Re: National Infrastructure Commission- 5G Call for evidence

Please find attached the Institution of Engineering and Technology's written response submission to the above consultation.

About the IET

The IET is one of the world’s leading professional societies for the engineering and technology community, with more than 160,000 members in 127 countries and offices in Europe, North America and Asia-Pacific. The IET provides a global knowledge network to facilitate the exchange of ideas and promote the positive role of science, engineering and technology in the world.

This submission has been approved on behalf of the IET’s Board of Trustees, and takes into account the views of IET Members under the guidance of the IET’s Communications Policy Panel and should not be taken as representing in any way the individual views of the organisations for which the panel members work.

The IET is happy to discuss these points with the Ministers or Officials.

Yours sincerely,

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Enc.
National Infrastructure Commission- 5G Call for evidence

The IET is pleased to respond to the National Infrastructure Commission’s consultation on 5G. Some of our members are at the very heart of 5G research and planning. As companies will be placing their risk investment on various parts of the 5G vision, so the Government and Ofcom can place bets where it gives its support. The most powerful outcome will result where the agendas of the government, Ofcom and the mobile network operators can be aligned. We suggest that the aim of the National Infrastructure Commission should be to ensure the UK puts some early, well-chosen 5G stakes into the ground by 2020/21. From the evidence we have to hand today, our choice of the top three 5G prospects for those stakes in the ground would be:

A Coverage

Do something really bold with the 700 MHz spectrum release to drive a leap in “very reliable and dependable” national coverage.

Ofcom has a lever to pull with a coverage obligation. Spectrum auctions can be in kind, e.g. Operators invest in new base stations or upgrades, such as raising the height of masts to 25m height, in return for spectrum allocation, rather than simply cash going to the Treasury.

There has to be a defined objective and we suggest it should literally be that people on every road in the UK should have reliable access to mobile connectivity. This would align well with a focus on Transport that could provide far reaching national benefits and productivity gains. This proposal also supports a reliable 5G connectivity “underlay” that helps the entire advanced wireless infrastructure function more responsively to customer demand.

B Capacity

Remove the barriers to the first one million 5G small cells, with Ofcom focus on wide RF channels in the 3.4-3.8 GHz band. “Access rights” should be granted to attach tiny cells to 1million public structures, lamp posts, transport structures etc., and an imaginative international initiative to kick-start early large scale economies

C Demand Attentive Networks

Catalyse with the help of the BBC, mobile network operators and smartphone suppliers a soft infrastructure for pre-streaming content ahead of demand. This links together the massive unused off-peak network capacity with the massive storage now being built into modern smartphones. This has the potential to remove up to 20% of traffic off the inevitably lower capacity wide area cells and provide a much better quality of experience for users, e.g. no loss of picture when a train goes through a tunnel. It also offers one of the first tangible consumer applications of 1-2 Gb/s data speeds as entire content can be sent in a very high speed burst as the users passes through very high capacity 5G cells.

Going forward the emphasis needs to be strongly on a network of networks, in line with international standards, to support whatever demand arises.

Our detailed response follows the questions raised by the NIC but we have added a question at the very start “What is 5G” as there are different interpretations in use across the world. We have added a section at the end on “Any other things the NIC should take account of”.

Page 2 of 10
We have not provided answers to every question but only those where we believe we can provide unique insights.

4.0 What is 5G?

To understand what 5G is one has to go back to its genesis. It began as a dialogue within the research community on what might follow 4G with a presumption that cellular mobile system technology tended to be subject to a generation change once every decade.

Different research groups brought distinct visions ranging from IoT to multi-Gb’s hot spots. The different visions were viewed as complementary rather than competitive. However a very early divergence took place between those with a limited view that 5G was only about a new radio interface (Radio Access Technology) and those that saw 5G as an opportunity for a more holistic view. The first is a sub-set of the second. The first also tended to pick up huge research momentum around the exploitation of milli-Metric wave spectrum, perhaps at the expense of research into the other possibilities.

The 5G all-encompassing vision is now being turned into road maps and global standardisation is now underway. Since different elements of the 5G holistic vision are addressing different parts of the market it follows that this will happen at different speeds. The important conclusions the IET suggest are drawn from this background are:

(a) The holistic vision of 5G is the more useful to the UK
(b) 5G should not be viewed as a “big bang” in 2020 but a far reaching change to be managed over a decade
(c) The National Infrastructure Commission needs to select from the holistic 5G vision those elements that are both ready to bring to market from 2020 and offer the best economic gain for the UK. The aim should be to get some well-chosen stakes into the ground
(d) The different 5G elements should not be artificially linked to a common time-scale but each taken forward on its own time-scale. It is fast time to market that will secure UK leadership.

Question 4.1

- What uses have been envisaged for 5G?
- Of those use cases identified, which appear most credible from a UK perspective, and over what timeframe?
- What is the potential scale of benefits?

Response

The 3GPP Global standards body has highlighted three use cases to be addressed in standardisation:

- Enhanced Mobile Broadband
- Massive Machine Type Communications
- Ultra-reliable and Low Latency Communications

This does not preclude other use cases and not everyone agrees it is necessary to couple “ultra-reliable” with “Low Latency Communications”. For example a more modest capacity mobile broadband optimised for reach (coverage) could have “reliability” as its key attribute. This would not be as ambitious, or costly, as “ultra-reliable” but nevertheless deliver far more dependable coverage. This may offer the UK much faster benefit than other options as Ofcom is releasing spectrum at 700 MHz that could be engineered to provide more reliable, in the sense of more dependable, national coverage.
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The Enhance Mobile Broadband (eMBB) and Machine Type Communications (MTC) build on use cases already proven in the market on existing technologies. Investing in 5G will have as its main purpose the lifting of the ceiling of the national infrastructure so capacity or massive connectivity scale-up to allow long term market growth and success of the digital economy and digital social space.

**Question 4.2**

What regulatory, planning and other key challenges need to be overcome to support the rapid and cost effective deployment of 5G across the UK?

- are there planning or wider legal issues which have the potential to hold back the deployment of 5G networks?

**Response**

The enhanced mobile broadband delivering a Gb/s society will be hugely challenging. The significant barriers are:

(a) **Early scale economies**: Getting early scale economies to break out of the vicious circle of initial unit costs of small 5G cells being high due to low volumes leading to poor uptake, leading to volumes remaining low and leading to prices remaining high.

There is British invented solution. GSM faced the same problem and the GSM Memorandum of Understanding proposed by the UK Government was the mechanism to combine the early procurement volumes of mobile operators across Europe. It was a voluntary agreement to go out to procurement in the same time-window that built up purchasing volumes to help industry to scale up and mobile operators to enjoy lower prices sooner. It speeded up the roll out of GSM to such an extent that it outpaced all its competitor technologies.

(b) **Access to wide RF channels in the 3.4-3.6 and 3.6-3.8 GHz bands**: The way 5G makes a leap over 4G technology is to be able to exploit an RF channel much wider than 4G has been designed for. So if there is no possible access to wide RF channels there will be no leap. Attention has turned to spectrum above 20 GHz where it is far easier to accommodate wide RF channels. However such higher bands are not suitable for users on the move or for users between fixed locations due to poorer radio propagation (see figure 1). It would be a step backwards for consumers and business customers that demand both capacity and contiguous coverage from their mobile service in order to connect to broadband networks wherever and whenever they want. See section 4.5 for what needs to be done.

(c) **Access to sites on a mass affordable scale** – Delivering a Gb/s society requires the number of cells in the UK’s mobile infrastructure to rise from the tens of thousands of the current cellular network to millions. There are three brakes on this process. Negotiating a site agreement is often lengthy and manpower intensive so the approach does not scale. Current cell site rents average £5000 per year and clearly that does not scale to millions of cells. Third, in a business model where adding another site adds another rent will lead, in a well-run business, to a constant pressure to minimise the number of cells and with potential pressures to take cells out of use as companies go through cyclic cost cutting. The site access/rent model does not scale. Central Government, Local Government and Public Utilities own huge real estates of buildings and other structures, street lights, traffic structures etc., to which a tiny antenna could be attached with little or no detriment. This offers an opportunity to transform the site access/rent model to something that would be scalable and transformational.
(d) **Access to space** - The advent of SDN/NFV (Software Defined Networks/Network Function Virtualisation) will lead to operators wanting to distribute computer processing & storage to the edge. Access to local exchange space/power proved indispensable to drive unbundled local DSL access. In a 5G era similar access rights on fair terms and conditions to any space/power/duct/pole, whoever the owners, could be incredibly useful for competitive Cloud-RAN base-band hotels and distributed compute platforms for SDN/NFV. It would maximise the flexibility for 5G deployment, architectural optimisation and efficiency. In a similar way that a smartphone memory/battery creates the foundation for innovative “apps”, the same principle applies to the space/power needed to host distributed compute processing/storage in order to unleash network innovation.

(e) **Commercial incentives to leap rather than creep** - There is likely to be one or more UK Mobile Network Operator willing to be an early adopter of 5G Gb/s cells. Normal market competition will take care of that. However the approach to roll-out will be a slow evolution. The first 5G cells will go into a relatively few locations of very high footfall and there will be no contiguous coverage. Gradually some link-up’s of coverage will occur. The coverage will slowly creep out to an eventual coverage of dense urban areas. Over this slow evolution the “mobile” customer experience of a Gb/s society is likely to be underwhelming and of itself will limit consumer demand.

The challenge is how to incentivise a coverage leap rather than the more likely slow evolutionary creep. It is worth adding that traditional coverage obligations attached to spectrum licences, usually expressed as a percentage of the population covered, will not work with small cells over high footfall areas. One such incentive could be making available “access rights” to attach tiny cells to 1million public structures such as lamp posts, transport structures etc. It could dramatically kick start the roll-out of 5G in the UK.

- Are there issues around working across industry sectors which may hold back the deployment of 5G networks?

**Response**

In the telecommunications market top executives meet at events such as Mobile World Congress and senior engineers are in constant touch through the global standards body 3G PP and the regional standards body ETSI. Therefore the framework for cooperation exists across multiple industry sectors (chips to software switches) for the deployment of 5G mobile networks and traditional devices, e.g. smartphones.

In the IT industry there are dominant players, Google, Microsoft etc. that will have no barriers to “over the top” deployment of 5G services for their eco-systems. All the problems of working across industry sectors congregate around new 5G services in vertical sectors that may have critical linkage to the 5G infrastructure itself. Here there is no framework of natural cooperation across say health and transport and the telecommunications sector and nor can anyone realistically move from an adjacent industry to force change through dominance.

Different vertical industries each have their own agendas, are largely ignorant of what is going on in other sectors and there is no place or time when the top Executive mingle to cross fertilise ideas and see mutual opportunities. The Government can use its “good offices” to get senior executives around the table from different industry sectors to catalyse complementary and mutually re-enforcing road map.

**Question 4.3**

- What are the infrastructure requirements for 5G deployment likely to be?
Response

The choice of radio spectrum will largely define the resulting 5G infrastructure in terms of its coverage and capacity and this in turn places quite different demands on the corresponding infrastructure requirements. This diversity is illustrated in the diagram below.

Figure 1 – Spectrum choice drives a coverage/capacity trade-off (numbers purely illustrative)

The 700 MHz infrastructure raises an issue of definition of whether it is classed as a 5G infrastructure. Most of the new services being described as 5G services require national coverage. The EU Commission has identified the 700 MHz band to be used across Europe for this purpose. However, it is very likely that only LTE (4G) network technology will be used for some time in the 700 MHz band. This raises an issue of definition as to whether a 700 MHz cell using 4G technology but carrying 5G services is a 4G or 5G cell. There is no value in making such distinctions. All technologies (WiFi, 2G, 3G and 4G) should be regarded as contributing to a 5G infrastructure. Note: The IET believes it may be useful to introduce the term “5G underlay” for a 700 MHz 4G network as this has the potential to be the connectivity layer that integrates all the other technology/spectrum bands to give users a more seamless and responsive 5G service

- what do the services and uses for 5G suggest about the infrastructure requirement?

Response

The three use cases identified by 3G PP of Enhanced Mobile Broadband, Massive Machine Type Communications and Ultra-reliable and Low Latency Communications each lead to a different infrastructure requirement. The convergence of mobile and broadcasting networks would also make particular demands on the network design.

- What level of UK coverage will be optimum and what does this mean for the challenge of delivering higher speeds and lower latency? Are there particular issues faced by urban, suburban and rural areas?

Response

The UK’s biggest mobile infrastructure challenge for the next 25 years will be mobile coverage. Everything is trending in the wrong direction:
Basic mobile coverage is actually going backwards as UK made a planning mistake in limiting the height of its cellular masts and trees screening many of them are growing in height to more effectively screen the radio signals. At the other end of the link smartphone radio performance is falling rapidly due to a runaway world of ever more diverse radio spectrum bands being released by regulatory authorities that demand ever more antennas to be packed into the tiny volume of a smartphone.

The LTE (4G) technology has a significant weakness in that the network capacity falls by up to a factor of 100 at the cell edge in the busy periods. This could manifest itself to users as a coverage problem in not getting the high data speeds they were expecting. It is something the NIC may want to highlight to the research/standards community as worth addressing as at 700 MHz the cells are very large so that the cell edges amount to an appreciable area.

Exploiting ever higher spectrum bands comes at a price of hugely rising costs of providing wide area coverage and hence a huge shrinkage of area coverage with these higher bands, as shown in the above illustration. This is why 5G access to the bands 3.4-3.8 GHz is so important, as at least there is the prospect of good 5G area coverage of Gb/s mobile connectivity over dense urban areas.

As mobile broadband data speeds have increased so the need for broadband backhaul becomes necessary and for many rural sites today the lack of fibre or microwave becomes a blocking issue to sustain coverage at these higher data rates. It is one illustration of the compelling need for a systems approach in infrastructure policy.

The release of the 700 MHz spectrum in the UK provides a once in a decade opportunity to do something really special for "very reliable" pervasive national mobile coverage to provide "a 5G underlay level" providing a basic connectivity for every other part of the 5G infrastructure. It probably involves incentivising some new masts but the main solution probably lies in the direction of accelerating investment in raising 10-20% of existing masts to a full height of 25m where the prime top of the mast slot goes to the new 700 MHz radiating elements in coverage challenged areas. The government has already acted to remove the planning restrictions on 25m masts over most of the country and so the policy challenge is incentivising the industry investment to raise mast heights at enough sites. The Treasury needs to regard "spectrum pricing" as a variable that needs to flex to pay for new sites and the 700 MHz spectrum auction is another lever that can be used by requiring bids in kind (e.g. number of masts brought up to 25m) rather than cash to the Treasury. These two measures could provide the necessary scale of incentive to deliver this leap in reliable and dependable coverage.

- Are there any 'no regrets' and 'low regrets' infrastructure investments that can be made to support 5G deployment?

**Response**

The "no regrets" infrastructure investment to deploy 5G at the very top of the list is the pervasive reach of fibre optic cable and ready access to it by third parties on fair and reasonable terms.

- In what ways could collaboration between infrastructure sectors speed up and improve deployment, and how might it be incentivised?
- Are there any relevant international examples in the deployment of telecoms infrastructure that the UK can learn from?

**No Response**
Question 4.4

Who should bear the deployment costs of 5G?

- What is 5G deployment likely to cost the UK?
- Are there international examples to draw on?

No Response

Question 4.5

Is the existing UK telecommunications model able to facilitate the efficient roll out of 5G infrastructure and technologies?

- Is spectrum policy and its management well placed to support future 5G technologies?

Response

Access to very wide RF channels. The big spectrum challenge of 5G will be access to very wide RF channels, of at least 100 MHz in the 3.4-3.8 GHz band. Why this is so important is that no mobile operator has an existing mobile spectrum holding under 4 GHz able to accommodate 100 MHz wide RF channels and without such wide channels, the 5G technology cannot deliver its clear advantage. The spectrum trading market that national regulators had hoped would emerge to allow players to buy the additional spectrum they needed has failed to materialise. This leaves new spectrum releases as the main opportunity. However a change in the approach of spectrum auctions is needed as the current approach leads to a high probability of spectrum fragmentation. Some urgent deep thinking about the impact of wide RF 5G channels on competition and the price of spectrum is also needed by Ofcom. Ofcom is aware of these issues but is under pressures to move ahead quickly to release the ex-MOD 3.4-3.6 GHz spectrum. The most straight forward solution is for at least one contiguous block of 100 MHz to be on offer in the 3.4-3.6 GHz spectrum auction and similarly when it comes to the release of 3.6-3.8 GHz. There are a variety of options for addressing any competition concerns.

Opportunity for liberalising indoor small cells – The sub-band 3.7-3.8 GHz has a significant practical constraint that existing satellite earth stations need to be protected from harmful interference. Thought might be given to the 3.7-3.8 GHz block being allowed for low powered indoor use under some form of “conditional” liberalisation, the condition being an effective means to control interference to make it easier to share with existing satellite earth stations. This could be combined with the sort of co-capacity shared indoor wireless units of the current BT “FON” model to deliver “inside-out” public 5G coverage.

Such a liberalised approach may also drive faster scale economies that feed across to the licenced 5G small cell technology.

Advanced Spectrum Sharing – There is a lack of a viable route that would have the full support of the mobile network operators to implement very advanced spectrum sharing technologies.
that could flexibility match spectrum resources to instantaneous demand to deliver the IET DAN\(^1\) vision (see below) of users having the perception of being connected to networks of infinite bandwidth.

4.6 Additional Question - “Any other things the NIC should take account of”

No matter how much investment is made in a wireless infrastructure there will always be locations and times of capacity constraints. The IET proposed a new philosophy called the “Demand Attentive Network (DAN)” with the vision of networks giving users the perception of infinite bandwidth. The realisation of that vision brings together in a number of developments such as “Big Data” informing a network of where demand is likely to arise and flexible uses of resources like “radio spectrum” to provide bursts of capacity at the place and time of peak demands. Embracing the DAN vision is one of the few areas where the UK could secure a competitive advantage from its digital infrastructure investments. It requires a systems approach to infrastructure.

DAN also challenges the venerable Internet TCP/IP protocols (whose limitations are now leading to a growing waste of investment) and spectrum efficiency, as ever faster access networks fail to deliver ever faster and more responsive down-loads, due to the way the TCP/IP protocols limit data flows over the Internet itself. This is an area where the NIC needs to look beyond the UK to influence a radical modernisation the Internet protocols through say the G20.

As ever more of our economy comes to depend upon wireless connectivity to the Internet, a high 5G priority has to be improving the end-to-end security. The 5G element must play its part in a systems approach to immunising the broadband network against malware, hackers and other means of damaging large numbers of on-line systems.

The IET Communications Policy Panel remains at the disposal of the NIC should they want to follow up any of our points or raise with us further issues.

**Annex - Summary of policy lever options to drive UK success in 5G**

1. Government to set national objective that literally every road in the UK should have reliable access to mobile connectivity

2. Government to use “good offices” to bring vertical industry leaders around the table with telecom industry leaders to catalyse vertical applications of 5G

3. Ofcom to find means to release to the market 100 MHz wide RF channels in the band 3.4 – 3.8 GHz for 5G small cells delivering 1Gb/s data speeds

4. Ofcom to consider the 3.7-3.8 GHz block being allowed for low powered indoor use under some form of “conditional” liberalisation perhaps linked to a private/public inside-out 5G public coverage

5. Ofcom to consider coverage obligation to attach to 700 MHz licences to deliver Government coverage objective of every road to have reliable mobile connectivity

6. Ofcom to consider a design of 700 MHz auction where bids are in kind (number of masts raised to 25m) rather than cash and spectrum fee rebates to pay for entirely new 700 MHz base stations to cover roads through rural areas

7. Government to champion reform of Internet TCP/IP protocols in the G20

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\(^1\) DAN [www.theiet.org/dan](http://www.theiet.org/dan)
8. Government to pass legislation empowering the National Infrastructure Commission to grant access rights to mount small 5G antenna on any building or structure owned by Central Government, Local Government and Privatised Utilities on appropriate terms and conditions that transform the site access/rent model to something that would be scalable and transformational.

9. Government to pass legislation empowering the National Infrastructure Commission to grant access rights on fair terms and conditions to any space/power/duct/pole, whoever the owners, to deliver competitive Cloud-RAN base-band hotels and distributed compute platforms for SDN/NFV.

10. Government to bundle together access rights for 1m small 5G antenna to be mounted to jump start 5G scale economies and earlier contiguous coverage.

11. Government to propose international Memorandum of Understanding bringing together countries and mobile companies willing to commit to install 1m small 5G cells per country on a common time-scale to drive economies of scale and early contiguous coverage.

12. Government to catalyse with the help of the BBC (with compelling content), mobile network operators and smartphone suppliers a soft infrastructure for pre-streaming content ahead of demand.

End of consultation response.