Strategic review of satellite and space science use of spectrum

QinetiQ Response

Space technology and applications are seamlessly integrated in all aspects of our lives, often without the users being aware. In science, space related research has enabled huge strides to be made in our understanding of our own planet and its changing climate, our solar system and beyond

UK has a leading reputation in the manufacture of space hardware and software. It is a world leader in the design and production of small, low cost satellites as well systems and subsystems for larger satellite missions. About 40 % of the world's commercial telecoms satellites include a significant element of UK manufacture[1]. UK developed software is to be found in many spacecraft and ground station systems.

Science services: UK scientists and science institutions play a leading role in a wide range of science missions, obtaining and interpreting space-related data and developing world class scientific knowledge – both in terms of understanding our own planet as well as our solar system and beyond.

Satellite and space operations and applications ('downstream' activities): UK is a particularly strong player in the downstream applications of space. A supportive business and regulatory framework, together with a Government policy and innovation environment and pro technology consumers are vital for this.

The Innovation and Growth Strategy (IGS), the joint Government and industry plan for the future development of the space sector has adopted an ambition to achieve market growth to £ 40 Bn by 2030, i.e. to increase its share of the global market from the current 7.7 % to 10 %. In terms of jobs, the IGS sets the bar at generating 100,000 jobs directly employed by the UK Space Sector by 2040. This is equates to 1 in 300 of the UK working population will be working in the space sector by 2040.

All the above space activities rely on the availability of spectrum. The IGS states that the £40 billion goal will be achieved through a mix of space infrastructure and space-enabled services. The majority of the growth will be obtained through downstream applications (£8 billion to £37 billion) which can only be achieved through dedicated areas of spectrum. This includes clean spectrum for Earth Observation applications to feed the downstream market.

[1] "Uk Spectrum policy Forum: UK Spectrum Usage and Demand" First edition PREPARED BY Real Wireless, March 2015

The information has been taken from the IGS, TechUK and companies that we work with. Additional points have been added specifically for our company interests. Several questions have been answered by TechUK and have been referenced in this submission.

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

QinetiQ believe that in undertaking this review, Ofcom should also explicitly take into account the interests of the global opportunities for UK industry as a priority alongside UK consumer and citizen interests. Space is a global business and involves many international companies. For instance QinetiQ work with many European partners, through ESA, to develop systems that impact globally.

Also the style of questions appears to be constructed from a very narrow understanding of the industry both for the satellite and space science. It appears that several specialist working groups have not been consulted in the construction of this CFI (e.g. UK Space Agency, Space Frequency Coordination Group, UKSpace, TechUK). The danger is that the full picture of the UK space sector will not be understood from this call, especially from a space science perspective.

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)?

See the answer to Question 1.

Question 3: Do you have any comments on our broad overview of the space science sector? In particular, do you have comments on the completeness of the list of applications, their definitions and their use of the relevant radiocommunications service(s)?

Trying to measure the value of the spectrum in monetary terms for the science will generate an incorrect worth to the UK economy. The concerns are that this process is asking too specialised questions leading to the real picture not being fully understood. Also the concern is that many of the stakeholders are not likely to respond to this call because of their reliance of spectrum, but not understanding the impacts of the proposals and mitigations. Specialised groups such as the Space Frequency Coordination Group (SFCG) need to be involved in this type of review.

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?

While the depicted value chain identifies the bulk of the categories of industry players, it is, depending on its intended purpose, potentially somewhat too simplistic.

For example, the categorisation of 'equipment manufacturers' hides a complex ecosystem from component and subsystem makers (including software providers) to system primes or integrators. In terms of the latter, the UK has particular world recognised skills in the manufacture of small satellites.

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

QinetiQ supply equipment to the telecommunication and navigation spacecraft. We also operate navigation satellites at our ground stations. QinetiQ work in the development of GPS and Galileo ground systems that will be essential to capture the 10% of the space market by 2040 as these feed into the downstream applications.

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

The table covers our UK and European operations with the frequencies that we support or developing systems to support. The number of end users is not quantifiable, but we are supporting the manned ORION flight around the Moon that has an impact of billions across the globe.

Band designation	Approximate Frequency range (GHz)	Useage
P	0.23-0.47	Cubesat Links
L	1-2	Navigation
S	2-3	EO and robotic missions
X	7-8	EO, Deep Space, Near Space, Military
K	25.500–27.000	Near Space (Moon)
Ka	34.200–34.700 31.800–32.300	Deep Space downlink

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)

QinetiQ programmes include working on the ISS and ORION EM1 flight which has the potential to inspire 10s of millions into STEM which has a massive impact on the UK economy.

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

Please see the TechUK submission.

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 see the TechUK submission.

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).

Please see the TechUK submission.

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.

Please see the TechUK submission.

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?

Please consult with the Space Frequency Coordination Group (SFCG) to ensure that the space science community is fully represented on available mitigation opportunities.

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?

Please consult with the Space Frequency Coordination Group (SFCG) to ensure that the space science community is fully represented on available mitigation opportunities.
For our applications we would like to see exclusion zones around near and deep space ground stations to prevent the damage to the UK economy. Recent example is that ESA has had to pull all its operations from Perth, WA due to re-use/sharing of spectrum for terrestrial applications and has cost the European taxpayer dearly (including the UK). This reduces available space data required to fuel the IGS aspirations.

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.

The UKSA, IGS and Space Frequency Coordination Group (SFCG) needs to be greatly involved in this process.

Question 14: Do you have any comments on our representation of the value chain for the space science sector? How do you think industry revenues are broken down between players at different positions in the chain?

Trying to measure the value of the spectrum in monetary terms for the science will generate an incorrect worth to the UK economy. The concerns are that this process is asking too specialised questions leading to the real picture not being fully understood. Also the concern is that many of the stakeholders are not likely to respond to this call because of their reliance of spectrum, but not understanding the impacts of the proposals and mitigations.
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Question 15: What is the extent of your organisations' role(s) in the value chain? Which space science applications (as summarised in Table 2 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.

QinetiQ are developing a system that can support manned Moon missions that will be used to inspire the next generation of scientist and engineers who will be required to the support the IGS aspirations.

Question 16: For each of the space science applications you use, provide or help deliver (as identified in Question 15), and taking into account your role in the value chain, where applicable please provide: - the specific spectrum frequencies used, distinguishing between the frequencies used for the science application, the frequencies use for downlinking data and, for TT&C; - whether the application is limited to use of specific frequencies and why (e.g. due to fundamental characteristics of the phenomena being measured and/or availability of technology designed for that frequency); - whether the applications use continuous or intermittent measurements; - the typical resolution and associated measurement bandwidths, including an indication of any implication for spectrum requirements; - the geography this use extends over (e.g. land or sea, and regional or global); - the location of the gateway station(s) for TT&C and downlinking data; - the estimated number of users.

Each spacecraft will be allocated a specific frequency within the given range and so a specific frequency is not possible to define. This will be determined by the agency that we are supporting (e.g. NASA, RSA, ESA, UK Space Agency, etc.) and given that the spacecraft is an international endeavour then these ranges needs to be protected. Any mitigations have been examined by the Space Frequency Coordination Group and should be used as an input to this call.

Timing Services:

- 1 151 – 1 214MHz GPS and Galileo
- 1 559 - 1 610 MHz GPS, Galileo and GLONASS

Space Science TT&C

- 450 MHz Telecommand for CubeSat operations
- 2110–2120 Deep Space Telecommand
- 2290–2300 Deep Space Telemetry
- 2025–2110 Near Space Telecommand
- 2200–2290 Near Space Telemetry
- 7145–7190 Deep Space Telecommand
- 8400–8450 Deep Space Telemetry
- 7190–7235 Near Space Telecommand
- 8450–8500 Near Space Telemetry
- 25500–27000 Near Space Telemetry

The estimation of the number of users is difficult to quantify given the data will be distributed across Europe (Sentinel - Copernicus) and will be accessible to millions. The reception and transmission to a manned Moon mission will reach 10s of millions in the UK, that will inspire the necessary scientist and engineers to support the IGS aspirations.

Question 17: For each of the space science 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).

Question 18: From your perspective, what high level trends will affect the space science sector in the coming years?

The main level of trends that will impact space science in the UK is the advent of ISS support and the development of Cubesats. The former will generate the inspiration needed to drive the UK economy in the areas of STEM and the layer will increase the upstream technology and downstream data. This will not only benefit the space industry, but also other highly skilled industries, such as aerospace, automotive, healthcare, clean energy.

Question 19: For each of the space science application(s) your organisation uses or provides, what are the a) current trends; and b) likely future drivers of demand for spectrum? Please include in your response: - the scale of the demand drivers; - the reason for additional demand (e.g. higher resolution radar data rates/bandwidth required) and whether this increased demand is for data delivery or for the taking of measurements; - whether increased demand can only be met at specific frequencies and why; 32 Call for Input - Strategic review of satellite and space science use of spectrum - any variations in demand drivers by geography (i.e. regional or global), and why; and - 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).

The current trends:

With the private investment in cubesat developments ensure that there will be more easily available data to fuel the downstream applications. With the government investment in the ISS and Tim Peake's flight will ensure that the general public will be suitably inspired to ensure that the next generation of scientists will deliver the IGS figures.

The future trends:

The IGS is driving the downstream markets to ensure the growth from £8 billion to £37 billion by 2040. This will increase the number of upstream systems, which also matches the IGS aspirations of from £1 billion to £3 billion as this can't be achieved through government funding. It has to be a majority from the private sector. This trend will be to put a greater demand on spectrum, for TT&C, data downlinks as well as the frequencies for Earth observation. We need to avoid the effects introduced in the SMOS data (see the answer to Question 20).

Question 20: Taking into account the drivers you have identified in your response to Question 19 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.

The space science sensors will become more sensitive and be more susceptible to interference.
The results from ESA's SMOS satellite have been impressive, but the mission has been bugged by patches of interference from radar, TV and radio transmissions in what should be a protected band – see Figure 1.

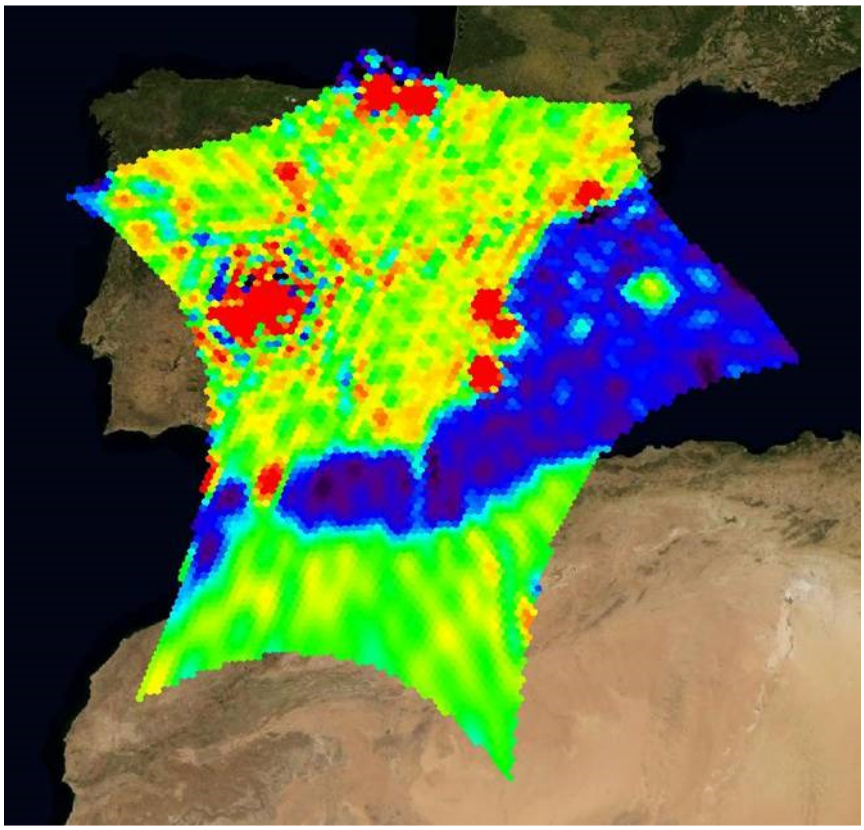

Figure 1 RF interference in the SMOS Measurements

This is the major challenge to the industry when we are required to deliver high quality data to the downstream application market. This is required to generate the required growth called for by the government / industry IGS targets.

Question 21: Are there any future developments, such as the radio astronomy SKA, that could reduce the demand for space science spectrum in the UK? Question 22: 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? To what extent do you believe that these mitigations apply only to certain applications?

The development in the SKA and radio science has the possibility of being spun into the area of space science in the ability of increasing the data downlinks – for instance transferring interferometry technology.

Question 23: 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?

Please consult with the Space Frequency Coordination Group (SFCG) to ensure that the space science community is fully represented on available mitigation opportunities.

Question 24: Beyond the activities already initiated and planned for the space science 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

Please consult with the Space Frequency Coordination Group (SFCG) to ensure that the space science community is fully represented on available mitigation opportunities.