Question 1: Do you have any comments on our approach to this review?

ViaSat Answer

Rapid growth taking place in all radiocommunication sectors requires all users of scarce radio spectrum resources to have a particularly sharp focus on efficient use and sharing. Spectrum scarcity means legacy policies which mandated exclusive use of spectrum may need to be reconsidered. While the satellite industry has previously required exclusive spectrum, recent advances in technology make it possible for previously unthinkable sharing scenarios – such as sharing between satellites and fixed terrestrial and even mobile users – to now be considered possible under certain circumstances.

The broad coverage areas of satellites means that satellite operators view their markets in an inherently international context. It is therefore of critical importance to satellite operators providing service in the UK that the regulatory regime here is not inconsistent with the rest of Europe or indeed, the rest of the world. By assisting in creating a favourable regulatory regime for satellite services both in Europe and worldwide, the UK fosters the development of satellite services within the UK.

Question 2: Do you have any comments on our broad overview of the satellite sector set out in this section? In particular, do you have comments on the completeness of the list of applications, their definitions and their use of the relevant ITU radiocommunications service(s)?

ViaSat Answer

ViaSat has observed the same type of service convergence as has been identified by Ofcom. In fact, ViaSat wishes to stress that the convergence between fixed and mobile satellite applications, as well as the increased blurring of the lines between military and civilian markets, has become the industry norm.

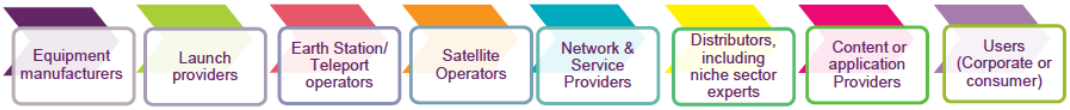
ViaSat's High Capacity Satellite systems are designed to allow both fixed and mobile terminals to operate seamlessly on the same network. This enables ViaSat to supplement the business case in residential fixed broadband markets with additional revenue from mobile broadband service to aircraft, ships and trains. Having revenue from both residential and mobile users makes the business case of deploying both networks more attractive and allows the cost of the network to be spread out over a larger user base. This in turn means lower costs to the end users. With the same network providing what were previously considered different services, it begs the question of whether the existing definitions of FSS/MSS are still applicable or even needed. Old service definitions and spectrum rules may need to be adjusted to account for this convergence.

Question 3: Space Sector Structure

Please see answer to Question 2.

Question 4: Do you have any comments on our representation of the value chain for the satellite sector? How do you think industry revenues are broken down between players at different positions in the chain?

Figure 2: Satellite sector value chain



ViaSat Answer

This appears to be a fair representation of the value chain in the satellite sector.

Question 5: What is the extent of your organisations' role(s) in the value chain? Which satellite applications (as summarised in Table 1 in section 3) does your organisation:
- use;
- provide: or
- help to deliver?

Please list all applications that apply and your role in each in your response.

ViaSat Answer

ViaSat, Inc. is in the business of producing innovative satellite and other digital communication products that enable fast, secure, and efficient communications to any location. We bring today's new communication applications to people not served, or that are under-served, by terrestrial networks in both the commercial and government sectors with a variety of networking products and services.

As such, ViaSat participates in the following parts of the above-referenced value chain:

Equipment manufacturer: ViaSat manufactures a wide range of earth station antennas and earth station modems and RF equipment, ranging from large earth stations in virtually every satellite band (as well as many earth observation and radio astronomy bands) to gateway earth stations and residential customer premise earth stations. ViaSat also manufactures mobile terminals in the L-, Ku- and Ka-bands.

Earth station/Teleport operator: ViaSat operates gateway earth stations throughout the United States for its ViaSat-1 network and will be constructing additional gateway earth stations for its ViaSat-2 network. These private gateways provide service access to the networks on ViaSat-1 and ViaSat-2 and are used for commercial teleport operations. Additionally, ViaSat operates a number of other gateway earth stations around the world in support of its global Ku band mobility network.

Satellite Operator: ViaSat currently owns three Ka band satellites: ViaSat-1 at 115 W, WildBlue-1 at 111.1 W, and ViaSat-KA-89W at 89 W. Additionally, ViaSat

has a lifetime lease on the US Ka band capacity of Anik-F2 at 111.1 W. ViaSat has contracted for two additional Ka band satellites. ViaSat-2, which will operate at 70 W, is under construction and will be launched in 2016. ViaSat also leases Ku and Ka band satellite capacity on approximately 24 satellites around the world.

Within the UK, ViaSat operates both AMSS and ESV services using FSS transponders in the 14.0 - 14.25 GHz band. While ViaSat-1's coverage area is limited to North America, ViaSat-2's coverage area will be significantly larger, as seen in the figure below.

Figure 1 - ViaSat 2 Coverage Area

Network and Service Provider: ViaSat's Broadband services can be divided into three categories:

1. Service to residential/business users, and
2. Service to mobile platforms such as aircraft, ships, trains, etc.
3. Services to nomadic users (temporary-fixed).

Residential Broadband - ViaSat currently provides its Exede broadband Internet services to residential and business customers in the United States using the ViaSat-1, WildBlue-1 and Anik F2 satellites. These satellites operate in the Ka-band frequencies mentioned in #1. ViaSat currently has over 700,000 Exede subscribers in the US. The Exede Service offers 12 Mbit/s download and 3 Mbit/s upload speeds for monthly subscriptions starting at USD 49.99/month. ViaSat will be greatly expanding this service when ViaSat-2 is launched in 2016. ViaSat also provides the technology (including the user terminals and gateways) behind the Tooway service in Europe, run by Eutelsat which services some 170,000 domestic consumers. ViaSat has been engaging with the UK Government (Broadband UK team) over the delivery of Satellite Broadband to the estimated 300,000 to 1.4 million households (1-5% of the population) who will never be able to access high speed fibre. ViaSat is supporting development of potential solutions for this market with the UK Space Agency and Broadband UK.

Mobile Broadband – ViaSat has provided broadband access to ships, trains and aircraft worldwide using Ku-band band satellites for over 10 years. We recently launched our Ka-band Exede in the Air service in 2014 and have over 500 aircraft currently using the service. While Ku-band and terrestrial-based services struggle to deliver 3-5 Mbit/s to each aircraft, ViaSat is able to offer 12 Mbit/s *to*

each passenger because of the much greater bandwidth and efficiency possible with its Ka-band satellites. ViaSat also has an agreement with Eutelsat to provide the Exede in the Air service in Europe using Eutelsat's Ka-Sat satellite, which operates in the 29.5-30.0 GHz band. When ViaSat-2 is launched in 2016, this will enable seamless broadband coverage for aircraft in flight stretching from the West Coast of the United States to the Middle East.

Nomadic Broadband – ViaSat provides broadband access to users in Ku-band but in the last few years have seen our Ka services utilised by satellite news gatherers and live event simulcast of concerts and other events, first responders (such as the US Red Cross) and utility companies. The same technology behind these services are also employed in Europe for similar markets, including several police forces in the UK and several power companies for incident response communications.

As ViaSat sells directly to airlines in the Mobile Broadband field, ViaSat can also be considered a *Niche Service Provider.*

ViaSat L-band Managed Services meet the need for real-time position tracking, managing remote assets and operations, and visibility into critical areas of the supply chain. Use our high- performance M2M terminals for a broad range of applications including emergency responders, oil and gas pipeline monitoring, mobile fleet management, and high-value asset tracking. Our L-band Managed Services use high-performance LightSquared and Thuraya satellite capacity where one terminal can be used for seamless roaming between satellite systems.

Question 6: For each of the satellite applications you use, provide or help deliver (as identified in Question 5), and taking into account your role in the value chain, where applicable please provide:

- *the specific spectrum frequency ranges used for each application, distinguishing between the frequencies used for service provision, for the feeder / backhaul links and for TT&C ;*

ViaSat Answer

Both ViaSat-1 and ViaSat-2 operate in the 28.1-29.1 GHz and 29.5-30.0 GHz bands (Earth-to-space) and the 18.3-19.3 GHz and 19.7-20.2 GHz bands (space-to-Earth), and ViaSat-2 also includes the 17.7-18.3 GHz (space-to-Earth) and the 27.5-28.1 GHz (Earth-to-space) bands. The satellite network provides service to small user antennas. In addition, a number of larger gateway-type antennas have been deployed for ViaSat-1 and additional earth stations will be employed for ViaSat-2. The gateway-type antennas have the capability of transmitting in any channel within the 28.1-29.1 GHz and 29.5-30.0 GHz bands (as well as 27.5-28.1 GHz for ViaSat-2). Uplink transmissions from the smaller user terminals currently occur in the 28.35-29.1 GHz and 29.5-30.0 GHz bands, but ViaSat will be seeking authority in the U.S. to operate user terminals in the lower portion of the 28.1-28.35 GHz band for ViaSat-1 and eventually the 27.5-28.1 GHz portion for ViaSat-2. We plan to ask for similar authority in other areas of the world as our satellite fleet expands.

Although we are currently authorized to use these bands, our equipment is able to operate anywhere from 17.7-21.2 GHz and 27.5-31.0 GHz. The number of users we can serve is directly proportional to the amount of spectrum we can access. With the same fixed costs spread out over a greater user base, this means that access to additional spectrum also reduces the cost per unit capacity and allows us to provide service at lower price points, benefiting the consumer and making the service cost effective in more applications.

The TT&C sub-systems operate at the edges of the uplink and downlink frequency ranges during all phases of the mission (i.e. 29.5 GHz and 19.7 GHz).

- *the coverage area for services links; or, in the case of TT&C and feeder / backhaul links, the location of the gateway station(s);*

The service area of the four current satellites (ViaSat-1, WildBlue-1, Anik-F2, and ViaSat-KA-89W) includes the continental US (CONUS), Hawaii, and parts of Alaska and Canada. The coverage for ViaSat-2 will include approximately 37 countries as depicted in Figure 1. There are a large number of gateway earth stations that provide connectivity for the ViaSat satellite network, the gateways are currently located in the US and Canada for the existing satellites. The gateways for ViaSat-2 may include additional country locations.

HCS technology relies on the extensive re-use of spectrum just as is done in cellular systems. Given the extremely high volume of data carried by HCS satellites, the requirements for gateway earth stations are thus much different from traditional satellites. ViaSat use many gateways with each satellite, and make them substantially smaller than typical gateway earth stations. ViaSat's gateways are usually geographically dispersed and are located where there is good fiber access.

- *the estimated number of users (e.g. MSS terminals, DTH subscribers, FSS earth stations);*

ViaSat Answer

ViaSat has seen significant growth in its residential broadband service since its introduction in 2012. Figure 2 below shows the growth of the service over the past 3 years.[1] With the FCC reporting in August 2012 that approximately 19 million people in the United States still lack broadband access, we expect these growth rates to continue for the foreseeable future.[2]

[1] ViaSat purchase satellite Internet provider WildBlue in 2011 and began migrating existing WildBlue subscribers to ViaSat-1 when it was launched in 2012.

[2] FCC Eighth Broadband Progress Report, available at: https://apps.fcc.gov/edocs_public/attachmatch/FCC-12-90A1.pdf

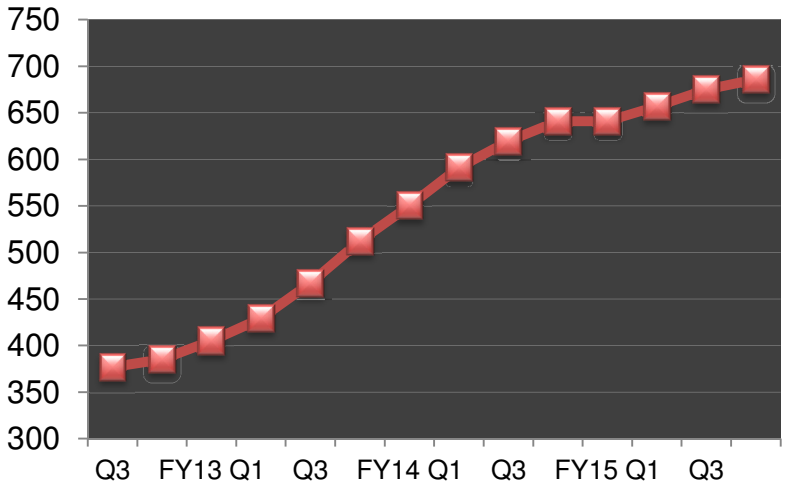


Figure 2 - Exede US subscribers (thousands)

Over 250 US government aircraft use ViaSat Ku services, several platform types are transitioning to a hybrid Ku-Ka service that operates globally on a principle known as "best available network". When the hybrid Ku/Ka-band equipped aircraft is within the coverage area of a Ka-band HCS satellite, it uses that network. When outside of HCS coverage the antenna switches to our global Ku-band network. ViaSat delivers the Ku service currently to the UK MOD's C17 transport aircraft. Over 280 business jets also access the Ku network.

ViaSat's Ka-band Exede in the Air service has seen dramatic growth despite being in service for less than 2 years. Over 400 aircraft are now in service between JetBlue and United. Another 100+ aircraft are due to be installed with the service in the coming year on JetBlue, United, El Al and Virgin America.

With the rapidly increasing interest in aeronautical broadband access, and the addition of trans-Atlantic capacity in 2016 with ViaSat-2, we expect the Exede in the Air service to experience a growth pattern similar to that experienced by our residential Exede service.

- *an estimate of the average use by end user (for those applications for which the demand for spectrum is driven by end user traffic); and*
- *for applications for which the demand for spectrum is driven by other factors, please state what the factor is and the scale of the factor (e.g. for DTH TV the number of TV channels broadcast by format).*
- *Please provide your response with respect to the UK, the rest of Europe, and other parts of the world where this may be relevant to UK use.*

ViaSat Answer

Residential/ SME Broadband services

ViaSat's Exede subscribers expect to follow the same usage patterns as any other broadband Internet user. The Exede CPE has standard WiFi and Ethernet connections, making the service indistinguishable from a terrestrial fixed or wireless connection. We find that users do not buy our service because it is a

satellite service; they buy the service because it provides good quality at a competitive price.

Data published by Cisco in Figures 3 and 4 below provide a good overview of the breakdown of traffic ViaSat sees over its network by device and by application. The growth rates projected by Cisco are consistent with the traffic growth rates we have seen. In fact, ViaSat believes the Cisco traffic estimates are somewhat conservative. In planning our network expansion, we generally assume 35% annual traffic growth.

Figure 3 - Global IP Traffic by Device[3]

Figure 4 - Global IP Traffic by Application Category

Mobile Broadband services

ViaSat has seen very strong demand for its Exede in the Air service since it was first introduced on its first customer, JetBlue, in 2014. In contrast to Air-to-ground, or Ku-band services, ViaSat's Exede in the Air service guarantees 12 Mbit/s download speeds to *each* passenger – not just to the plane. As a result of the drastically higher speeds it provides, ViaSat is seeing very high usage rates

[3] Source: Cisco VNI Global IP Traffic Forecast, 2014–2019, available at: http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/VNI_Hyperconnectivity_WP.html

on board its equipped airlines. The average take rates on JetBlue today is 43% (i.e. 43% of the passengers on a given flight use the service). We routinely see flights with take rates between 60% & 90%.

JetBlue allows free service for full web browsing, email, social networking, VPN & short video clips. For USD 9.00 passengers can purchase a premium service that allows long form streaming (Netflix, Hulu).

Traffic data for a typical single aircraft is shown below for a transcontinental US flight.

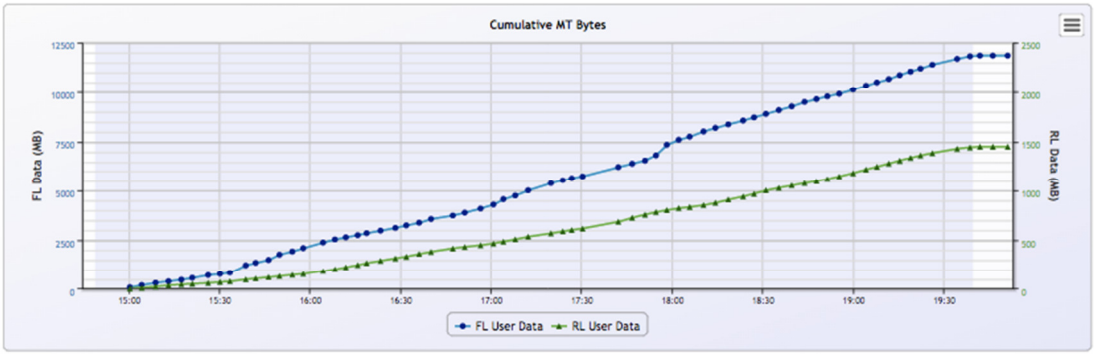


Figure 5 - Example Traffic Usage: Single Aircraft, Transcontinental Flight

Question 7: For each of the satellite applications you provide, please could you indicate how UK consumers and citizens benefit from their use? Where possible please also provide an indication of the scale of the benefits (either qualitatively or quantitatively).

ViaSat Answer

For *residential/SME broadband*, the UK is one of the largest markets in Europe. The UK market on its own is not sufficiently large to justify a dedicated satellite, but the UK is a very important national market in the greater European/EMEA market. By enabling satellite broadband in Europe through increased access to spectrum and favourable regulatory environments, UK consumers will have access to these services. Today, ViaSat's Exede Internet broadband service is offered in North America and our technology provides some services in the UK and Europe.

ViaSat has plans to expand its service globally in the next few years, including in the UK. Satellite is one of the most cost effective technologies for delivering broadband to areas that are beyond the reach of terrestrial technologies or in areas where it is uneconomical to deploy terrestrial networks. In its *Infrastructure Report 2014* Ofcom estimated that 15% of UK households do not have access to 10 Mbit/s service. Whilst this number may decline somewhat in the coming years, it is likely that a significant percentage of UK households will continue to not have access to such service because of the cost considerations that drive terrestrial broadband network deployment. Next-generation satellites such as ViaSat-2 can provide this service regardless of a user's location.

ViaSat has been working with DCMS Broadband UK team and the UK Space Agency to determine how to address the UK's "digital divide" in part by using satellite broadband. Key is that current satellite broadband generally runs at 12 Mbit/s but trials show that 24 Mbit/s and 30 Mbit/s are feasible on our current modem, with speeds above that in the near future. The "fixed residential" satellite broadband market is estimated between 300,000 to 1.4 million households (1-5% of the population) who will never be able to access high speed fibre. Some of these may not take up services, or will use 4G, but there are also a significant number of rural businesses and users in suburban areas and villages that are simply left behind. ViaSat is supporting development of ideas in these markets with the UK Space Agency and Broadband UK.

The benefits to UK citizens are manifold, including ensuring that the Governments "digital by default" agenda is taken forward and also providing the satellite capacity that can then also service emergency services (surge and fall-back communications), critical infrastructures and security tasks. The Gross Value Add (GVA) for example by being able to connect rural businesses will have significant benefit for the UK economy.

In addition to serving the unserved, HCS satellites have now achieved a cost per Mbit/s ratio that allows satellite to compete directly with terrestrial alternatives in many areas. Using its first-generation ViaSat-1 satellite, ViaSat has proven its ability to compete with terrestrial broadband service providers in terms of speed, cost and quality of service. ViaSat's next generation of satellites will bring even more capacity and capability and allow our services to keep pace with advances in terrestrial broadband for the foreseeable future. By making spectrum available for next-generation satellites, Ofcom will support BDUK and the UK Space Agency in making satellite a complementary technology to terrestrial broadband providers, particularly in less densely populated areas where there is limited connectivity and crucially also enabling more .

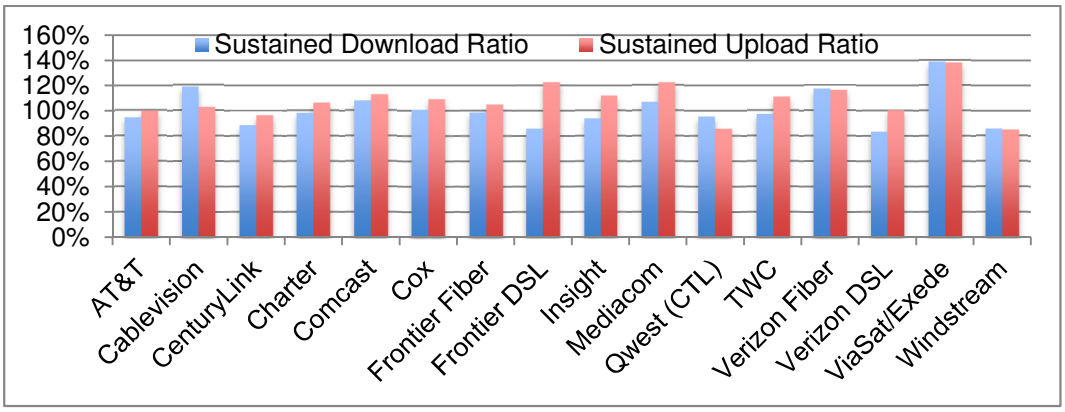


Figure 6 - Ratio of advertised vs. delivered bandwidth, US broadband service providers

However speed is but one indicator of performance; page load times, quality of service and bundling all contribute to the user experience. Satellite broadband page load times now compare favourably with fibre (tests show fibre averages 2.5 to 3.5 seconds and satellite now achieves sub 4 seconds). It is also noteworthy that in both 2013 and 2014 in the US, ViaSat's Exede service was ranked by the Federal Communications Commission (the FCC) as the "no 1

internet service provider for delivery on promise".[4] The FCC study measured actual service performance for thousands of subscribers for four delivery technologies – DSL, cable, fibre and satellite – and evaluated services from 14 of the US's largest broadband providers. Notably:

- On average, Exede Internet delivered 161 percent (over 19 Mbit/s) of advertised upload speed of 12 Mbit/s. This compares to 108 percent for fibre-to-the-home and cable-based services and 99 percent for DSL-based services.
- Exede service had the least amount of variation in performance based on the time of day, consistently ranking at 130 percent and above of advertised speed.
- During peak periods, 90 percent of Exede consumers received 140 percent or better of the advertised speed of 12 Mbit/s.

In order to provide these services satellite service providers need spectrum. The more spectrum that is available, the more users can be served and the higher the speeds are that can be provided. ViaSat believes that a significant demand for satellite broadband exists in Europe and the UK and that this demand will only increase over time. As such, ViaSat is actively pursuing opportunities which will lead to introduction of its Exede service in the UK and Europe in the near future.

Satellite broadband is perfectly suited to address rural/unserved areas of the UK. While numerous studies exist on broadband penetration, they are often misleading in their conclusions and address only part of the issue of broadband availability.

An example is the report commissioned by BT on International Benchmark of Superfast Broadband (defined as connectivity of at least 30 Mbit/s).[5]

---

[4] FCC Measuring Broadband America, available at: http://www.fcc.gov/measuring-broadband-america

[5] Analysis Mason, "International benchmark of superfast broadband, *27 November 2013."* available at: http://www.analysysmason.com/PageFiles/44401/Analysys_Mason_Superfast_broadband_benchmark_Nov2013.pdf

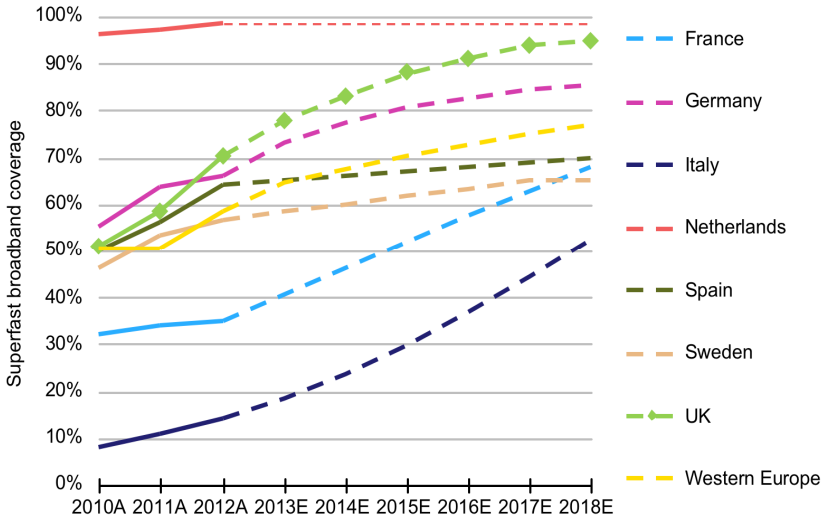


Figure 7 - *Coverage of superfast broadband (% of premises passed) including all fixed network technologies*

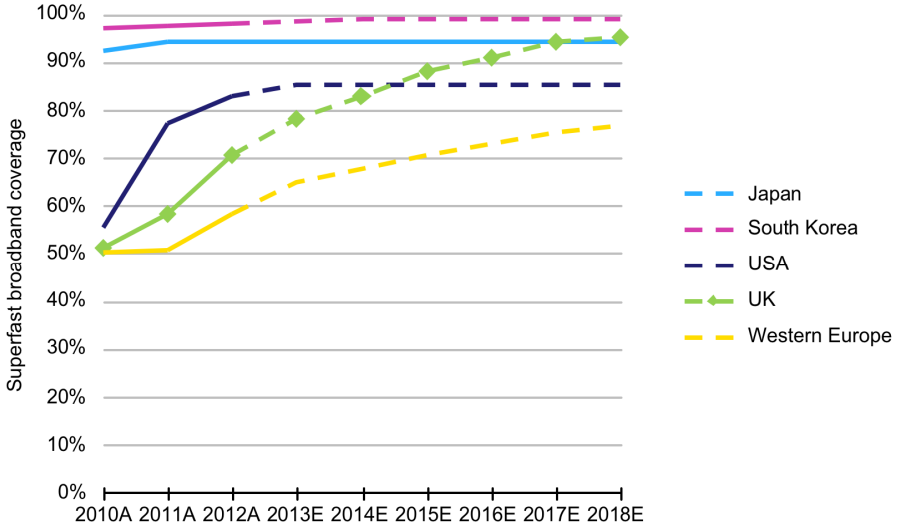


Figure 8 - Coverage of superfast broadband (% of premises passed) including all fixed network technologies, UK and non-European benchmark countries

Whilst these charts seem to paint a favourable picture of superfast broadband rollout in the UK, closer examination raises some questions. Firstly, as with many forecasts, the Analysis Mason data address broadband availability, not broadband adoption. As detailed adoption data is often difficult to come by, studies tend to count whether a single provider offers superfast broadband in a given area – regardless of the cost of that service, the degree of competition or even the ability to actually access the network.

For a more accurate picture of actual adoption of broadband by Internet users, Akamai provides a very useful reference point. Every quarter Akamai publishes a "State of the Internet" report that provides data on the connection speeds accessing its content servers.[6] As Akamai explains in its reports: "through its globally-deployed Intelligent Platform, and by virtue of the approximately two

[6] Source: http://www.akamai.com/dl/content/q4-2014-soti-report.pdf

trillion requests for Web content that it serves on a daily basis, Akamai has unique visibility into levels of Internet penetration around the world."

Even when using Akamai's statistics for connections above a lower 15 Mbit/s threshold, the actual usage of broadband connections in the UK is much lower than the statistics seen in other reports, including those produced by Ofcom.

Figure 9 shows the actual percentage of Internet users accessing Akamai's servers from a selected group of countries. As can be seen, the percentage of UK users accessing the Internet with speeds of 15 Mbit/s is significantly lower than the very high coverage rates projected by Analysis Mason: 22% vs. almost 90%.

Global Rank	Country	% above 15 Mbit/s	QoQ Change	YoY Change
-	Global	12%	0.6%	37.0%
1	South Korea	61%	-7.7%	16.0%
2	Hong Kong	41%	11.0%	84.0%
3	Japan	34%	2.5%	24.0%
4	Sweden	31%	9.2%	61.0%
5	Switzerland	30%	2.6%	50.0%
6	Netherlands	30%	1.9%	35.0%
7	Latvia	29%	1.4%	63.0%
8	Lithuania	26%	50.0%	209.0%
9	Romania	23%	12.0%	320.0%
10	Norway	22%	2.9%	50.0%
11	**UK**	**22%**	**9.7%**	**42.0%**
12	Finland	21%	4.4%	55.0%
13	Denmark	21%	13.0%	50.0%
17	United States	18%	-3.1%	39.0%
26	Russia	11%	-11.0%	62.0%
27	Poland	11%	-2.5%	33.0%
29	Hungary	11%	-7.2%	94.0%
34	Germany	9%	3.0%	40.0%
38	France	6%	10.0%	40.0%
41	Turkey	4%	77.0%	621.0%
45	Italy	2%	5.0%	39.0%

Figure 9 - Percentage of users accessing Akamai servers using at least a 15 Mbit/s connection

At least part of the reason for this low adoption rate is a lack of competitive alternatives in underserved areas. While much attention is paid to un-served areas, the issue of "under-served" areas is also quite significant. Large numbers of subscribers have only 1 broadband provider. The chart below provides statistics from the United States.

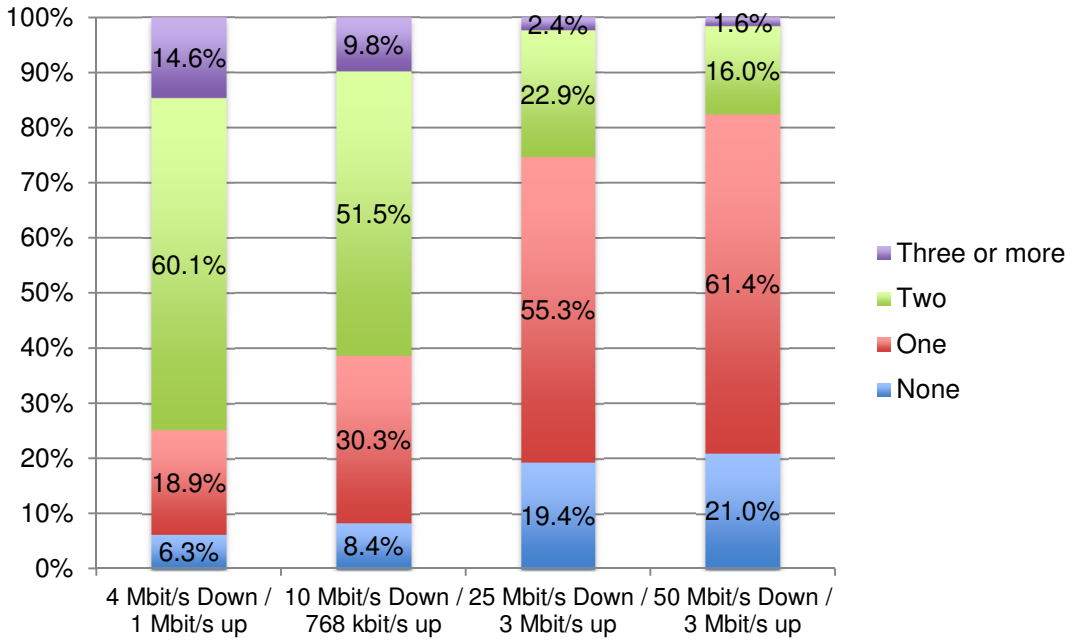


Figure 10 - Number of providers available to US broadband subscribers

Part of the reason for this lack of competition is the cost of terrestrial superfast broadband networks. Fibre networks, for instance, are quite expensive and once a company has laid fibre in a given market, the cost of laying a competing fibre network is very high compared to the potential gain in subscriber revenues which usually have to be gained through aggressive pricing. Whilst some variation may exist between the US data in Figure 10 and the UK due to differences in population density, the economics of fibre deployment apply equally in each country. The fact is, once a fibre network is deployed, the business case for deploying a second network is greatly reduced since the first network deployed must capture as many subscribers as possible to cover the high cost of fibre deployment. As an example, the sample business case used by the FTTH Counsel Americas assumes that the model fibre deployment will capture over 60% of subscribers passed.[7]

What does Fibre infrastructure cost in Europe? The FTTH Counsel Europe commissioned a study of the cost of reaching the EU 2020 broadband objectives according to the EC Digital Agenda for Europe 2020 Goals:

- 100 Mbit/s speed to 50% of population
- 30 Mbit/s speed to 100% of population

The FTTH Counsel Europe created a realistic business model using Germany as an example. The study assumed that fibre was laid only to the building (FTTB), allowing cost savings for multiple dwelling units. FTTB costs were then calculated *only* for 100 Mbit/s goal. The result? Reaching the EU 2020 broadband goals in Germany for the 100 Mbit/s goal alone would reach € 46.4 Billion. This yields a cost per home activated: € 1,410 (not including Customer Premises Equipment) or £986.70.

[7] See "Example of initial financial spreadsheet" for FTTH deployment; available at: http://www.ftthcouncil.org/p/cm/ld/fid=373

In contrast, the Subscriber Acquisition Cost (SAC) for ViaSat's Exede service is roughly €650 (£455)/subscriber. That figure includes the cost of launching the satellite as well as the associated CPE. As shown in Figure 11, these costs compare quite favourably to the cost of terrestrial technologies. What is more important, however, is that SAC for satellite broadband *is the same everywhere in the satellite's coverage area*. The cost of providing the service is location independent.

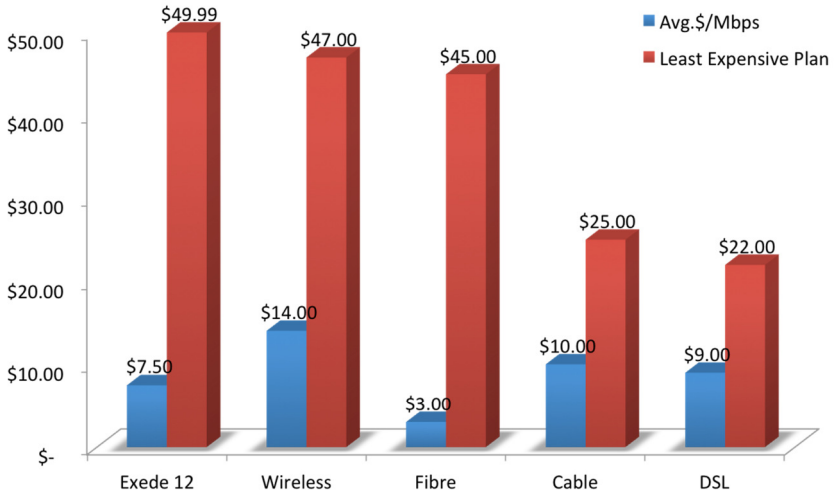


Figure 11 - Comparison of broadband technology costs

The service customers receive from satellite broadband compares quite favourably to traditional terrestrial alternatives in terms of price and quality. Figures 12 and 13 show the current pricing plans ViaSat offers for its Exede service in the United States as well as the plans that are being rolled out in preparation for the launch of the new ViaSat-2 satellite next year. Most notably, the vastly increased capacity of ViaSat-2 has allowed us to eliminate the service caps that have characterised satellite broadband service for so long.

Figure 12 - Current Exede Pricing in US

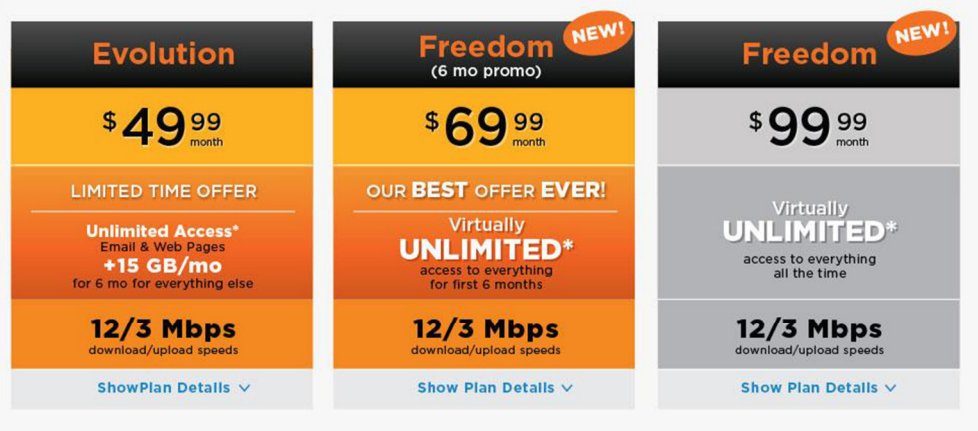


Figure 13 - New pricing plans to be rolled out in 2016 with launch of ViaSat-2

ViaSat believes that this combination of low subscriber acquisition cost and attractive service pricing will make the next generation of satellite broadband services due to launch next year an attractive alternative for a much broader segment of the public. Whilst addressing rural and unserved areas, satellite broadband is poised to be a competitor to terrestrial alternatives in suburban and urban markets also.

ViaSat's experience with its Exede service in the United States has shown that satellite broadband can compete with terrestrial alternatives. Whilst one might think that satellite broadband users would be concentrated in rural areas, this is not the case. ViaSat's Exede subscriber distribution follows closely the US population distribution. Figure 14 shows a United States Census Bureau map of the US population from 2010 (the year the last census was held). Figure 15 is a map of Exede subscribers. The close correlation of subscribers to population density shows that the Exede service is not seen as merely a service of last resort. It is seen as a serious competitor to terrestrial broadband alternatives.

In the past arguments have been made that adoption of satellite broadband in the United States is higher than that expected in the UK and Europe due to the relatively lower population density in the US. As the preceding data show, however, acceptance of satellite broadband does not depend on geography or pricing, but on service quality and cost. So long as a broadband service provider can offer a good service at a competitive price, the consumer does not care what technology is used to provide the service. For this reason, ViaSat is confident in its ability to not only cover unserved markets in the UK and Europe, but also compete directly with terrestrial technologies in suburban and urban markets.

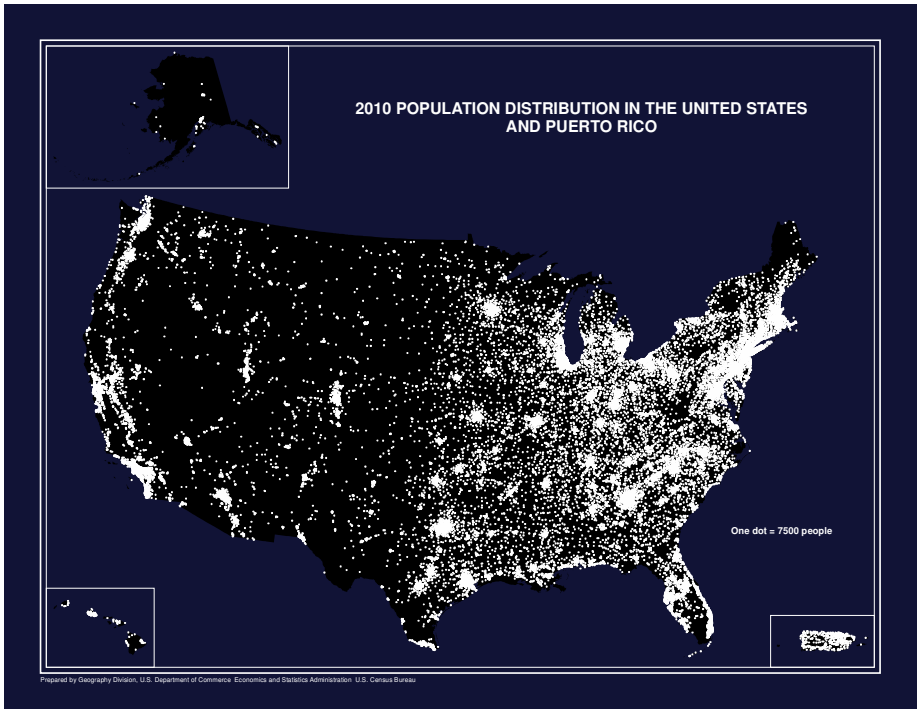


Figure 14 - US Population Density based on 2010 US Census data

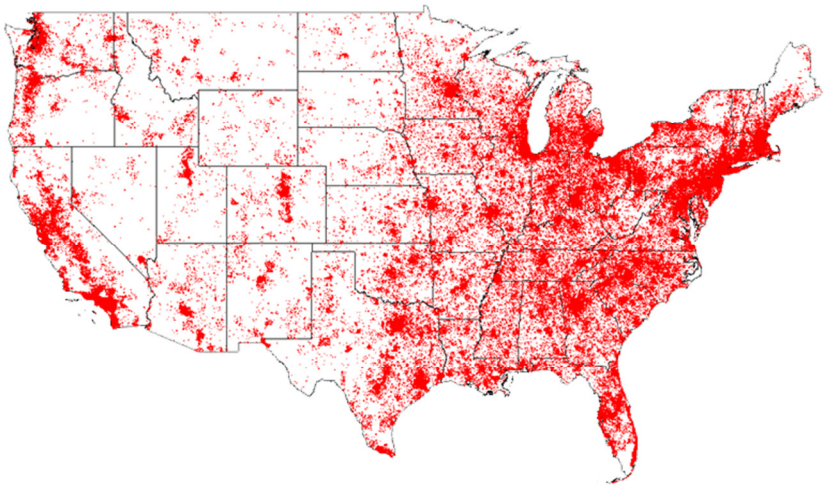


Figure 15 - ViaSat Exede subscriber distribution

In addition to residential users, there is a significant market for broadband access in ships, aircraft and trains. The adoption of aeronautical broadband among airlines has grown dramatically in the last year with most major airlines either announcing plans to equip their fleets with satellite broadband or planning deployment in the near future. A recent study conducted by Valour Consulting showed that 47% of airlines surveyed currently deploy some kind of in-flight communications solution and that 85% planned to either add or upgrade connectivity in the near future. Valour estimates that the number of Wi-Fi equipped aircraft will grow from the current (2014) level of 3,543 aircraft to 12,267 aircraft by 2024. This represents a significant increase in demand for spectrum to

serve this unique and strategically important market. Valour also expects that Ka-band "will become the dominant technology" in this market.[8]

The growth in demand from passenger trains as well as the shipping industry has followed this trend. Satellites are uniquely placed to serve these markets and access to spectrum is seen as an important component in the future growth of the aviation, rail and shipping industries.

UK airlines and their passengers will benefit greatly from this increased connectivity. For airlines, the ability to connect an aircraft with an affordable broadband connection opens the possibility of a number of operational applications such as equipment monitoring, increased access to weather information, crew internet access, in-flight rebooking, remote medical assistance (to avoid unnecessary flight diversions) and other non-safety applications. Passengers will benefit from greatly increased in-flight entertainment and productivity options. Whereas current in-flight connectivity options are cost prohibitive, Ka-band satellite systems will allow passengers to have a home/office-like connectivity experience while flying. Video conferencing/chat, video streaming, access to social media will all be available with the same quality and reliability as on the ground.

Question 8: From your perspective, what high level trends will affect the satellite sector in the coming years?

ViaSat Answer

ViaSat sees the following trends in the satellite sector in the coming years:

1. Concentration of capacity where it is needed

Satellite capacity has historically been distributed evenly over satellite coverage areas. This worked well for video distribution and narrowband VSAT networks due to the broad coverage and relatively uniform user distributions common in these applications.

With the advent of High Throughput Satellites providing broadband Internet service, coverage needs to be focused where users are located. The use of small spot beams will enable HTS operators to concentrate satellite capacity where it is needed most.

2. More use of commercial networks by government/military users

The last 10 years have seen a rapid increase in the usage of commercial satellite systems by government and military users. Given the significantly shorter procurement and deployment times for commercial satellite systems and the ability to share costs with commercial users, we expect commercial satellites to play a growing role in serving the needs of government users. Advances in

[8] See press release on Study, Business Wire, Nov. 20, 2014, available at: http://www.businesswire.com/news/home/20141120005076/en/55-Aircraft-Equipped-In-Flight-Connectivity-2024-Valour#.VNH8NFXF8-A

security and greatly increased bandwidth will allow satellite providers to offer government users the same or even higher levels of availability, bandwidth, integrity and security than is possible using exclusive government frequencies and satellites. By working together with government users and allowing commercial access to previously exclusive government satellite frequencies, both commercial and government users could benefit from greatly enhanced and lower-cost services.

3. Increased Sharing with Other Services

In order to gain more access to spectrum, the satellite industry must adopt a more flexible and collaborative approach to spectrum sharing. The use of very small spot beams, cognitive radio techniques, advanced waveforms, better use of terrain shielding and other methods can all contribute to a much more intensive and efficient use of spectrum. Both the satellite and terrestrial communities must work together in a collaborative approach to design sharing rules for different bands that take into account these approaches.

Working with the terrestrial community to find new ways to share spectrum will allows satellite operators to keep up with the projected demand identified in response to Question 6.

Question 9: For each of the satellite applications you use, provide or help deliver what do you see as the a) current demand trends; and b) underlying current and likely future drivers of demand for the satellite application(s) your organisation uses or provides?
Please include in your response for both a) and b) above:

- *the scale and future impact of the trends/drivers on demand;*
- *any variations in the type and scale of trends/drivers by geography (i.e. in the UK, the rest of Europe, and other parts of the world where this may be relevant to UK use) and why;*
- *whether future demand is expected to be temporary or intermittent, and the reasons for this.*

In your response, please provide any evidence which supports your position on the drivers of demand (e.g. forecasts, studies and statistics).

ViaSat Answer

ViaSat views satellite as being a method of delivering broadband that is comparable to terrestrial solutions, and thus we are subject to the same trends and pressures as those solutions. The increase in streaming applications is driving a 35% annual growth in capacity demand per sub, but there is no elasticity in price, so to remain competitive we have to drive costs down at rate that matches the 35% annual capacity demand growth. ViaSat is confident in its ability to do so for the foreseeable future by building satellites that deliver more capacity for a given price and by deploying the capacity more efficiently. In addition, we expect to realize further efficiencies by reducing the cost of the ground network infrastructure through innovative system design and quantity-of-scale, and by increasing the integration of user terminals.

A second factor driving demand is the increase in demand from mobile users, such as ships, aircraft and trains. These users show the same type of demand

growth exhibited by other terrestrial users and, as outlined above, ViaSat believes that we believe we can provide a very affordable service that keeps economic pace with the demand for capacity.

One of the more compelling examples of the demand for broadband satellite services is the fact that ViaSat's service in the United States is currently approaching the capacity of the ViaSat-1 satellite. With ViaSat-2, we expect to be able to continue growth of the service for the next several years thanks to our ability to share spectrum with Fixed Service (LMDS) and NGSO FSS users operating in the lower part of the Ka-band.

Question 10: Taking into account the drivers you have identified in your response to Question 9 above, what (if any) challenges is your organisation concerned about in meeting potential future demand? Please provide the information by application and band, along with any supporting evidence, if available.

ViaSat Answer

ViaSat believes that the spectrum currently available for broadband satellite services can provide an economically attractive service to far more consumers than any previous satellite system could do. As outlined in our response to Question 6, however, access to additional spectrum would provide a substantial increase in the number of users we can serve and the type of applications we can provide. As discussed further in Question 13, access to additional parts of the Ka-band would enable these benefits with little to no impact on incumbent users of the band.

Question 11: Do you have any comments on the list of potential mitigations we have identified? What likely impact would each of the mitigations have on spectrum demand? E.g. what order of magnitude increase in frequency re-use might be achieved? To what extent do you believe that these mitigations apply only to certain applications?

- *improvements to satellite antenna beam focusing technologies. These would enable a satellite to use smaller beams so that frequency bands can be re-used through geographical discrimination, thereby increasing the capacity of the satellite (for example the use of high throughput satellites);*

- *new transmitter and receiver technologies and standards that could enable better use of spectrum. These include innovative and more spectrally efficient waveforms, better compression techniques and techniques to filter out unwanted signals;*

- *increasing the efficiency by which satellite networks share spectrum resources with other users (e.g. terrestrial applications);*

- *changes to satellite network parameters, such as the minimum diameter of the transmitting earth station or limits on the power flux density radiated towards other satellites, that could reduce the orbital separation between GSO satellites;*

- *greater utilisation of existing available orbital slots through better co-ordination between satellite networks. This may lead to a higher proportion of actual satellites deployed compared to the total number of satellites filed with the ITU, some of which may be just "paper-satellites".*

ViaSat Answer

ViaSat believes that innovative sharing techniques can facilitate even more efficient use of spectrum by satellite and terrestrial mobile networks. In this respect, ViaSat urges Ofcom not to assume that the circumstances that led to previous approaches to spectrum management still apply. For instance, a variety of cognitive and other sharing technologies exist and are being developed that can facilitate satellite uses of spectrum without impeding terrestrial uses in the same bands. These recent developments should negate the decades-old perception that increased use of spectrum by satellite operators somehow would constrain use of the same band by terrestrial users.

It is no longer necessary to impose limitations such as restricting satellite access of certain frequency bands to gateway stations only since sharing technologies and techniques have been proven to facilitate successful noninterfering operations. Notably, many bands shared by terrestrial and satellite services are conducive to opportunistic uses by small satellite terminals through cognitive sharing techniques (including dynamic spectrum databases) and sophisticated radio terminal technologies (including dynamic beam forming). Terrestrial base stations operating in the Ka- and V-bands likely would have small coverage areas, narrow beams and limited aggregate coverage. If this is the case, there likely will be ways that satellite operators can make opportunistic use of the same spectrum in nearby areas based on information regarding the locations and frequencies of these stations. Ofcom has previously recognized that such technologies could facilitate co-existence among terrestrial wireless operations, and these technologies can also be employed to enable coordination with satellite earth stations in those terrestrial bands.

ViaSat is already implementing dynamic channel assignment in the 17.7-19.7 GHz in its current generation of satellite user terminals. Cognitive Radio Techniques such as this could help in the 27.5-29.5 GHz uplink band. Use of cognitive radios that are able to access databases of existing FS users has already been studied by the EU-funded Cognative Radio for Satellite Communications (CoRaSat) project.[9] Unlike the downlink where there is no risk of interference into FS systems from satellite earth stations, sharing in this uplink band requires the satellite earth stations to have knowledge of FS deployments that may receive interference from the earth station's operations. This can only be accomplished through access to a central database.

There are of course concerns that need to be addressed before such a database-oriented solution can be implement. Cost of maintaining the database, confidentiality of FS information and aggregate interference must all be addressed. These issues, however, are not insurmountable. The cost of maintaining the database, for instance, could be recovered using license fees on satellite operators wishing to use the band. Confidentiality can be addressed by

[9] CoRaSat technology Roadmap available at:
https://drive.google.com/file/d/0B1mFLmtVhf61TXY0QmluSXljamM/view

making available on that information needed to calculate whether an interference event might occur. Other solutions can be studied further in cooperation with the FS community.

ETSI has made progress on a Technical Report further developing the work done by the CoRaSat project. ETSI TR 103 263 V1.1.1 provides additional information on how cognitive radio techniques can be used to enable sharing between FS and FSS systems in the 17.7-19.3 GHz and 27.5-29.5 GHz band. ViaSat will continue to participate in the development of this TR and urges Ofcom to take into account this draft TR as part of this consultation.

In order for increased sharing to occur, however, there must be some sharing of the burdens. While ViaSat does not wish to imply that the FS community's access to spectrum should be restricted, sharing will require flexibility regarding provision of information and adoption by the FS community of technologies that promote sharing.

Ofcom should support technical studies within both the CEPT and ITU to determine whether and under what conditions cognitive and other sharing techniques can be used to enable greater sharing between satellite and terrestrial users.

Question 12: What other mitigation opportunities do you foresee that we should consider? For what applications are these likely to be applicable and what scale of improvement are they likely to deliver?

ViaSat Answer

See answers to Questions 11 and 13.

Question 13: Beyond the activities already initiated and planned for the satellite sector (e.g. as part of WRC-15), do you think there is a need for additional regulatory action that may, for example, help your organisation to address the challenges it faces?
In your response, please indicate what type of action you consider may be needed and why, including any evidence to support your view.

ViaSat Answer

The key to providing high-speed, high-quality broadband satellite Internet services to residential and mobile users is access to adequate spectrum. As ViaSat pointed out in its response to the Ofcom Above 6 GHz CFI, satellite broadband systems will need continued access to "dedicated" spectrum bands—a base of "core" spectrum where they can operate on an unimpeded basis - to maintain and expand capacity to meet growing demand throughout Europe and the UK. Equally important, however, is having access to spectrum available for "opportunistic" use in bands that may be used for other purposes, such as terrestrial services. This type of opportunistic use by satellite networks occurs today in certain parts of the Ka band and could be expanded in the near future as well.

ViaSat believes that innovative sharing techniques can facilitate even more

efficient use of spectrum by satellite and terrestrial mobile networks in the 27.5-29.5 GHz band. In this respect, ViaSat urges Ofcom not to assume that the circumstances that led to previous approaches to spectrum management still apply. For instance, a variety of cognitive and other sharing technologies exist and are being developed that can facilitate satellite uses of spectrum without impeding terrestrial uses in the same bands. These recent developments should negate the decades-old perception that broad use of spectrum by satellite operators somehow would constrain use of the same band by terrestrial users. **It thus is important to re-examine the band segmentation plan in the current ECC/DEC(05)01 to determine whether it is possible for satellites to access additional parts of the 27.5-29.5 GHz band without imposing undue constraints on the Fixed Services**.

ViaSat believes that a number of new sharing techniques may allow satellite earth stations and terrestrial fixed service stations to co-exist in bands previously reserved for FS alone. Due to the very narrow beamwidth of FS antennas operating in the 27.5-29.5 GHz band and the deployment, there may be large geographic areas where use of FS-exclusive frequencies by satellite earth stations can occur without interfering with FS stations through the use of cognitive radio techniques. This type of sharing has already been approved in the 17.7 - 19.7 GHz satellite downlink frequencies, as recognized in the recently adopted ECC Report 232. ViaSat's user terminals are able to operate in line with this Report due to their ability to dynamically assign receive channels to frequencies that are not used by FS links. If a terminal is unable to close a receive link due to interference, it simply moves to another channel until it is able to close a link. In this way ViaSat is able to find unused frequencies even in areas that may have heavy FS usage.

There are many scenarios that are conducive to opportunistic uses by small satellite terminals through cognitive sharing techniques and sophisticated radio terminal technologies (including dynamic beam forming). The specifics of how satellite and terrestrial systems can share more spectrum must be studied further in the CEPT and ITU. It is essential, however, that these studies are allowed to proceed on a rational, technical basis. Any time sharing studies are undertaken, there is a risk that the outcome is undermined by unreasonable protection demands by incumbent services. To achieve increased spectrum efficiency, Ofcom must be a fair arbiter between parties to ensure that fair and rational sharing discussions take place based on reasonable technical analysis.

Similarly, ViaSat believes there is potential to allow commercial access to the 30-31 GHz band without compromising the important function this band plays for government users. Whilst this band has been reserved for government usage in order to ensure the protection and flexibility for the wide variety of usage envisioned for this band, recent advances in cryptography, mobility and link integrity allow commercial networks to offer capabilities and security that exceed what is available for current government-only networks. Again, any change in access rules to this important band can only be made in consultation with the affected user base. In this regard, it will be important for Ofcom to facilitate this discussion so that both government and commercial users can benefit from even more advanced, secure, robust and fast broadband services.

Government policy toward funding of broadband is another potential obstacle to the development of satellite broadband in the UK. The UK is an attractive place from a legal and regulatory perspective for satellite communications and service providers. Broadband delivery is however complicated in terms of state aid,

largely due to EU regulations, which disadvantage satellite broadband provision compared to fibre.

In terms of delivering Broadband, Satellite has not been viewed by the EU as Next Generation Access (NGA – defined as optical networks) technology, nor has the role of satellite (which already delivers speeds between 6-20 Mbit/s at a price point of £30-40 per month) been seen as part of a coherent digital solution. It is odd that a technology such as HCS that is so ideally suited to delivering broadband services is excluded from consideration as part of the solution to this need at the EU level. There is a State Aid constraint on the market in that currently satellite is regarded as suitable for Basic White areas only (<2 Mbit/s), which further restricts improvement to services. ViaSat is seeking to support Ofcom and the UK Space Agency in tackling these issues.

ViaSat appreciates the opportunity to take part in this consultation and looks forward to providing additional information to Ofcom to facilitate its work on this important consultation.