through two related policies:

- award of new mobile spectrum licences to use spectrum between 790–862MHz ('the 800MHz band') and 2500–2690MHz ('the 2.6GHz band') in early 2013
- liberalisation of 2G spectrum (in the 900MHz and 1800MHz bands), such that existing 2G operators can refarm their existing spectrum assignments for 3G/4G use.

Ofcom is scheduled to auction spectrum in the 800MHz and 2.6GHz bands in January 2013. In the 800MHz band, Ofcom is making two different types of frequency lot available: generic lots of 2×5MHz in 800MHz blocks one to four (791–811MHz and 832–852MHz), which are being made available without any associated coverage obligation, and a specific 2×10MHz lot in the remaining blocks five and six (811–821MHz paired with 852–862MHz), which includes a coverage obligation.[121]

In the 2.6GHz band, Ofcom is proposing to package the paired and unpaired spectrum in 2×5MHz blocks, incorporating 14 paired blocks and nine unpaired blocks (one unpaired block is reserved as a guard band between the paired and unpaired blocks). In the paired band, the auction design allows up to 2×20MHz of spectrum to be awarded for concurrent use at low powers (rather than for individual use at higher powers), based on market demand (that is, if there is no demand for concurrent low-power licences to be offered, then all of the paired spectrum will be sold for individual use).

In order to reach an agreement regarding the refarming of 2G spectrum, Ofcom has consulted upon the conditions for 2G to 3G refarming (more broadly referred to as liberalisation) in a sequence of public consultation documents over the past few years. The most recent consultation was a document published in January 2012.[122] As a result of these consultation documents, Ofcom decided that the three existing 2G spectrum holds should be allowed to retain their existing spectrum for 3G use. Ofcom has subsequently liberalised use of the 1800MHz spectrum (held by EE) for LTE, but, to date, has only liberalised the 900MHz spectrum (held by Vodafone and O2) for use by UMTS.

While Ofcom's decision to liberalise existing 2G licences for the current licence holders originally left the UK's 3G entrant, Three, at a disadvantage compared to the other operators, this has now been

121 The coverage obligation requires the purchaser to provide a service with a sustained downlink speed of at least 2Mbit/s to 98% of the UK population, incorporating 95% of the population in each UK region (England, Scotland, Wales and Northern Ireland), for outdoor and selected indoor locations.

122 http://stakeholders.ofcom.org.uk/binaries/consultations/award-800mhz/summary/combined-award-2.pdf.

partially rectified through the private sale of 1800MHz spectrum from EE to Three.[123] It is noted that the 1800MHz spectrum that EE will divest to Three will not be available for Three's use until late 2013, however.

The resulting distribution of 900MHz and 1800MHz spectrum in the UK is now as follows:

Figure G.1: Distribution of 900MHz and 1800MHz spectrum in the UK, following transfer of 1800MHz spectrum from EE to Three [Source: Analysys Mason, 2012]

Operator	900MHz	1800MHz
Vodafone	2×17.5MHz	2×5MHz
O2	2×17.5MHz	2×5MHz
EE	-	2×45MHz
Three	-	2×15MHz

As a result of Ofcom's decision to liberalise the 1800MHz band for LTE use, EE recently launched the UK's first commercial 4G service, with the intention of covering all of the major UK cities by the end of 2012. O2 has also refarmed some of its 900MHz 2G spectrum for 3G use. Vodafone is yet to refarm its 900MHz spectrum.

G.2 France

ARCEP completed its spectrum auctions for 4G licences in the 800MHz and 2.6GHz bands in late 2011. It has additionally been involved in the refarming and reauthorisation of what were originally the 2G 900MHz and 1800MHz bands, since 2006. This spectrum refarming process was closely linked with the introduction to the French mobile market of a fourth 3G operator, Illiad Free Mobile (Free). Award of the new 3G licence and the associated refarming of 2G spectrum were completed ahead of the auctions of 800MHz and 2.6GHz spectrum, so that all players, including the new 3G entrant, could bid for new 4G spectrum. In early 2006, ARCEP began the process of liberalising the 900MHz and 1800MHz spectrum bands to be used for technologies other than 2G, with the SFR and Orange licences renewed to allow use for UMTS service provision. This increased liberalisation came with more coverage obligations and was extended to Bouygues when its GSM licences were renewed in 2009.

As a result of interest from SFR and Orange to enter into refarming of the 900MHz licences, a beauty contest for a fourth 3G licence was launched in 2009. This was won by Free, requiring SFR, Orange and Bouygues to make available part of their spectrum allocations within a certain time period after the beauty contest results:

- Bouygues: to free up 2×4.8MHz of spectrum outside high density areas, within 18 months of the authorisation of a fourth operator

123 Conditions placed on Everything Everywhere as a result of the T-Mobile/Orange merger required the combined operator to divest 2×15MHz of spectrum.

- SFR: to free up 2×2.4MHz of spectrum inside high density areas, within two years of the authorisation of a fourth operator
- Orange: to free up 2×2.4MHz of spectrum inside high density areas, within two years of the authorisation of a fourth operator.

As a result of the 2009 EC Decision on the harmonisation of the 900MHz and 1800MHz bands[124] and the corresponding 2011 amendments[125], the 900MHz and 1800MHz licences are now technology-neutral in France, allowing them to be used for UMTS, LTE or WiMAX technologies.

Unlike in the 900MHz band, there has not yet been any refarming of spectrum licences in the 1800MHz band. However, a public consultation and potential redistribution could be triggered if one of the current licence holders were to request it.

Before spectrum was refarmed, the distribution of 900MHz and 1800MHz spectrum was as shown in the table below:

Figure G.2: 2G spectrum holdings in France before redistribution [Source: 2008 European mobile spectrum bands, ERO]

Operator	900MHz	1800MHz
Orange France	2×12.4MHz (high density), 2×10MHz (other areas)	2×23.8MHz
SFR	2×12.4MHz (high density), 2×10MHz (other areas)	2×2.8MHz, 2×21MHz
Bouygues Telecom	2×9.8MHz (all areas), 2×4.8MHz (non-high density areas)	2×26.6MHz (high density), 2×21.6MHz (other areas)

Following the refarming of the 900MHz spectrum, and taking into account the introduction of Free to the mobile market, 900MHz and 1800MHz assignments are now as shown in the table below:

Figure G.3: 900MHz and 1800MHz assignments per operator in France after redistribution [Source: Mobile bands in CEPT, ECO]

Operator	900MHz	1800MHz
Orange France	2×10MHz	2×23.8MHz
SFR	2×10MHz	2×2.8MHz, 2×21MHz
Bouygues Telecom	2×9.8MHz	2×26.6MHz (high density) 2×21.6MHz (other areas)
Free Mobile	2×5MHz	-

124 (2009/766/EC), Official Journal of the European Union, Commission Decision, October 16, 2009, http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:274:0032:0035:EN:PDF.

125 (2011/251/EC), Official Journal of the European Union, Commission Decision 2011/251/EC amending Decision 2009/766/EC, 18 April 2011, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:106:0009:0010:EN:PDF.

The 800MHz and 2.6GHz auctions subsequently awarded additional spectrum to all four operators. Free Mobile gained 2×20MHz of spectrum in the 2.6GHz band, which was more than two of the incumbents (Bouygues and SFR), which gained 2×15MHz each. Free Mobile did not secure 800MHz spectrum (which was won by the existing three players), but Free has secured rights to access SFR's network on a national roaming basis.

G.3 Ireland

ComReg chose not to refarm the existing 900MHz and 1800MHz spectrum licences administratively, but rather to conduct a combined auction involving existing 900MHz and 1800MHz assignments, plus new spectrum in the 800MHz band. The new licences awarded as a result of the auction come into force from the end of the current licence period. The 2.6GHz band is not available at present for 4G use in Ireland, since it is being used by a broadcaster providing multipoint video distribution services (MVDS) as a cable-TV replacement service in rural areas.

The results of the combined auction were announced in November 2012. The auction split the available spectrum into 5MHz paired blocks (lots) that were available on a generic or bidder-specific basis. The licences were also made available across two 'time slices' as a result of differences in the end dates of previous licensing periods:

- Time Slice 1: begins in early 2013, ending in mid-2015
- Time Slice 2: begins in mid-2015, at the end of Time Slice 1, and lasts for 15 years.

Those licences in existence during Time Slice 1 are a combination of legacy licences, which will continue to be GSM-only, and liberalised licences, which will be those newly allocated as a result of the auction and licensed for technologies including GSM, UMTS, LTE and WiMAX. All licences during Time Slice 2 are liberalised.

Before the 2012 combined spectrum auction, the distribution of 900MHz and 1800MHz spectrum was as shown in the table below:

Figure G.4: 2G spectrum holdings in Ireland before the 2012 auction [Source: 2008 European mobile spectrum bands, ERO]

Operator	900MHz	1800MHz
Vodafone Ireland Ltd	2×7.2MHz	2×14.4MHz
Telefonica O2	2×7.2MHz	2×14.4MHz
Meteor Mobile	2×7.2MHz	2×14.4MHz

The results of the auction, published in November 2012, indicate the following liberalised and legacy licences for Time Slice 1, covering the period 2013–2015, as shown in the table below:

Figure G.5: 900MHz and 1800MHz assignments per operator in Ireland during Time Slice 1[Source: ComReg Frequency Arrangements and Results of the Multi-Band Spectrum Award Process, 2012]

Operator	900MHz	1800MHz
Vodafone Ireland Ltd	2×10MHz (liberalised)	2×15MHz (liberalised)
Telefonica O2	2×10MHz (liberalised)	2×14.4 (legacy)
Meteor Mobile	2×5MHz (legacy) 2×5MHz (liberalised)	2×10MHz (legacy) 2×10MHz (liberalised)
Hutchinson 3G (Hi3G)	2×5MHz (liberalised)	2×10MHz (liberalised)

Similarly, the auction results show that for Time Slice 2, covering the period 2015–3030, the licences will be as shown in the table below:

Figure G.6: 900MHz and 1800MHz assignments per operator in Ireland during Time Slice 2 [Source: ComReg Frequency Arrangements and Results of the Multi-Band Spectrum Award Process, 2012]

Operator	900MHz	1800MHz
Vodafone Ireland Ltd	2×10MHz	2×25MHz
Telefonica O2	2×10MHz	2×15MHz
Meteor Mobile	2×10MHz	2×15MHz
Hutchinson 3G (Hi3G)	2×5MHz	2×20MHz

This combined auction additionally resulted in liberalised 800MHz spectrum licences of 2×10MHz in both Time Slices 1 and 2 for Meteor, Telefonica and Vodafone. All of the liberalised licence holders have a coverage obligation of 70% of the population of Ireland, within a period of time determined by whether or not it is an existing mobile network operator (MNO):

- Existing MNOs have three years from the issue of the liberalised licence to fulfil this coverage obligation.
- New entrants have seven years from the issue of the liberalised licence to fulfil the 70% coverage obligation, with an interim coverage obligation of 35% of the population of Ireland within three years.

G.4 Sweden

The Swedish Post and Telecom Authority (PTS) has auctioned spectrum for 4G services in the 800MHz, 1800MHz and 2.6GHz bands, but has also negotiated an agreement between existing operators to redistribute existing 900MHz and 1800MHz assignments. This was primarily to even out spectrum assignments between the original 2G operators in Sweden, and the new 3G entrant, Hutchison 3G (H3G).

The 900MHz band was redistributed following a joint application submitted to the regulator by the five operators proposing a reassignment of 900MHz spectrum, in order to enable a 2×5MHz block to be assigned to H3G. In the 1800MHz band, reassignment of 2×10MHz of spectrum to each of the 2G operators was made by direct award to those operators, and the remaining 2×40MHz of spectrum in the 1800MHz band was auctioned.

Sweden was also one of the first European countries to auction 4G licences for the 2.6GHz band, and then subsequently 4G licences for the 800MHz band.

Four operators originally held 2G spectrum in Sweden in the 900MHz and 1800MHz bands (TeliaSonera, Tele2, Telenor and Swefour). Three operators held 3G licences in the 2.1GHz band (a TeliaSonera and Tele2 joint venture, Telenor and H3G).

However, it should also be noted that Tele2 and Telenor subsequently combined their network operations into a single company, Net4Mobility. The combined entity was allowed to bid for 4G spectrum in the 800MHz and 2.6GHz bands, and redistribution of 1800MHz spectrum has also resulted in Net4Mobility being assigned a combined spectrum holding.

Before spectrum was redistributed, the distribution of 900MHz and 1800MHz spectrum was as follows:

Figure G.7: 2G spectrum holdings before redistribution [Source: 2008 European mobile spectrum bands, ERO]

Operator	900MHz assignment	1800MHz assignment
TeliaSonera	2×7.2MHz	2×18.4MHz
Tele 2	2×6.7MHz	2×3MHz
Telenor	2×7.2MHz	2×3MHz
Swefour	2×6.8MHz	2×3MHz

Following reassignment, and taking into account the creation of Net4Mobility, 900MHz and 1800MHz assignments are now as follows:

Figure G.8: 900MHz and 1800MHz assignments per operator after redistribution [Source: Mobile bands in CEPT, ECO]

Operator	900MHz	1800MHz
H3G	2×5MHz	-
Net4Mobility (Tele2 and Telenor)	2×6MHz	One 2×5MHz block until May 2017, a further 2×20MHz until 2027 and a further 2×10MHz until 2037.
Tele 2	2×9MHz	-
Telenor	2×5MHz	-
TeliaSonera	2×10MHz	One 2×10MHz block until May 2017 and a further 2×25MHz block until 2037.

In the 800MHz band, H3G, Net4Mobility and TeliaSonera each hold 2×10MHz of spectrum. In the 2.6GHz band, Net4Mobility holds 2×40MHz of spectrum, TeliaSonera holds 2×20MHz and H3G holds 2×10MHz. There is a coverage obligation on one of the 800MHz licences, to cover areas of low population density with 4G services. All of the 900MHz licences have coverage obligations attached, for 2G/3G coverage.

G.5 Denmark

In 2007, the DBA (previously known as NITA) began discussions relating to the refarming of GSM spectrum licences in the 900MHz and 1800MHz bands. The goals of this process included:

- the introduction of a new entrant into both of the spectrum bands
- the lifting of technology restrictions imposed on the licences
- the redistribution of spectrum in both the 900MHz and 1800MHz bands to allow each licensee contiguous bandwidth.

The introduction of the “Frekvensforum” in June 2007, with is twice-annual meetings involving all market players, gave DBA a forum in which to discuss the refarming decisions and processes with all interested parties between 2007 and 2010. It was at the Frekvensforum meeting in June 2008 that the mobile operators indicated their interest in the beginning of formal negotiations on the topic.

On 30 October 2009, DBA published its consultation on the redistribution of licences in the 900MHz and 1800MHz frequency bands[126], with all comments received and its final decision being made in December 2009.

The result of this consultation was that operators holding licences in the 900MHz band had the terms of their licences extended, from the original end dates of 2011 or 2012 to 2019, while some redistribution of the spectrum allowed all operators to have access to contiguous spectrum, with 2×5MHz freed up for auction. Similarly, redistribution of spectrum in the 1800MHz band enabled 2×10MHz to be available for auction, with 1800MHz licence terms maintaining their June 2017 end date. For all of these refarmed and newly created licences, it was made clear that at the end of the licence periods there would be no opportunity for renewal and that all spectrum would be re-auctioned.

The freed up spectrum blocks were auctioned off in late 2010. These auctions involved caps on the existing licence holders, such that they could not buy this spectrum. The results were announced at the end of 2010 and Hi3G won the spectrum in both the 900MHz and 1800MHz bands.

The distribution of 900MHz and 1800MHz spectrum before refarming and the 2010 auction is as shown in the table below:

Figure G.9: 2G spectrum holdings in Denmark before redistribution [Source: 2008 European mobile spectrum bands, ERO]

Operator	900MHz	1800MHz
TDC	2×8.8MHz	2×2MHz, 2×14.2MHz, 2×9.4MHz
Telenor	2×8.8MHz	2×7MHz, 2×12MHz
TeliaSonera	2×1.4MHz, 2×2.6MHz, 2×7.2MHz, 2×2.8MHz	2×14.2MHz, 2×14.2MHz

126 https://bdkv2.borger.dk/Lovgivning/Hoeringsportalen/Sider/Fakta.aspx?hpid=2146000927

Following the refarming of the 900MHz spectrum, and taking into account the results of the 2010 auction, 900MHz and 1800MHz assignments are now as shown in the table below:

Figure G.10: 900MHz and 1800MHz assignments per operator in Denmark after redistribution [Source: Mobile bands in CEPT, ECO]

Operator	900MHz	1800MHz
TDC	2×9MHz	2×19.4MHz
Telenor	2×9MHz	2×19.4MHz
TeliaSonera	2×11.8MHz	2×23.6MHz
Hi3G	2×5MHz	2×10MHz

While DBA wished to liberalise the spectrum licences, it delayed the lifting of the GSM technology restrictions on the existing operators until nine months after the completion of the 2010 auction, in order to allow the new entrant to compete. After this point, all mobile technologies that can co-exist with GSM, including UMTS, HSPA and LTE, can be deployed in the 900MHz and 1800MHz bands. Similarly, the individual coverage obligations placed on the licence holders no longer have to be fulfilled by GSM.

G.6 Netherlands

The Dutch Spectrum Agency, Agentschap Telecom, has decided not to renew the current licences held within the 900MHz and 1800MHz spectrum bands, but instead to repackage this spectrum into new, technology-neutral licences. These licences have been awarded as part of the Dutch multiband auction held in late 2012. The auction was run using a combinatorial clock auction format and sold 2×5MHz blocks of spectrum in the following bands:

- 800MHz
- 900MHz
- 1800MHz
- 1900MHz
- 2.1GHz
- 2.6GHz.

The results of this auction were announced in December 2012.

With all of the original 900MHz and 1800MHz licences due to expire by 25 February 2013, a transition period has been created, to allow time for operators to move technologies and equipment between different frequency allocations. This transition period could last for a maximum of 21 months; applications had to be submitted within 20 days of the completion of the multiband auction.

Before the 2012 multiband auction, the distribution of 900MHz and 1800MHz spectrum in the Netherlands was as shown in the table below:

Figure G.11: 2G spectrum holdings in the Netherlands before the 2012 auction [Source: 2008 European mobile spectrum bands, ERO]

Operator	900MHz	1800MHz
KPN	2×12.4MHz	2×18.4MHz
Vodafone	2×11.4MHz	2×5.2MHz
T-Mobile	2×10MHz	2×31.8MHz

As a result of the multiband auction, the spectrum assignments in the 900MHz and 1800MHz spectrum bands will move, following any transition period granted, to those shown in the table below:

Figure G.12: 900MHz and 1800MHz assignments per operator in the Netherlands after the 2012 auction [Source: Agentschap Telecom, 2012]

Operator	900MHz	1800MHz
KPN	2×10MHz	2×20MHz
Vodafone	2×10MHz	2×20MHz
T-Mobile	2×15MHz	2×30MHz

Area coverage obligations are imposed upon the 900MHz and 18000MHz licences, which vary based on the time since the licence was issued and the number of licences owned by the mobile operator. Specifically, for each 2×5MHz 900MHz licence these are:

- coverage of an area of at least 257km^2 within two years of licence issue
- coverage of an area of at least 2,576km^2 within five years of licence issue.

For each 2×5MHz 1800MHz licence, the coverage obligations are:

- coverage of an area of at least 37km^2 within two years of licence issue
- coverage of an area of at least 367km^2 within five years of licence issue.

While the multiband auction resulted in redistributing the 900MHz and 1800MHz spectrum between the original three mobile operators, Tele2 was able to gain some sub-1GHz spectrum in the 800MHz band. Tele2, KPN and Vodafone all won a licence for 2×10MHz of 800MHz spectrum.

G.7 Italy

AGCOM has chosen to use two different policies with regards to the release of their 900MHz and 1800MHz spectrum from GSM. They reassigned their 900MHz spectrum, while auctioning off some of the 1800MHz band.

For the 900MHz spectrum, they began the process of refarming it to be used for 3G services from October 2009. However, the nature of the historical 900MHz spectrum allocation, which was fragmented by both operator and geography, made it difficult for operators to have access to sufficient concurrent spectrum, in order to launch these services. As a result, in 2009, they reassigned the spectrum allocations among the existing operators, reserving one 2×5MHz spectrum licence for a new entrant. While some operators lost spectrum overall, this reassignment resulted in larger contiguous spectrum allocations for all of the operators.

Additionally, AGCOM harmonised the end date of the 900MHz licences with the GSM licences in the 1800MHz band, setting them all to 31st January 2015.

In September 2011, AGCOM ran a multiband spectrum auction, selling technology-neutral licences in the 800MHz, 1800MHz, 2010–2025MHz and 2.6GHz bands. The licences available in this auction included three 2×5MHz lots of 1800MHz spectrum, with a 17-year licence term. The auction lasted 22 days and the three lots of 1800MHz spectrum were won by Telecom Italia, Vodafone and WIND.

Before the 2011 multiband auction and the 2009 spectrum reassignment, the distribution of 900MHz and 1800MHz spectrum in Italy was as shown in the table below:

Figure G.13: 2G spectrum holdings in Italy before 900MHz reassignment and 1800MHz auction [Source: 2008 European mobile spectrum bands, ERO]

Operator	900MHz	1800MHz
Telecom Italia	2×1.2MHz, 2×1MHz, 2×8.4MHz	2×15MHz
Vodafone	2×10.2MHz, 2×9MHz	2×15MHz
WIND	2×3MHz, 2×4.8MHz, 2×1.8MHz, 2×1.8MHz, 2×3MHz	2×15MHz

After the completion of the reassignment and auction processes, the distribution of 900MHz and 1800MHz spectrum in Italy was as shown in the table below:

Figure G.14: 900MHz and 1800MHz assignments per operator in Italy after 900MHz reassignment and 1800MHz auction [Source: Mobile bands in CEPT, ECO]

Operator	900MHz	1800MHz
Telecom Italia	2×5MHz (UMTS), 2×9.8 (GSM)	2×5MHz (UMTS/LTE), 2×15MHz (GSM)
Vodafone	2×5MHz (UMTS), 2×9.6 (GSM)	2×5MHz (UMTS/LTE), 2×15MHz (GSM)
WIND	2×9.6MHz (GSM)	2×15MHz (GSM)
H3G	2×5MHz (UMTS)	2×5MHz (UMTS/LTE)

G.8 Belgium

In 2008, BIPT began its spectrum release process, by liberalising existing 900MHz licences and allowing operators to run 3G networks across this spectrum. This liberalisation was extended to the 1800MHz band in November 2011, as part of BIPT's decision on the use of UMTS and LTE technologies in the 900MHz, 1800MHz and 2GHz bands[127]. As an additional part of that regulator

127 http://www.bipt.be/ShowDoc.aspx?objectID=3626&lang=En

decision, BIPT determined that a roll-out of an LTE network across the 900MHz or 1800MHz spectrum would also be possible using the current licences.

Before the process of spectrum liberalisation began in Belgium, the distribution of 900MHz and 1800MHz spectrum was as shown in the table below:

Figure G.15: 2G spectrum holdings in Belgium before spectrum liberalisation [Source: 2008 European mobile spectrum bands, ERO]

Operator	900MHz	1800MHz
Proximus (Belgacom Mobile)	Two 2×6MHz (non-contiguous)	2×15MHz
Mobistar	Two 2×6MHz (non-contiguous)	2×15MHz
KPN (Base)	2×4.8MHz, 2×3MHZ, 2×0.8MHz	2×22MHz

Despite the spectrum liberalisation policies undertaken in Belgium, there have so far been minimal changes to the spectrum allocation in the 900MHz and 1800MHz bands, as can be seen in the table below:

Figure G.16: 900MHz and 1800MHz assignments per operator in Belgium after spectrum liberalisation [Source: Mobile bands in CEPT, ECO]

Operator	900MHz	1800MHz
Proximus (Belgacom Mobile)	Two 2×6MHz (non-contiguous)	2×15MHz
Mobistar	Two 2×6MHz (non-contiguous)	2×15MHz
KPN (Base)	2×10MHz[128], 2×0.8MHz	2×22MHz

In a second BIPT decision made in November 2011 on the repartition of spectrum in the 900MHz, 1800MHz and 2.1GHz bands, it was concluded that the current spectrum allocations would be maintained until 27 November 2015, at which point a reassignment would take place.[129] This reassignment would involve the reservation for spectrum in both the 900MHz and 1800MHz bands for Telenet-Tecteo Bidco, an MNO currently only operating in the 2GHz band.

The regulator in Belgium is also now preparing to auction 800MHz licences for 4G use. 4G licences to use the 2.6GHz band were auctioned in November 2011 and won by the three existing operators and a fourth operator, BUCD.

128 It appears that the 2×2.2MHz of spectrum originally dividing the KPN 900MHz spectrum allocations has been assigned to KPN in the period between August 2008 and January 2012.

129 http://www.bipt.be/ShowDoc.aspx?objectID=3625&lang=En.