Response from Ericsson Ltd

to

The Digital Communications Infrastructure Strategy

Consultation Document

Issued by

DCMS and HM Treasury

October 2014

Ericsson is grateful for the opportunity to contribute to this valuable exercise by Government. We look forward to seeing a strategy emerge from this consultation to guide the next administration in improving productivity and increasing GDP by the implementation of a world class information infrastructure.

Q1 Views are sought on:

a) Is this an appropriate role for Government?

Yes this is an appropriate role for Government. In particular it is essential that a set of desired outcomes be established if the market is to have confidence in the nature of interventions in the case of market failure

b) What other high level principles might the Government adopt?

The key additional principle is making all departments work towards the same goals. Furthermore it is rather important that the devolved administrations are part of the policy formation but do not then have different policies in any intervention stage. The needs of devolved administrations should be art of the whole policy and not be seen as infighting later. That is because it devalues the public view of the intervention when differences in implementation happen.

We think it is necessary to consider the needs of the Networked Society through an understanding or at least a vision of how people will live their lives in the future. We need to consider the needs of the Digital Economy in support of society, education, trade and government.
See Ericsson research here:

http://www.ericsson.com/thinkingahead/networked_society/stories/#/film

c) What resources do you consider the Government should aim to deploy to effectively manage its role?

The main problem is the undesirability of creating more posts and the need to formulate responses when needed. The task of checking whether policies are likely to be achieved could be given to Ofcom. However Ofcom are not in a position to determine suitable remedies given that the policy needs to be re-assessed at the time of noting potential failure in order to ensure that the response is proportionate. Consequently the resources to be deployed will need to be a joint board which has inputs from the watching brief given to Ofcom, DCMS and the Devolved Administrations. It is also recommended that inputs are sought from the Local Government Association on a regular basis as well as the consumer groups which Ofcom supports.

Q2 What potential opportunities are there for Government to leverage its combined buying power to support policy objectives?

These predominantly exist in the area of IoT.

The government can kick start equipment volumes in the NHS and in public sector housing. In order to be effective we need to consider how to ensure that volume purchasing for economy can be ensured without dilution because of public sector

purchasing policies and competition law.

For the NHS, monitors using MBB can be envisaged to interwork with measuring equipment provided by GPs. The challenge is to centralize both supply and the distribution on results. Individual practices can be free to choose their own systems to store patient data but it should always be retrieved from a single warehouse design which goes with the measurement equipment. Subsequent generations of replacement equipment would use the same communications interfaces to deliver data to the warehouse. This allows evolution of communications equipment independently from the warehouse and allows proliferation of GP systems as happens today. However the all-important innovation and volumes can be achieved by government intervention at the right point to ensure economies of scale.

The use of presence and movement sensors on the same basis can significantly aid social services but again the intervention is about common systems to reduce installation costs as well as device costs. There is also a need to ensure that there is only one delivery system to make secure because this kind of presence reporting can be a real security threat if information is released incorrectly

Q3 If migration to IPV6 is required, are there any barriers to that migration and if so how might these be addressed?

It is not evident that IPv6 is an inevitable requirement in the UK for a while yet. For many the explosion in numbers of devices presages the need for IPv6. However we have added as many Mobile IP devices as fixed ones without that increase. SIP in 3GPP was meant to be an unavoidable reason for IPv6 but it hasn't happened.

The reason simply is that most applications do not actually require full any-to-any connectivity at the network level with connectionless data. Most applications are actually using application level data exchange where the transport is connection oriented. These connections are often peripatetic but connections none the less because that makes security easier. If we rely on connectionless with massive number of stations we find ourselves with a key distribution problem because we have to validate the packets before passing them to application layers in order to protect the applications from attack. The technology to protect and challenge connection level traffic is much more mature.

The use of connection oriented technology which use keep-alive messages means that we do not have to initiate communications from central devices very often and that in turn means that NAT including carrier grade NAT works well.

The only real need for IPv6 is where an "any-to-any" connectivity is needed for devices that are so large in number they cannot use IPv4 addresses that are shared by other always on devices and demand to be available quickly and to be accessed only by IP addresses rather than using some auxiliary paging system. A characteristic of such devices is that they must be turned on all the time, which many them rather power hungry. Whilst we do not know the possible distribution of devices volumes by type power hungry devices will either be permanently carried by people or vehicles with access to power sources or fitted in fixed devices with power sources. The document notes that tablets will tend to be WiFi only in future and although it is not said explicitly this is possible because they can tether either to domestic WiFi or portable WiFi from smartphones. There is reason to suppose that the demand for extra addressing is not that high as architectures initially have to deal with NAT. Some NAT configurations can be punctured for particular protocols using automation through UPNP, although manual configuration is less of a security risk. What causes a

difficulty is that such puncturing is not provided on carrier grade NAT because users have no way to control the router providing the final NAT.

There do not appear to be any barriers to introducing IPv6 in a dual stack mode if operators want to do so. There is however a cost to managing two address spaces in parallel and handling the data retention requirements for both addresses. Today most user routers do not have v6 address handling capability turned on and the distribution of IP addresses to the devices in the home is not practically at the same level as for v4. Many devices in the home will already be using v6 internally using link-local addresses. The barrier to IPv6 is perhaps that it adds cost for ISPs but delivers no discernable benefit. There are also costs in ensuring the DNS entries are maintained for both addresses. Users can change the IP address of a device within their allocation at will and may well do so for security reasons.

The real barrier is that commercial success is not available to applications which only offer IPv6 until everyone has access without having to take special measures. This requires the industry to pay up front costs for something that has no return. We really should not be surprised that no one wants to push it.

The way to overcome the problem is to place some must have service only on IPv6. The one most likely to force acceptance would be connected to the Customs and Revenue but the loss of coverage caused by exclusivity would be the reason it would not be allowed.

In more rational times we would have simply regulated that IPv6 was required to permit any-any connectivity by issuing a determination with an industry agreed deadline that allowed most devices to be updated on a similar cycle to 5GHz WiFi. Then by giving a dispensation on the data retention requirements until a threshold traffic intensity was reached, whilst retaining LI capability. This in fact can be done by placing the requirement only on superfast broadband if implemented with the agreement of Openreach and Virgin Media. It is not clear that such an approach could be adopted today.

Q4 Is an ongoing disparity of broadband services inevitable? If so, should this be addressed and how might this be done most effectively?

An ongoing disparity is inevitable. It is there in every utility even water where such a fundamental as mains drainage is not available everywhere. The closest we get to coverage everywhere is with broadcasting where the cost of adding remote users is fixed because we can fall back to satellite. That solution is available for broadband but has serious delay and cost disadvantages compared to receive only services such as broadcasting.

The communications as a human right lobby have to explain why superfast broadband is more important than potable water, mains drainage, electricity and gas. For internet connectivity ADSL and satellite at least provide coverage practically everywhere which mains gas cannot.

Q5 How symmetrical will digital communications networks have to be in the future? Will this differ across user types? What implications does this have for fixed and wireless broadband provision?

Summary points:

- There are few consumer/volume applications which require a symmetric service

- Those that do require a reasonable amount of upstream capacity, but as downstream speeds increase, they doesn't justify full symmetry
- Downstream performance can be limited by upstream performance and latency due to the need for TCP and SSL acknowledgment messages, therefore, "decent" upstream capacity should be provided
- What would constitute "decent" upstream performance?
    - This could be the subject of serious research (or at least research of existing research)
    - Empirically, a ratio of 6:1 would be the minimum to be confident
        - With a downlink of say 24Mbps this would support an upstream flow of up to 4Mbps which would be good enough for the most common application, two way video calling
        - Above 24Mbps the problem diminishes further
- Businesses are more likely to justify the need for symmetry

This is always an interesting topic with enthusiasts usually suggesting that Skype video calls and the like show why there needs to be more symmetry. We do not see this as likely. When one considers the use of even a home network during the business day or at peak times there are more often than not multiple information flows in progress. Full symmetry would be necessary if all of the flows were symmetrical and symmetry was needed for the aggregate. However with downloads web browsing and media downloading the requirement for high speed symmetry seems a somewhat specialized requirement with no obvious significant use case.

The reason that most enthusiasts give for wanting symmetry after being challenged with the lack of applications is that asymmetric systems arise from sharing architectures as seen in Broadband Passive Optical Networks. There is an assumption that if a direct and exclusive fibre is delivered to the premise that there is a way to upgrade just the links that need new systems. It is this possibility that is at the root of the future-proof claim rather than applications might need up to 1 Gigabit/s. Now whilst it may be true in the limit the reality is that whilst changing out a modem for one end user tail is possible it is highly uneconomic. It also requires significant space to place a variety of old and new equipment types with power and access. The shared systems are simply more cost effective in most cases. There are, of course, some topologies where a suitable building exists to accommodate large quantities of fibre terminations and fibre modems. An example of this would seem to be B4RN, however in urban areas it is not easy to see where the space could be found.

In radio systems we are moving to Carrier Aggregation where additional capacity can be added as needed in both directions. For radio the spectrum to allow handsets to use this mechanism which needs simultaneous use of multiple bands with separate output filters needs to be possible.

The use of specific single user terminals for video calls is perhaps the real need for symmetry. However the use of such terminals is unlikely to need greater than HD resolution for most purposes that can be envisaged today. With real time encoding we should not expect this to be at half the rate for HD broadcast because the coder complexity would be prohibitive but there seems little need for more than 5Mbits/s of symmetry. So we arrive at the key issue, it is not the degree of symmetry per se that is important but the upstream capacity for most connections should be capable, if sited optimally, to send an upstream HD video call. The need for more than one call simultaneously ought probably to indicate that a business grade solution is needed. None of these criteria drives a conclusive case for point to point fibre.

Q6 Which countries should be our benchmarks on communications infrastructure to ensure that businesses remain in the UK and continue to invest?

The important comparators for the purpose of this consultation are those countries which are competitors for inward investment. Whilst comparison with the US and Japan* is what we normally do, the reality is that we are looking for overall investment then the state of digital links is important for establishing a local customer base and having a flexible local workforce.

(*NB – Broadband performance in Japan has been aided by the installation of dark fibre whenever utility networks have been attended to for other reasons. This approach commenced in the mid 1980s).

If the target is to allow the UK workforce to work from home in a global market then comparison with other English speaking countries is what is important. We should be cautious of course that this places us in a market with low cost economies such as India as we have seen with call centres. If the Indian networks were as good as ours we would lose that work to them. In real terms the comparators are not easy to choose as they have presumed objectives and values needed to interpret them.

We should therefore look at US, Ireland, Canada and Australia for the second purpose, Sweden, France, Germany, Ireland, Poland, Romania for the first purpose.

Q7 What metrics do you think should or will become relevant in comparing network performance in different countries? Which metrics should most appropriately be used as the basis to set objectives for government policy?

We have no input on this question since there are problems with comparability on almost all measures but speed and coverage

Scenario 1 General

3.6 In this scenario levels of users' digital competence will have risen, but significant numbers of users' skills will not keeping pace with technological changes. This will define the digital divide, rather than whether there is access to high speed networks.

3.7 Audio visual content will remain the largest consumer of bandwidth in the home and services such as Netflix will continue to increase in penetration. Viewing of linear television will remain strong and increased storage capacity on set top boxes will provide alternatives to downloading content via catch up services. Although 4K services will have arrived, take up will be modest. Whilst there has been some modest increase in the use of IPTV services, the other platforms – DTT, satellite and cable – will remain strong.

3.8 Use of smartphones, tablets and other mobile devices will have increased but the rate of penetration will have slowed. There will be a steady movement of people switching from 3G to 4G services as coverage levels reach 98% of the population, but time per day spent on mobile devices will not increase significantly and there is no real movement away from using WiFi rather than the mobile network to connect. Initially as people move onto 4G services data consumption increases, but this will stabilise. 5G services are being planned.

3.9 Increased volumes will require greater backhaul capacity and traffic through internet exchanges will also increase but there will be greater availability of fibre services, whether fibre to the cabinet or to the premises. Content service providers will continue to invest in content delivery networks, with the caching of content moving increasingly into the network to meet consumer demand. The use of cloud based services will continue to grow.

3.10 The IoT will grow. By 2022 over 350 million additional devices will be connected in the UK. The majority of these devices however consume little bandwidth, although there will be a need for reliability for time sensitive communications.

3.11 The use of online public services will continue to grow, with citizen transactions with government moving increasingly online, and with growth in e-health and online education applications and services.

3.12 Online users in more densely populated areas will see continued improvements in the level and capacity of services. In other areas the Government's superfast broadband strategy will have delivered a minimum of 24Mbps so that networks are likely to be able to meet the likely demand for consumers and small businesses. Corporate users will be able to obtain the greater speeds, bandwidth, resilience and security they require through known developing or existing products and competition. Mobile coverage has exceeded the coverage obligation on O2's 4G licence as a result of the work of the ESMCP and MIP projects and cover over 99% of the population and all major roads and railways. The other mobile networks will continue to match this coverage.

Scenario 1 Technology commentary

3.13 In a world where the majority of devices will be wireless, providers will seek to deploy a heterogeneous infrastructure combining fixed, cellular and WiFi technologies that delivers the lowest cost per bit but is capable of delivering a user experience that will evolve at a pace dictated by access capability.

> We take it that the scenario means that the wireless devices connect using WiFi inside domestic premises or workplaces to gain access to fixed networks. Such fixed network access is taken to be under the control of the householder or business whoever provides the equipment. Whilst wireless operators can effectively reach inside most dwellings fixed providers cannot reach outside most dwellings. The competition is one-sided. What are termed WiFi technologies usually means WiFi wholesalers, and it

is not at all clear that they will be able to attract custom from wireless operators. A further class of WiFi exists where the fixed network provider might offer WiFi capacity as a wholesaler using equipment in customer's premises but not under the control of those customers. That is in the same class as WiFi wholesaler's since the capacity is not free to the wireless operator and a customer could be paying (via a wireless provider) for his fixed provider to sell capacity on his broadband that he could have used for no additional cost. We would suggest that a rational response would be to get the consumer affected to put a wireless operator femto/access point in his premises instead and cut-out the fixed operator from the money flow. For wireless operators a good response then is to use their own WiFi base stations but customers need to see a benefit in using these as compared to simply using what capacity reaches inside their homes, in order to justify the purchase and trouble of installing the access point as well as powering it.

The situation inside workplaces is different with many networks potentially used by workers but only one endorsed by the business itself. The consequence is that user's personal capacity needs will be met almost always by service from outside the building.

Since the vast majority of workplaces are in built-up areas the spectrum crunch will actually really only hit there and not in suburban areas or even rural areas for customers who are not actually mobile.

This means that the building penetration issue will be extremely important is the urban workplace areas where users are concentrated during the normal working day.

3.14 Devices will be smarter and roaming between access media will be automated but all traffic will pass over the specific radio environment, cellular or other radio. At a device level this will be transparent to the user.

This will be possible but is only going to happen if the data goes to the wireless operator over the local internet connection. If users have autonomous control there cannot be session continuity as IP addresses will change.

3.15 Everyone will have the same minimum level of service but in many areas will be limited to a single access medium. The access network will become more dynamic in nature supported by a suite of software defined network applications that monitor and optimise the network fabric. The benefit of this is predominantly permitting the operator to optimise capital and operational expenditure.

A Software Defined Network is actually aimed at the core of networks not at edges. Its power is distributing predictable traffic volumes at target facilities. The problem with access networks is that the statistical predictability afforded at the core as a result of aggregation is not there at the edge. SDN in the core does not require co-operation between operators but at the access it does. Furthermore it requires competitors to forgo competitive advantage in which they have invested to the advantage of a competitor who has not invested. The situation only arises when there is additional traffic that could be competed for since the competitor cannot carry it and it is not clear why co-operation is in the interest of the party who made the investment.

Given the analysis of residential versus workplace traffic needs and means of fulfilment the need for network competition is most keen in urban areas where costs are most predictable. Furthermore the ONS workzone geography from the 2011 census tells us where the target areas are and there will need to be a significant move to home working to change this geography. When that change happens the it will shift the traffic to user's homes.

Today the kind of sharing between networks is possible but is a premium service because the user pays for three subscriptions, one for the combining service and two separate access services. The proposition is effectively that the access services will provide the combining service free and pay the second network for connectivity. It is not at all clear why this would be done other than as a business premium service which does not attract most consumers.

3.16 Overall the physical network will not have changed significantly. Retaining the current physical topology results in the building of network silos in order to support key infrastructure investments such as IoT. The capacity provided by these networks will not be available to the broader consumer population.

An assumption in this scenario is that ESMP has been delivered and we are at 2025. By then we expect that 700MHz will be available and the base stations that provide 800/900 MHz will have 700 MHz rollout underway. There is capacity to provide IoT connectivity with even greater coverage than ESMP in terms of reach using the LTE Cat-0 from 3GPP Release 12. We would expect tributary networks to connect via general data networks rather than the 3+3 MHz of Class-0 spectrum. This aligns with our preference for spectrum to be general purpose rather than dedicated.

The dedicated networks using licence exempt spectrum or dedicated spectrum appear to be based on a management charge and the reach of the general purpose IMT network may be better and provide lower overall costs for users. There can be competition and spectrum and network capacity will be used efficiently while giving a service everywhere.

3.17 The access network will be delivered over a common physical layer, used by many operators with competing services housed in the same physical infrastructure. Bundling of services will be provided within the aggregation layer of the network. This will ensure a high level of security in the access domain but limits the ability of the operators to optimise use of bandwidth and other assets resulting in long investment cycles and a reduced pace of innovation.

The access layer needs multiple physical layers with at least fixed and wireless at every served location. It is necessary to cope with visitors outside premises as well as those inside them. So it is not clear what is meant by a common physical layer.

The aggregation layer is presumably the wholesale layer, e.g. Openreach or MBNL. So the services are not bundled at that layer they are bundled at the retail layer above and may include services of specialist providers as happens today with Internet Telephony Service Providers.

Provided retail providers control the access to the SVCs that they use to end customers they can have control over the capacity and how it is used. What they cannot guarantee is that all the traffic they want to send can actually be sent because there will be fair queuing for contended access and admission control in the upstream direction. Such content management is perfectly feasible were it not for net neutrality ambitions. However the limitations caused by the investment cycles are inevitable if there is not some kind of charging by volume. Today there is charging by volume in the core with ISPs offering flat rate tariffs with a risk of congestion.

3.18 Quality of content delivery will define the experience for many consumers. Content providers will mandate, and will pay for, deeper caching within the operator domain to ensure the quality and cost of delivery remains sustainable. Economy of scale will be key in the ability to innovate and deploy new services, operators have delivered a virtualized content delivery network (CDN) capability but this will be limited to the big

providers of content. New entrants will be forced to use managed services which offer little or no differentiation or control over user experience.

The notion that content providers will pay for more caching within the operator domain seems uncertain. Caching just outside the operators domain is something that benefits the owner of content more than the network operator. However, if the network operators want to differentiate on content then that is a matter for them to fund. If it were otherwise the content provider would be funding market distortions and could be accused of anti-competitive behaviour. However more seriously he could back a loser if network investment plans fall back because of unexpected problems. If content owners maintain caches outside the operator's networks the behaviour of new entrants is unaffected other than by them offering sufficient capacity to end users.

3.19 Ultra High Definition (UHD) video content will be available across all access media. The traditional broadcasting multiplexes will carry a small number of UHD channels leveraging advanced statistical multiplexing techniques and high levels of compression. In this scenario it will not be possible for an all IP broadcast delivery infrastructure to be achieved and DTT and other platforms will continue to be popular.

The scenario has 24Mbit delivery to all users which will allow delivery of UHD 4k programmes to one display in each home, in fairness it seems less likely that typical homes will find space for more than one such display.

There is evidence that when large screen HD TVs became available families returned to watching material together rather than alone in different rooms as a consequence of children's bedrooms offering insufficient space for large screens.

The expectation would be that DTT could carry only two 4k programmes and the scope for the kind of statistical multiplexing that allows so many SD programmes is not likely to work efficiently. Simultaneous sport programmes would be a particular challenge and a rather likely occurrence. The notion that the future performance of DTT will prevent dominance of IP delivered 4k programming within this scenario is not particularly credible

3.20 The core, aggregation and data centre infrastructures will have evolved to a high degree; with levels of dynamic programmability and automation providing agility to the management and provisioning of core bandwidth. User consumption of bandwidth will lack flexibility, with users signing up to a contract and having little ability to control their service level on demand.

Nothing in the scenario causes the expectation that the statement in the final sentence is true. Having such flexibility in the technology underpinning this scenario is just a matter of commercial risk. The point that the access network may not have excess capacity is hard to challenge when the current policy has led to an effective monopoly for wholesale supply of superfast broadband. It would appear that a regulatory remedy could be provided if needed. Failing that, multi-link systems involving traffic sharing are already available and could encompass LTE modems in due course if there is widespread failure to invest in wholesale residential broadband.

Q8 Do you agree with this scenario or elements within it? Where do you agree/disagree? If you disagree what alternative scenario do you envisage?

In the comments about WiFi in 3.8 we would suggest that there is likely to be a distinction between homes and workplaces. Our expectation is that for most residential users WiFi will remain the key access and we expect that femto could make no serious

headway other than for home working reasons. Whilst in the office we expect that pico cells and small cells will make headway inside offices. We also expect that homeworkers Femtos will interact with the office based small cells in terms of access to resources whilst not in radio relations. There are advantages to making business connectivity work in this way with a true anywhere anytime access to business resources without having to negotiate any local access. There will also be a case for carrier provided or mediated WiFi access in certain cases but their existence is not going to be apparent to the business user. All of these capabilities are possible now and awaiting rollout and the enabling technology is essentially enterprise cloud with secure access via mobile carriers.

We agree that content caching will move into the network but disagree about who will fund the extensions with operators networks.

Q9 What are your views on the technology commentary underpinning this scenario? To what extent might the infrastructure/technology discussed evolve irrespective of demand and how far will it be a direct consequence of the level of demand?

Comments on the technology commentary were made inline above.

Q10 Are there technologies not identified here that you think will have a major impact on the performance of existing infrastructure or the deployment of additional infrastructure in the next 10-15 years?

Fibre to the Distribution Point (DP, typically less than 80m from the home) has not been mentioned but it will be mature by 2016 and should have started to change the speed limitation is rural areas not blessed with self-provided fibre as well as some difficult urban areas. Going hand in hand with fibre to the DP we suspect that the widespread use of Voice over WiFi as a substitute for fixed voice will start. This will allow the retirement of PSTN equipment which was first installed between 1984 and 1997 with a fifteen year life expectancy. We believe that the PSTN will be changed dramatically and that assumptions that are made almost without realising them about the way in which fall-back to the PSTN is always possible may start to break down.

Q11 Are there wider environmental issues not reflected in the scenario e.g. the price or availability of energy that will affect this scenario and in what way?

Current energy policies are having a serious effect on investment in energy and the lack of investment in base-load generation may cause shortages when intermittent sources are not available. In addition we may face limitations in supply of gas to feed power stations as well as significant price volatility if LNG supplies are auctioned amongst European markets, even when more capacity from the US is available in a few years from now. All of these factors point to a difficulty in reliance on mains power for communications infrastructure and in particular emergency service access and despatch. There may be additional costs for larger capacity batteries for mobile base stations and home fibre PSTN terminals as well as for powering Fibre to the DP installations.

There should be regulatory freedom for fixed voice operators to withdraw the service, including the removal of line power. The energy costs to the operater and the nation associated with fixed voice over copper are extremely high. Voice can be implemented as one of many services over general purpose broadband.

Q12 How likely is any unforeseen disruption to this scenario and what area might it occur?

The scenario is an evolution of the current situation and what could happen to disrupt it is a variety of economic or policy interventions. Perhaps one of the most sensitive areas would be not to use LTE on commercial spectrum for the Emergency Services Network. In addition if there were to be widespread rolling power cuts as a result of lack of power generation before suitable backup systems were deployed there could be a backlash against the reliance on technology which underlies the scenario. Equally increased public concern about the security of using the technology could have adverse effects. All of these things are in effect public policy interventions although some of them might be unintended.

None of these mechanisms seem likely on the basis of evidence to hand at this time.

There should be more concern over the resilience of services and infrastructure. This requires better planning and regular testing.

- There are numerous reports of diverse duplicate fibre routes being found not be so in the event of an accident
- Concentrations of services based on cloud servers are efficient but present common points of failure
- The nation's economy is now highly likely to be crippled if there was a failure of Amazon's Web Services

Scenario 2 General

3.21 Demand and levels of expectation about what services and applications will be available will have risen. Alongside this there will be an expectation that these services will be accessible wherever and whenever people want and that the user experience will be a good one. This will matter more to the consumer than what maximum speed they might theoretically be able to receive.

3.22 There will be a continued shift towards smartphones and tablets, the latter mainly connected through WiFi rather than having SIM cards. The increasing simplicity in the use of these devices will have a noticeable effect on the digital divide as fear of the technology is removed and enables greater levels of digital competence among users.

3.23 Audio visual content will remains the most popular type of content and people will expect to be able to access this content wherever they are and enjoy a seamless user experience. Traditional linear television delivery will remains strong, but there will be increased, often complementary, use of catch up services and over the top providers to view content when on the move.

3.24 Demand for wearable technologies continues to evolve, but these devices are seen as more luxuries than essentials (although wearable medical devices are becoming more widespread) and so will be the province of the early adopters. Use of these devices will be concentrated in city centres or other areas of high concentration of people - shopping centres, sports stadia, major tourist sites and transport hubs.

3.25 Consumers will expect multiple devices to connect together without fuss and to receive services across devices seamlessly and that the market will have resolved interoperability issues that affect connectivity between different types of devices. Silos across the value chain and existing business models will limit the ability or willingness of the market to respond to these needs, leading to a slower adoption or take up of services.

3.26 Home and remote working will have increased, but the majority of demand will still be related to the physical work place. Businesses, the majority of which are small businesses, will increasingly need to engage in the digital world to meet the needs of their customers. They will require more symmetrical networks to allow greater uploading and sharing of files and require a greater degree of security and resilience. Increasingly they will want a service that meets their specific needs, rather than services that have been created for the larger business or the individual consumer. Cloud based services will continue to grow steadily, but uncertainties in areas such as ownership of data will result in uneven progress.

3.27 Machine to machine communications will increase the number of connected devices, which significantly exceed the numbers of people connected. In purely enterprise environments growth will be robust and exceeds current estimates. Use in cities has will evolve rapidly fuelled by Government interest in encouraging smart cities. Concerns about over reliance on technology, will spill over into their use in health care and other areas.

3.28 The digital divide will have narrowed in terms of availability of high speed connectivity, but will manifest itself in other ways, such as differing levels of confidence in being able to use services.

Scenario 2 - Technology commentary

3.29 This scenario has a significant overlap with the first scenario and so these comments deal with the likely differences from a technical point of view. The significant difference between this and the first scenario is a stronger growth in demand and changes in technology led by that demand.

3.30 The changes will include the following. Network Investment will be concentrated in some areas. Operators will use the most cost effective access technology. It will be left to the device and application layer to make the best use of the infrastructure available. This approach provides an elevated user experience and will lead to innovation particularly in small cell technology.

> This is somewhat confusing in that operators have always used the most cost effective technology. The different is that in some cases they will permit access networks paid for by others to supplement their footprint. The approach does indeed allow access in more places but innovation in small cells flows from different goals. Small cells are needed to supplement normal macro sites to access principally workplaces and the public realm to obtain higher densities of data throughput from spectrum. In those places where it is not justified spectrum wholesalers may offer WiFi in the public realm. Small cell technology is evolving to reduce the load on the coverage network provided by the existing macro base station grids at the same time as the capacity of that grid itself is increasing. In essence the small base stations are not competing with the other access mechanism rather they are complemented or augmented by the wholesale or site specific WiFi access to fixed network tails.

3.31 Physical access medium such as cellular, cable and FTTX will remain siloed with the subscriber having to choose the type of operator/access provider that best meets their needs, where there is a choice.

3.32 Evolution of fibre virtualisation techniques will make optimal use of existing assets. Caching will be the preferred means of improving user experience providing the highest return on investment and most control to the content community. Providers will seek to minimise spend on core capacity choosing to cache content on a per content provider basis.

> Provider caching is rather dependant on copyright issues since the copies must not exist as separate entities if copyright issues are not to be important. In terms of pay per view the systems are not sufficiently common to permit this optimal state. Nor does it

seem likely that the business will have settled on a common framework in eleven years from now given where we are today as a starting point.

3.33 There will be some convergence between telecommunications and broadcasting with 4G's broadcast capability being deployed particularly in urban areas where networks are denser. 5G standards will be agreed with 5G networks operating in a number of countries. UK operators will be making plans for deployment of 5G networks, based on their existing shared infrastructure, and rolling out first by utilising and upgrading the heterogeneous networks in urban and other places with significant amounts of people.

By 2025 there will be 5G networks however a large part of 5G aspirations will be implemented as additions and evolution of LTE. We expect that for extremely high bit rates in certain places there may be different technology within 5G, but it is not expected that such technology is likely to be used on the spectrum in the current pipeline. The new technology is likely to be aimed at spectrum over 6GHz which is not currently assigned for mobile use and the first move will not occur until WRC-19 and finalisation probably not until 2022 so rollout will only just have started for extreme bandwidth services by 2025.

The parts of 5G that apply to under 5GHz can include a host of improvements to improve cell coverage even beyond what is achievable with LTE-Advanced which is being worked on now. We would expect those to be available much sooner that the high bandwidth service and be related to Carrier aggregation and cell coverage improvements. These capabilities rely in large measure on Digital Signal Processing improvements and the use of multiple antennas, transmitters and receivers. These improvements flow from combining systems at multiple physical locations and are not obtainable by simply using smaller cells per se. This leads to the need for very fast interconnect between radio heads and processing elements which cannot in general be provided by IP or Ethernet connectivity.

Whilst the indications are that mobile will be able to use some LTE streams to broadcast very heavily consumed content it will not be as a substitute for DTT but will complement it for those away from conventional receivers. The current Ofcom position on 470-694MHz which was recently endorsed by the Lamy report suggests that the migration to sharing between broadcasting and mobile broadcasting will not occur until after 2030. There seems little incentive for public broadcasters to treat mobile as a fourth must carry delivery mechanism after DTT, Satellite and Cable. Instead the mobile service will look like a mobile extension of the complementary IP delivery service.

3.34 The device manufacturers provide handsets or devices that offer an always best-connected experience that exploits the mix of access technologies. Processing and radio management are complex limiting battery life and innovation of device capabilities.

We currently expect to see four carrier devices in testing by the end of 2016 so we might expect that up to 600Mbit handsets may be available by 2018/19. Because they use so much radio capacity we expect to see the new 5G modulation systems aiming to take the burden of very high speed devices sometime after that and perhaps by 2022. Today the power consumption of devices is being reduced by restricting uplink use and allowing lower powers. Those trends will continue and a 5G goal for the systems above and below 6GHz is to reduce power consumption dramatically. However a great deal of the power drain flows from use of the display and as a percentage we expect that to increase as radio efficiency improves.

3.35 Networks in urban areas are optimised and some network silos are removed to support

the significant increase in IoT applications, especially those relating to smart cities and smart non-residential buildings, where there is now a business case for additional investment.

We do not understand the technical premise that is being expounded here.

Q13 Do you agree with this scenario or elements within it? Where do you agree/disagree? If you disagree, what alternative scenario do you envisage?

We agree that better application coverage will remove the current obsession with speed, at least in the short-term. Whilst only anecdotal when applications are available all of the time and do not appear to be limited by response times we tend to stop looking that the speed of connections. Speed is a way of looking who might be to blame for poor performance. Now two different approaches are looking to give the appearance of sufficient bit rate. The first is that mobile networks LTE-Advanced and 5G architectures are looking to improve the speed using advanced techniques. Secondly the application providers are looking for new protocols such as HTTP/2 and SPDY to tailor the application experience to the available bit rate. Taken together these will make sufficient speed the norm for most people a lot of the time and speed itself will become less important except when the appearance is not there because of real problems.

Learning from the Broadband Stakeholder's Group reports we expect that the rollout od superfast will take fixed network users including those of residential and business WiFi to find that applications are always fast enough nearly all the time up to 2025. For those that have lower speeds judicious investment in FttDP can resolve the issues and in principle the speed issue is resolvable if investment is enabled.

The rest of the scenario is generally as we would expect although smart city funding directed through local government may be over optimistic. We expect there to be significant linkage to public transport and distribution industries as well as urban traffic control systems. It is not clear that there is sufficient common vision and market commonality to make these smart techniques work outside London by 2025.

Q14 What are your views on the technology commentary underpinning this scenario? To what extent might the infrastructure/technology discussed evolve irrespective of demand and how far will it be a direct consequence of the level of demand?

Comments on the technology commentary were made inline above.

Q15 Are there technologies not identified here that you think will have a major impact on the performance of existing infrastructure or the deployment of additional infrastructure in the next 10-15 years?

The use of satellite as an IP multicast system to augment fixed networks with caching at the customer's premises rather than in the network will be rather disruptive. It allows lower costs per terminal that conventional networks for broadcast encrypted material. Users will choose what they want to have available for access from what is a local media server. This is likely to be a way of distributing 4k content without fast fixed or mobile internet connections. We suggest it for this scenario because lower use of the network in Scenario 1 means that this additional capacity isn't needed.

We expect conventional networks rather than satellite to be how the access keys are delivered and payment is arranged.

Q16 Are there wider environmental issues not reflected in the scenario e.g. the price or availability of energy that will affect this scenario and in what way?

The threat of power cuts and the unstable price of electricity may have an impact of modal choice for devices. The widespread use of smart meters can lead to elective power demand reduction. Consumers will be encouraged to reduce demand at times of peak demand and mobile systems can be used to time shift power demand by relying on handheld mobile access rather than fixed access when power costs are high. We can expect socket adaptors that turn off when energy prices are high and shed load. Users will be free to put them on whatever power loads they choose and turning off broadband always reduces the attractiveness of using fixed computers and so on without actually exposing them to power down in a disorderly manner.

See previous comments on regulatory freedom to close down fixed voice over copper services.

Q17 How likely is any unforeseen disruption to this scenario and what area might it occur?

The scenario is rather reliant on business growth and increasing disposable income. Therefore a further recession would be able to knock it off course. Also addition security issues and revelations which may follow from increased security needs could reduce the confidence in increased digital reliance which forms the cornerstone of this scenario.

One or other of these events is likely to be more than 30% probable given that we are starting another campaign against terrorism and could find ourselves subject to financial shocks from the EU and energy issues.

Scenario 3 General

3.36 People's expectations will be that coverage and connectivity are hygiene factors, taken for granted, and that fixed, mobile and WiFi will seamlessly work with each other. Devices will also be simple to use and utilise whichever connectivity is available or best delivers the service required. This will drives convergence and bundling.

> Ericsson consumer research shows expectations are very high of performance, coverage and future services.

3.37 Demand will be user specific and not location specific. The distinction between consumer and small business networks will become blurred and with increased home and remote working, demand will drive better quality of service across all networks. The corporate market will continue as a distinct market. Improvement of performance in networks will drive an ongoing expectation for even better networks. Voice traffic will shift predominantly to mobile and this with the IoT will drive network expansion. Fixed lines will only be retained for broadband connectivity with copper being phased out.

3.38 There will be continued demand for television in a linear and non-linear form across satellite and DTT but with a high degree of personalisation in addition to demand for IPTV and mobile viewing. It will be immersive and more effective transmission methods will be sought to further enhance the user experience. There will be a move from 4K to 8K standards. Radio will be increasingly delivered by streaming to connected devices. Satellite still will have a role in broadband, especially in the less populated areas and continues to be innovative on the delivery of television services.

3.39 Cloud technology will be the norm, with symmetrical and high capacity broadband networks available. Content will be stored on the internet closer to users to meet the need for instant access to such services. Each home will be a home network with equipment readily available, easy to use and affordable and equipment will automatically connects wirelessly to each new electronic device.

3.40 Deployment of connected devices will exceed expectations, driven by smart homes, smart cities, smart energy, e-Health and the growth in the intelligence of machines. And driverless cars will lead to safe motoring requiring ubiquitous road coverage.

3.41 A significant increase in demand will require superfast speeds of over 1Gbps applying to both uplink and downlink, and this will be fuelled by ongoing changes in user behaviour, new devices, technology and content. Resilience will be expected, delivered both by having fixed and mobile networks covering the country, with availability or capacity, reliability, low latency and noise levels. This group of service metrics will replace the current emphasis on speeds and be regularly updated. Networks will be more scalable and able to respond more rapidly to demand through virtual network management. SMEs will require these service metrics, together with greater transparency around quality of service and enforceable Service Level Agreements. The majority of businesses will fully embrace working digitally as competitive forces make this essential. This will create additional demand across the board and across the country. Significant differences in service provision across geographies will not be tolerated.

3.42 There will be significant convergence of fixed and mobile networks and broadcasting, as well as devices, as both business and consumers will want to consume content whether on the move or not. All broadband prices will be relatively affordable given their interdependence with WiFi and mobile operators will price to encourage high data usage.

Scenario 3 – Technology commentary

3.43 Delivering the underlying infrastructure to realize this scenario requires a sea change in

the approach to many elements of the telecommunications environment.

3.44 In a world where the majority of devices will be wireless, providers will seek to deploy a heterogonous infrastructure combining fixed, cellular and WiFi technologies that delivers the lowest cost per bit but are capable of delivering a user experience that will evolve rapidly over time. By 2025 5G technologies will form an important element of this capability. In order to achieve ubiquitous and consistent connectivity, a denser radio access network will be required regardless of radio type.

> This level of radio het-net access will require fibre access to small cells in the public realm. The current restrictions on sharing ducts to get dark fibre access to base stations must end, only dark fibre can give the latency and capacity needed to operate and combine multiple remote radio heads in common signal processing facilities. The distance from radio heads to processing functions is also limited because of timing constraints.

3.45 Fibre access will be required at a far more granular level than is seen in the current infrastructure. In order to guarantee user experience it should be symmetric and resilient. Building out to this level will provide a number of benefits. In addition to allowing subscribers and business to support the relentless evolution of applications and devices, a more granular access network will expedite and optimise the deployment of other applications and technologies such as 5G, M2M, public safety and smart cities.

> True though this is in general, Ethernet fibre systems will not meet the needs of 5G and public safety. They can bear the smart city traffic to the extent that local delay is not significant and M2M can be handled to the extent that it is not carried over IMT and 5G. For managing cellular system based of 5G and LTE-Advanced or any other IMT system we need dark fibre availability.

3.46 The access network will be virtualised or support virtual overlay networks to ensure consumer, business and public service applications can run in parallel with no possibility of cross connection or infiltration through configuration or malicious access by third parties (denial of service attacks, hacking etc).

> It is not virtualised but partitioned and over-provided in this vision. It seems to maintain a wholesale model rather than infrastructure competition in the fixed network. That seems to be probable but has investment limits. We assume that infrastructure competition continues between mobile networks but that they do not attempt to compete with fixed networks on capacity in the generality of cases.

3.47 The IoT will be widely deployed leveraging the very lowest bit rate radio and fixed overlay technologies such as Power Line Technology through to high bandwidth traffic types such as video to support public safety requirements. This connectivity is will be delivered over the fibre access infrastructure although in many cases reach will be sufficient to allow access at a lower volume of sites.

> We expect IoT to be delivered over a wide variety of technologies. The ability to connect to portable things such as toys and games is a particular example of why specifying a particular network type is inappropriate. The use of very low bit rates on tributary networks within homes does not dictate how a particular tributary network will communicate with other servers.

3.48 Whilst the internet will remain international the data centres providing the Internet exchange and peering environment will have devolved to a more regional model which will have evolved significantly to support the federation of CDNs bringing connectivity and content closer to the user. In addition to large managed CDNs which support the

caching and processing of data from graphics to telemetry, large content providers will also have created a set of overlay CDNs that are optimised and scaled to ensure a high and measurable level of quality.

> Such a move would involve a two sided model where CDNs pay for content delivery and hence have an incentive to reduce transport costs by regionalisation. However the carriers have the opposite incentive because regionalisation would reduce revenue streams. Such regional centres would make the costs of smaller players higher and hence increase the barriers to entry and reduce competition.
>
> The use of encrypted tunnels and SPDY will actually have the opposite effect as cloud providers seek to act as aggregators and control the experience such that CDNs will sit as part of the aggregators cloud offering. A good example would be the evolution of Amazon bringing together cloud services for all their clients. Now it is not clear that the current regulatory framework means that Amazon will be encouraged to regionalise within the UK and there is at least a risk that they could choose to operate their servers elsewhere. As data moves to the cloud we should be aware that much of it will be outside the UK in future.

3.49 UHD content will become the normal delivery medium for video content. The traditional broadcasting multiplexes will carry a small number of UHD channels leveraging advanced statistical multiplexing techniques and high levels of compression. The proliferation of over the top technology and the ability to provide a single viewing experience will allow fast delivery of new channels and content offering over the IP network. In this scenario it will be possible for all IP broadcast delivery to be achieved allowing the release of spectrum to further enhance wireless coverage.

> We believe this scenario (UHD is the norm) is unlikely by 2025. Ofcom and the EU have said that they will only review the situation for possible release after 2030. The Lamy report suggests the review be in 2025. Without a change in that position the spectrum will be tied to carrying the existing multiplexes. The transition costs would cause broadcasters to stop channels and it is difficult to see where the revenue to support the DTT transmissions when most viewers are on IP would come from. Today HD is difficult to fund because any viewers are not new but move from SD if only UHD is broadcast the advertising value would fall dramatically whilst the conveyance costs would go up. That is not sustainable without a change to the advertising market which cannot be compelled and is not a technology matter.

3.50 Overall the physical network will have been overhauled with new physical facilities and a set of agreements that provide fast and cost effective access to capability when needed. Traffic profile will have shifted significantly in response to the proliferation of cloud techniques. Technologies such as Terabit Ethernet will be used to connect large Infrastructure providers to the backbone networks. These connections will be virtualised by provider and are defined once again by agreed specification of both physical and logical interfaces.

3.51 The fabric of the UK infrastructure will be dynamic. Wireless access requires significant levels of dynamic programmability to cope with heterogeneous access. Capacity will not be dedicated to any one application, access or geographic area. Dynamic capacity management will ensure the optimum use of infrastructure and provision of seamless resilience.

3.52 Security of the infrastructure will be embedded at all levels.

Q18 Do you agree with this scenario or elements within it? Where do you agree/disagree? If you disagree, what alternative scenario do you envisage?

The shift of voice to mobile will occur for residential users as a result of VoWiFi and the use of FttDP removing the copper pair. The maintenance costs associated with the copper pair will fall away and be charged directly as a maintenance charge rather than hidden as a voice service. In business VoLTE will be what moves voice to mobile rather than fixed networks. The increased activity will have shattered many assumptions bout and the current structure of the PSTN as we know it.

The assertion about 8k standards is dubious because of timing. The industry moves in cycles and 4k will still be being exploited heavily in 2025.

There is reason to doubt that cloud servers will be distributed to be close to users. Firstly because the topology of various networks over shared access will all follow the transmission paths of the wholesale network. Secondly the cloud locations will be where energy costs are low and more importantly energy supplies are abundantly available. Right now that does not mean London but equally it is not all over the place.

Content caching in the home network will indeed be the norm and for many that will be content delivered on satellite on a European-wide basis with purchase direct from the studios. The same mechanisms wills be available over the fixed network to buy British content but the role of operators as intermediaries will be reduced. One might expect that the Premier League sells its content this way and obtains a common price throughout Europe bypassing broadcaster competition in the primary market and continuing to support them as a delayed secondary market.

Driverless cars will require massive up-front coverage investment by mobile operators without an observable return on capital. The opportunities for use of road infrastructure facilities inside cities will be a big commercial issue where long framework contracts that are recently let will delay the start until 2020 and beyond. It is not clear that the driverless car scenarios are realistic whilst driver assistance systems are quite achievable but not likely to be ubiquitous.

We currently see the most attention being paid to driverless and connected cars. More attention needs to be paid to end to end intelligent transport systems in particular the road and rail infrastructures.

The spirit of paragraph 3.41 is accepted but there is nothing to suggest that things will be as widespread as suggested. It appears rather too utopian and ambitions will be scaled back. By 2025 there is no reason to believe that in excess of 1GB symmetrical access is going to be required. For example with no further improvement in codecs beyond H.265 8k would require some 4x 16Mbit so a three TV home would need 200Mbits. This is within what can be achieved by FttDP in urban areas and as an alternative we could easily use satellite delivery on Ka band from a number of orbital slots. The use of satellite is inherently possible for these TV services and the issue is what beyond TV will demand those colossal bit rates. The reality is and this questionnaire has supposed that the majority of content is video by data volumes. We agreed with that in other scenarios and we also believe it in Scenario 3. There is unlikely to be any application that is as data hungry as video because it would require large amounts of capital to use it by building equipment that needs those data rate. The only candidates would seem to be medical applications where the limits to growth are caused by it requiring public expenditure. There are unlikely to be new markets that will go from non-existent today to large take-up in 2025 and need 1Gbit/s, the present costs will dissuade any such development until mass market requirements have caused them. Wait until 2035 when it will be 8k's turn to drive the market and a fibre network is therefore demanded by everyone.

Q19 What are your views on the technology commentary underpinning this scenario?

To what extent might the infrastructure/technology discussed evolve irrespective of demand and how far it be a direct consequence of the level of demand?

Comments on the technology commentary were made inline above.

Q20 Are there technologies not identified here that you think will have a major impact on the performance of existing infrastructure or the deployment of additional infrastructure in the next 10-15 years?

No

Q21 Are there wider environmental issues not reflected in the scenario e.g. the price or availability of energy that will affect this scenario and in what way?

In the widest sense of environmental issues the big unknown is EU membership and policy interventions. We have a starting point based on competition which continues to be different to that in other member states. Exist from the EU would cause significant economic and trade issues.

A significant increase in the price of energy would cause issues to do with investing to reduce energy usage on a large scale and for many better controls of part heating dwellings may be a better solution than whole house efficiency improvements. This may cause increases in applicability of smart home technology rather than less use of it.

Q22 How likely is any unforeseen disruption to this scenario and what area might it occur?

Such a high end scenario is susceptible to anything which causes economic uncertainty. There are too many of those causes to address at this stage.

General

Q23 Are there factors, for example technical or unrelated to the regulatory framework, that could create bottlenecks and delay future infrastructure deployment in the UK in this timeframe, that would result in demand not being met or the UK not being seen as a leading digital nation?

When we look at where people spend their working day the ONS Workplace geography from the 2011 Census shows us the areas that will benefit from extra coverage and what degree of coverage is needed. There will be no surprise that it is mostly in town centres with parts of London figuring heavily. For those areas small cell coverage will need to be put in place to augment coverage inside buildings which is likely to apply to only one operator. The interesting point from the new geography is that for England and Wales some 80% of the working population can be found in only 10% of the area. That of course means that there will be significant amounts of infrastructure needed in those places. Typically we worry about problems in the countryside to increase coverage but the real battle is going to be in congested cities and town centres. The problem is finding space on buildings, and backhaul. As explained elsewhere we see that the critical need is dark fibre availability and the economics of using it.

The issue of getting access to the carriageway to dig it up is a major issue if we are not able to use existing ducts. Access to dark fibre is a major issue in obtaining the best performance from future network. Local authorities should not plan their traffic infrastructure without giving consideration to how it could be re-used for telecommunications.

Although regulatory we have to point out that fibre tone rates based on the bits being high value business telephony which is how the VOA rates fibre is absurdly unworkable. The bit rate we use in mobile telephony is related to the sample rate of a baseband signal of 20MHz per channel for two analogue components. We use that bit rate even if there is no data being transmitted and the current fibre tone method is completely unsuitable, it is not that we need different regulation per se but the VOA needs to adapt to a new reality with a realistic scheme.

Councils, landlords and the VOA need to reset their view of telecommunications providers. As data volumes increase the value of each bit falls as the end user only has a relatively stable share of pocket for telecommunications. Networks make local areas attractive to employers and the economic benefits of increased local GVA should be what councils and shop owners see. The days of milking networks as the data rate increases have to stop or investment will have to stop. We need a sea change in the way that the value of networks is perceived since they now are close to essential even though not treated as statutory undertakings for historical reasons.

Q24 Do you expect commercial providers to deliver future infrastructure and meet demand on a purely commercial basis, or is some form of public intervention likely? If public intervention is likely how might that work with the commercial provision of infrastructure? What form might that intervention take?

We expect commercial providers to deliver infrastructure on a commercial basis to permit the equivalent of the 98% coverage condition in the 800MHz licence of O2 to be met. We also expect small cell coverage at employment sites and meeting places, such as stadiums, as well as key Public Realm sites to be met commercially. In residential areas we expect the needs at shopping centre and other aggregation points

to be met commercially too. However it is not our view that residential urban areas will get the kind of bit rates associated with workplaces. Working at home and Evening use is expected to be dominated by WiFi even though the dominant tool by time is expected to be smart phones and tablets. The use of voice over WiFi will proliferate as will remote access via the fixed network to mobile networks. Where users are linked to mobile clouds for their employer local femto devices may be used to give the same service in the office, at home and on the move.

The fixed networks will continue to take the entertainment load in the home with entertainment services to smart-phones, tablets and TVs all using the fixed network. The predicted large and volumes of data will continue to be directed at fixed networks with them also being used as an access network for mobile players.

We do not see the mobile network in general terms setting out to replace the fixed network as a substitute except in very special cases. However those special cases may include fixed network like structure that use the same technology as mobile networks to create whole fixed network equivalents. Ericsson has experience in providing such a service in Australia as part of the NBN. We do not see such implementations having sufficient scale to be commercially built without at least gap funding. However it is not clear that the structural issues associated with the wholesale fixed market will be resolved in a way which makes radio systems the first choice of the implementers.

If government wants radio to be able to offer a service that is greater than the coverage obligation beyond what is predicted for commercial coverage then some form of intervention is needed. Now the new ECN proposals may allow the intervention for emergency service coverage so we should consider whether further intervention is needed where ECN use still leaves a gap. However there will probably be an expectation by many that small cell type of capacity should be available beyond workplaces, shopping areas and key locations in the public realm.

Providing the extra capacity will need intervention but the intervention in the form of MIP seems to be enormously wasteful. Furthermore such intervention is to meet a desire for better service above what is already equivalent to the Universal Service Commitment applied through licence conditions. These will not be white areas for intervention.

For fixed networks the model used in BDUK intervention so far will need to be given periodic targeted boosts but it seems unlikely that a significant change will be justified by 2025. We would recommend a review around 2025 to see what future provision might be appropriate but do not expect such a review to result in a major programme on the fixed network before that date.

As for the form of intervention we suggest that local authorities at the lowest level possible should enter into arrangements with a single supplier to gap fund improvements above the USC equivalent in their area in the form of economic development. There should be funding as capital allocations to compensate the councils. The current approach to gap funding as state aid would not realistically permit such schemes. The choice of an operator may be subject to a local referendum if the public request it but the lock in effect for additional coverage will reduce the gap funding and having one operator will reduce the costs. The challenge of this is not underestimated but a new approach is needed if we are to get coverage at higher levels in rural areas at affordable costs.

Q25 Which current or draft legislation might prevent or facilitate the emergence of any of the scenarios?

Net neutrality applied in the way specified in the version of the Connected Continents

Regulation as proposed by the European Parliament effectively prevents normal network management to protect mobile networks from the effects of mobile users. If capacity were provided at the level which seems to be required it would increase the cost significantly. That cost and the reduced profitability would reduce the rate of investment and certainly Scenarios 2 and 3 would not happen.

Q26 Do you have views on which scenario (or combination of scenarios) is most likely and should influence the development of future strategy?

Scenario 2 is of course the most likely target scenario but without encouragement scenario 1 is the most likely outcome.

Q 27 How might efficient investment in communications infrastructure be supported, for example by changes in the regulatory framework?

Ofcom should force duct sharing in all areas where mobile operators ask for access to existing ducts. The access should be then applicable to all ducts not just Openreach ducts. Ducts used for urban Traffic Control Scheme where they are owned by non-operators should also be affected. Suitable protection rules would be needed but a firm timetable would need to be applied to prevent the creation of schemes being used to deflect demand to other duct and conduit operators.

The VOA should abandon notional rateable values on WiFi and base station schemes installed in buildings where service is permitted to multiple tenants even though installed at the request of one. Such behaviour reduces coverage and makes it more expensive to cover inside buildings. It is little more and a tax of opportunism since if multiple systems were installed for each tenant there would be no separate taxable hereditament for the base station. There is a danger that the location of the shared baseband processing would be separately taxable because of sharing. This should not happen.

We welcome changes on planning permission for small cells and mast extensions. The new rules should be reviewed within five years to ensure they are working.

Back once more to non-domestic rates the fibre tone for specialist dark fibre installations and a new basis of valuation for small base stations is required. These sites are not likely to be as profitable as previous macro sites and the purpose of the micro sites is to stop the macro sites from being congested, hence without the small sites the value of the macro sites will fall. A thoroughgoing review of the way in which telecommunications infrastructure is rated is well over due. The existing arrangements are really tied to the value of a PSTN but expresses differently for different operators; time for a change.

We are still waiting for the changes to the Communications code and way-leaves. By the time we install small cells there will be a new set of issues that may not be considered and should be. Operators cannot plan service when open to rent uncertainty especially not charges that increase based on usage.

Q28 Are any further regulatory measures necessary to incentivise the rollout of future mobile infrastructure in currently underserved areas?

State aid changes for mobile extension projects so that the majority of gap funding schemes can be regarded as De Minimis and not subject to costly procedures. Such schemes may involve granting access to sites at peppercorn rents. Needless to say the benefits should not be undermined by the VOA making costs higher by using standard rating tones. If government wants to encourage such rollouts then the whole of government must co-operate or it is not a serious desire.

Q29 Is there a role for a revised USO or USC to ensure that minimum consumer demand requirements are met and to reduce the potential for a new digital divide? What might this look like?

The BDUK scheme with its capital funding and a lower value for the USC has been welcome. For mobile the licence condition of 98% indoor commitment has taken on the same role as a USC where the capital is effectively assured and the operation expenditure is self-financing. The value of the USC is currently too low and Ofcom

are looking at what it might be based on real usage. Their approach is to see below what speed use of the Internet is artificially constrained and thereby disadvantaging users. This work should continue over time and when the number of users with speeds less than the constraining figure reaches a trigger point then further technological intervention should be considered. The trigger will be a subject of debate but a starting suggestion would be 20%.

Now a USO is different from a USC in that it provides operational expenditure subsidies usually as a levy on operators based on turnover. This is in effect a tax and we do not support a further USO since it would reduce investment whereas the change to state aid we recommend and the review of USC for fixed will encourage efficient investment by gap funding.

Q30 In terms of supporting future innovation and long-term investment in infrastructure, what areas of broadcasting regulation may have served its purpose by 2025 -2030 (or indeed earlier)? What future technical developments may also have longer term implications for regulation and wider public policy?

There is a danger that what is possible is significantly different from what is likely in broadcasting.

The regulations in this area relate mostly to content production and we do not have significant comment to make in the context of this review.

Q 31 Are there changes to the EU Regulatory Framework that the UK might seek to encourage more competition in UK markets?

There may come a time competition market definition laid down by the commission guidance is insufficient or limiting. The government may wish to consider how to add new markets for consideration rather than appearing powerless. If were possible to introduce narrower targeted market reviews there could be justification for removing the wider reviews earlier.

As suggested in a previous response reduce the state aid controls to make small cell gap funding by local councils de-minimis to encourage investment for local development purposes.

Q 32 Should Government seek changes to the European regulatory framework which put more reliance on competition law and how might this be done?

Whilst the framework does envisage a gradual withdrawal of ex-ante regulation to wards competition law in respect of market dominance there is a tendency to over regulate. It has been noted particularly in the matter of the connected continent proposal that regulation is being used as a substitute for continued work to promote competition. A useful change would be to ensure that most action in the area of communications should be by Directive and EU regulation should only be used where the matter is agreed with unanimity. In essence this has no effect on the impact of proposals as Directives would still be approved by qualified majority vote but it would promote the establishment of competition above regulation. Since that is the stated aim of the original policy there is re-enforcement of the original aims.

Q 33 In what ways can you see competition driving technological change in the UK in

the future?

It seems that in general fixed networks will not see competition driving change very easily in fixed networks. Cable already has a lead and with installation of new cables and the next generation of technology it can maintain that lead within its footprint. However the digging of further ducting to extend that cabling is significantly more expensive than cable change. For the Fttx wholesale business there has already been competition present but it has not been sufficient to drive technology change past where we are. Outside the competitive area between Cable and Fttx there is little evidence of sustained competition.

Now it is true that radio based systems can offer an alternative in some areas but the wholesale customers seem unwilling to take wholesale supply from more than one source. This is apparently an economic choice with is underpinned by the single source being fairly well regulated and secure with regulated prices. Such a market has very high barriers to entry at the wholesale level. Given that the retail level providers are reliant on the wholesaler they cannot differentiate with technology which they cannot control.

In the case of mobile operators the continued competition nationwide at both wholesale and retail levels provides a significant opportunity for competition based on technology. Furthermore the standards world is ready and working hard to make those changes available to the market. Therefore we see mobile networks being driven by technology change to obtain competitive advantage where the market can sustain competition. The places where competition can drive the use of technology is in high usage areas where loss of customer volume is significant. It will be particularly true for business customers.

For consumers away from their workplaces the availability of connections via the fixed networks actually works to reduce the need to respond to competition other than in the public realm. That is why the will be a potential need to provide intervention funding to match urban levels in some places.

Q 34 How can the regulatory framework keep up to date with new business models and changes in technology?

The changes proposed earlier to non-domestic rate valuations and mentioned in para 4.36 are very necessary for small cells. The bit rates are very high in local connections to remote antennas but this is low level digital sampling date needed to optimise use of combined antenna arrays to be spectrum efficient. The current valuations reflect an older reality where highly coded business voice calls were used to set the rates; essentially the rating system is based upon the value of whole or parts of the PSTN as it was designed in the past. A new model is urgently needed.

We agree that public access site such be made available at low rents as part of council's economic development role. Once again we caution about the rating system being disconnected from these initiatives.

The Universal Service Directive is written in a frame of reference that assumes the existence of PSTN and ISDN along with their historic definitions. There is significant interaction between those definitions and the Privacy Directive and the issues surrounding calls which annoy people and so on. This is a widespread problem and the introduction of SIP as an inter-network protocol and the end of life nature of the PSTN and ISDN may be making solutions difficult to find. There should be a review of what is expected of networks to ensure that ambitions are realistic.

It is important to consider removing regulation which may prevent innovation and evolution.

Q35 Are there any changes to legislation other than the Communications Act 2003 that would incentivise the provision of communications infrastructure?

The revision of the non-domestic rating system as outlined earlier to reduce fibre valuations to encourage use of fibre for small cell efficiency.

Reduction of non-domestic rating valuations for standard Mobile small sites to reflect lower returns from these new sites and stop discouraging investment.

The changes proposed earlier to permit duct sharing when requested and not just by telecommunications providers.

Q36 Would there be benefits to investment from a focus on broadband only services? Are there any barriers to the emergence and adoption of broadband only services, whilst still providing necessary access to emergency services?

There seems little doubt that the costs of rolling out Fibre to the DP in rural areas would benefit from removal of the underlying baseband voices service with its significant length of vulnerable overhead copper cable.

The issue about network powering for emergency service has been understood for many years and whilst the UK had a set of requirements in the past that required network powering it was lost on the introduction of the EU framework. Indeed it was inevitable that it was lost in a technology neutral framework. Importantly regulators and administrations did not fight to ensure that it was retained. The changes to condition 4 requiring back up power are not really rational. For example if it is truly a protection measure then users would be prevented from using only DECT phones and would be forced to use a fixed wired instrument in at least one place in a property. There is no such compulsion.

The measure was a clumsy attempt to put backup in devices which were fibre only based on the assumption that there was a wholesale provider who could be compelled to install the battery. The issues are many; power cuts as we may expect them in the future will be longer than one hour, users will be encouraged to turn off loads to save peak generating capacity, users may self-install. Furthermore many see mobile networks as a backup for local power loss although it is less realistic in the case of rota power cuts.

The location mechanisms specified in NICC ND1638 allow a means of providing location information for VoIP calls but the market seems not to want to engage. This is not surprising as the costs fall on ISPs who do not get revenue from the voice service. The use of VoIP in an overlay manner is what causes these issues and we can expect that where the copper baseband is removed location systems will be provided by at least some telephony providers but the overlay providers may not do so.

The issues around number portability cannot be resolved without a central database solution for telephony. Given the ever reducing profitability of telephony and what appears to be a refusal to invest in it the problem will not be resolved without closing

whole exchanges and transferring them to FttDP.

Q37 How might copper access networks evolve over time alongside other access technologies? Is there a role for policymakers in helping manage any transition from copper to other access networks?

The term copper networks used here is not helpful and not what needs to be considered. What you are concerned with is the move from PSTN services predominantly delivered using analogue or digital based band to ones derived from IP access.

The use of copper as part of the IP access delivery system is going to viable and cost-effective for many years and should be disconnected from a debate about the delivery of voice services.

There is an assumption that the PSTN is mainly homogenous with services defined by the BT offerings which were very interoperable. With derived voice systems this interoperability breaks down and apart from the services for BT's Fibre to the Home service the only thing that is available on most services is basic call with regulatory compliance. The richness of the PSTN is already dying and business service richness is already well denuded.

When the PSTN is not provided by existing switches the future of number portability is in doubt since networks have to provide it for fixed numbers at no cost but they are not guaranteed to stay in business and there is no number portability provider of last resort. This happened in the case of Atlantic Telecom and numbers were lost for some users. However the proposed fixed number portability scheme was lost because of its effect on mobile number portability. The government and Ofcom are sleep walking into what could be a significant loss of functionality in the PSTN which is continuing to fragment. There is the means to generate industry standards in NICC but the means to enforce them relies on the commercial dominance of BT by including compliance in contract terms but there is no regulatory compulsion to apply standards if BT wholesale is not involved. The problems of fragmentation are happening now and turning off baseband networks will make it worse. The government has been complacent about the loss of utility and reliability of the PSTN for so long it may be inevitable that there will be a collapse which may or may not be related to analogue baseband switch closures.

Q38 Views are sought on whether there are any additional actions the Government should consider to ensure:

a) That the provision of all areas of the UK's digital communications infrastructure remains competitive in order to ensure that the UK can take full advantage of growth opportunities in the Digital Age;

b) Aside from legislation and adapting the regulatory framework in the broad sense which other actions should the Government take to encourage investment in communications infrastructure?

c) That potential investment in the provision of digital communications infrastructure offers a suitable risk and reward profile to ensure that they can be financed by the private sector.

No Response.

Q39. Views are sought on:

a) The case for the UK to invest to gain 'early mover advantage';

No Response.

b) In what areas in particular the UK should aim to see investment;

Further strengthening the fixed network and ensuring that it has the ability to expand capacity everywhere whilst bottlenecks are anticipated rather than simply tolerated.

In wireless networks to ensure the promise of 5G app coverage improvements are met in workplace and public places and especially on transport systems.

Appropriate investment should ensure that everywhere in the UK has sufficient capacity wireless coverage for applications of a generic kind, which must include access to government services. Investment in those services themselves is vital and should be seem as an improvement rather than cost cutting.

c) Are there any actions not covered elsewhere in this report that the government should consider to ensure digital communications infrastructure is in place before it is needed and such that it helps generate need.

Irrespective of whether Communications is treated as a statutory undertaking it should be a matter about which regulations require statements in Local Plans.

Q40 How can we maximise the current R&D and innovation UK landscape to help take advantage of the opportunities provided by future technologies? What needs to be done by Government and its agencies, and industry to tackle any gaps?

The UK has almost no credible world-class R&D landscape in the communications market beyond Television and Satellite. There are no indigenous R&D facilities in fixed or mobile networks any more. UK operators have reduced their spending in R&D to a devastatingly low level with new entrants normally providing no funding. In general the market is supplied by foreign manufacturers and UK specific features are low in priority.

To be successful an innovation needs to be aimed at markets at least as wide as Europe and the R&D effort with the know-how to position that relative to other offerings and address non-UK markets is not here anymore.

There are few incentives which make the UK a particularly attractive place to site R&D when the operators choose not to purchase equipment to make such facilities something which will assist sales. There really is nothing to be gained from doing R&D in the UK now that the historical R&D centres have all been closed. There would need to be a change in tax treatment to offer reduced taxation and grants which may well be beyond those permissible in law to offset the higher operating costs in the UK.

Q41 In which future communications technologies do you consider the UK has, or could achieve, an international leadership position?

Thanks to historical positions by the BBC and IBA later helped by Sky we still have

dominance in TV technology and world leadership in DVB. Ericsson is pleased to be part of that though our R&D in Southampton. We see that this may be fragile if the future policy of the BBC is not to continue to work with UK manufacturers in support of broadcasting technologies.

Q42 What more could government and industry do to exploit future technologies, associated new applications and emerging business models?

No response.

Q43. What role might local bodies in have facilitating the future delivery of digital communications infrastructure?

We suggest that Local Authorities should include information in their Local Plan as to what communications facilities they expect to be created in their local areas during the plan period. Local suppliers would then be able to comment on the plans and their appropriateness which would be tested in any local enquiry by a planning inspector. This is essentially the communications equivalent of the sustainability test required of Local Plans. There may be changes needed to allow the inclusion of such information based on today's guidance. The purpose of such inclusions is to make identification of local market failures explicit without the need to follow the same procures of market review that happened in the case of BDUK. The failure will be apparent when investment has not happened in time for local plan development events. There will for example be an immediate problem if high speed internet open access is not available at a proposed development which is included in the plan. Local Authorities would be able to specify planning conditions and highway adoption conditions that meet the plan requirements which are not possible today.

Q44 How can councils maximise the digital communications infrastructure in their local area to support their work on economic regeneration?

They should consider the opportunity of ensuring that facilities which are built for their administrative purposes are able to be re-used in the widest possible sense. They should consider the use of section 106 agreements to acquire open access ductwork under their control and work with bridge authorities such as Network Rail to create these and ensure bottlenecks are not allowed to stifle progress.