Your response

Your response should include details of:

- a description of the relevant technology;
- a view of the potential impact of the technology on the sectors we regulate, preferably
- identifying the impact against the criteria listed in section 3.16 of the call for inputs;
- the current state of development of the technology, including any demonstrations of
- feasibility;
- any unresolved issues which need to be addressed for the technology to achieve full
- potential;
- references to key publications and the leading groups working on the technology; and
- whether you would be open to discussing the technology in more detail with Ofcom.

Your response

Confidential? – No

Ofcom - Emerging technologies and their potential impact on the communications industry

Met Office submission – September 2020

Introduction:

The Met Office is the UK's National Meteorological Service, a Public Sector Research Establishment and an Executive Agency of the Department for Business, Energy and Industrial Strategy. The Met Office is responsible for monitoring and forecasting the weather and runs the Met Office Hadley Centre, which provides climate science and services to help people and organisations understand and prepare for climate change, including the monitoring of global and national climate variability and change. The Met Office is also responsible for providing the UK's space weather monitoring service through the Met Office Space Weather Operations Centre, which provides 24/7 forecasts and warnings for Government, responders, critical national infrastructure providers and the public.

Environmental vulnerabilities of emerging technologies:

As new technologies emerge, consideration must be made for the impact of environmental factors such as weather and solar conditions on their effective operation and any vulnerabilities associated with the environment. While some technological developments build on existing capabilities where there is some understanding of their environmental vulnerabilities; the development of entirely new technologies presents new challenges in terms of environmental vulnerability. As new systems are being developed and public reliance on these technologies increases, the potential impact of environmental factors should feature prominently as their suitability and resilience is assessed. The impact of new technologies on existing systems should also be considered to ensure that technological developments do not result in degradation of critically important communication systems. Further details relating to these issues are outlined in the response below.

Space weather:

Space weather phenomena have always been present, but as modern society has become more reliant on technology and systems such as satellites, power and radio communications, the potential for space weather to impact on public life increases. The effects of space weather can impact on the efficacy of many modern technical and interconnected systems, particularly those with a reliance on access to space (e.g. GNSS or satellite communications). This can lead to degradation of signal and/or services, or total loss of services. A 2017 report by Innovate UK estimated the economic impact to the UK of a five-day disruption to GNSS at £5.2bn and found that the transport network, maritime sector and emergency services could be substantially impacted.

Understanding any vulnerabilities of new and emerging technologies to space weather is therefore important, particularly where these may support services critical to national infrastructure, security, life dependent services, or the day-to-day functioning of modern society. It should be noted that when assessing any such vulnerabilities, the holistic system needs to be examined (e.g. in the case of GNSS, not just the physical risk to the satellites, but also the risk to signal propagation and reception on the ground, including factors such as power supply).

As the owner of the space weather risk on the National Risk Register, the Met Office should be engaged in assessing the risk posed by space weather to new and emerging technologies. This will ensure that risks are appropriately recognised, mitigation actions can be considered, and advisory services can be developed that provide information to enable appropriate procedural decisions to be made and mitigating actions to be taken at the right time.

5G network case study:

The Department of Culture Media and Sport (DCMS) commissioned Ordnance Survey (OS), the University of Surrey's 5G Innovation Centre (5GIC) and the Met Office to undertake research into enabling geospatial data. This examined the associated granularity (level of detail) and weather data for use in cellular planning of 5G communication networks in spectrum bands above 6GHz.

The involvement of the Met Office in this work reflects the fact that 5G networks have an increased vulnerability to signal degradation due to weather conditions, compared to previous generations of mobile networks. At the proposed 5G frequencies, the wavelength of the electromagnetic (EM) radiation is comparable with the dimensions of intervening rain drops and other hydrometeors such as snow, sleet, fog or drizzle, which results in the increased absorption and/or scattering of the EM wave. The occurrence of heavy rain in the UK has the potential to significantly attenuate 5G signal strength, even over the relatively short path lengths envisaged due to line-of-sight constraints.

As part of the Met Office's work with 5GIC, several case studies were identified where heavy rain was experienced at the 5G test sites of Bournemouth and Swindon. The Met Office then produced 100m resolution rainfall datasets for both sites, which were converted to free path attenuation values at each of the five proposed 5G frequency bands. The result was high resolution spatial datasets of meteorological parameters together with 5G attenuation values, which were passed to project partners at 5GIC to be assimilated into detailed propagation models.

The impact of UK rainfall was found to be most severe at the higher frequencies (71 and 83GHz). The study also indicated that at lower 5G frequencies, the enhanced attenuation

effect of melting snow may also provide additional challenges, even for those networks that were designed to cope with higher intensity rainfall events.

The implication of these conclusions is that, while future 5G networks will be able to operate in the UK environment, the impact of weather must be factored in to the design to assure an all-weather service at an acceptable capacity, especially to inform the range over which a base station can propagate and that the cell edges will not be shortened in varying seasons.

Autonomous vehicles case study:

In partnership with the National Physical Laboratory (NPL), the Met Office has recently explored the impact of the weather on the perception sensors on which the emerging fleet of Connected and Autonomous Vehicles (CAVs) will depend for their safe and efficient operation. A key output of the this work has been to influence the environmental elements of the publicly available specification, *PAS 1883 Operational Design Domain (ODD) Taxonomy for Automated Driving Systems (ADS) – Specification*. The ODD is important because it represents the "envelope" within which a CAV is deemed safe to operate and includes both weather and the communications connectivity that is available to the vehicle, including 5G comms, amongst others. Of particular note is that the environmental sensitivities of the CAV sensors may be closely related to those of the communications systems. For example, the CAV mm-wave radars are likely to operate at 77GHz. A possible implication of this is that the scenarios where the CAV may benefit most from externally supplied information about its challenging operating environment may also be those where the communication environment is most impacted by the weather. Similar arguments will apply to all autonomous forms of future mobility including air and sea. To summarise, in considering the environmental sensitivity of emerging communications systems, it will be necessary to consider if there are correlations with the demand for their services.

Conclusion:

Environmental sensitivity of new communication technologies

Over recent decades, increasing bandwidth requirements have led to adoption of higher frequencies for wireless communication. Frequencies greater than approximately 10GHz are subject to highly variable atmospheric attenuation, mainly resulting from precipitation, which can impact performance and resilience. Detailed knowledge of both the climate (for network design) and real-time meteorological conditions (for network management) will be key in reducing their impact on future wireless communications technologies operating at attenuating frequencies.

Variations in the refractive index of the atmosphere due to changes in pressure, temperature and humidity, impact the speed and direction of propagation through the atmosphere. New wireless technology that requires knowledge of the speed of propagation to better than approximately 1 part in 100,000 (for example to enable highly accurate geolocation), may similarly benefit from knowledge of atmospheric conditions to compensate for atmospheric effects.

Limiting the impact of new technologies on existing communication requirements

It is important to ensure that any new technologies do not have a detrimental impact on existing meteorological observing technology and appropriate spectrum management is vital to achieving this. Continuity of meteorological observations is particularly important for climate science, where long-term records of the earth system are vital. The Met Office is in no way opposed to the introduction of emerging technologies and we will continue to seek

opportunities to work with industry and other partners to determine whether meteorologically relevant information can be extracted from these new technologies for wider public good. By continuing to engage with Ofcom on both national and international matters, the Met Office aims to maintain sufficient access to the spectrum we require in order to continue to provide critical weather and climate services, including being recognised throughout the UK as an operator of key national infrastructure. The Met Office stands ready to support Ofcom with any future work in this area and is willing to provide any further information should it be required.

References:

'Economic impact to the UK of a disruption to GNSS', London Economics, 2017. Commissioned by Innovate UK. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/619545/17.3254_Economic_impact_to_UK_of_a_disruption_to_GNSS_-_Showcase_Report.pdf