5G

Smart Cities

Cities and Technology Background

1. What is a 'Smart City'? A Smart City links different systems such as labour markets, education, healthcare, transportation and utilities through digital technology to provide a more efficient and cost effective way of life. A Smart City takes many aspects of city life and improves them through digitalised technology.

2. Urban environments are constantly expanding with 55% of the world population now living in urban areas. In 1950, just over 751 million people lived in cities and today that figure exceeds 4.2 billion. The United Nations predicts the percentage of humans living in cities will reach 68% by 2050, adding a further 2.5 billion people to urban environments around the globe. Overall, our cities are constantly getting bigger, more crowded, and new cities are frequently being formed.

3. Many of these new cities are trying to accommodate this increase in urban population by creating Smart Cities. These cities will be dependent on new, innovative technology requiring ultra-fast speed for their functioning and efficiency. 5G technology provides the capability for Smart Cities to harness these new innovations which include artificial intelligence, computer vision, sensors, and drones.

4. The ever increasing urbanization of the planet, together with governments looking to heavily invest in Smart Cities, means it is important to plan the effective development of such cities. Planning to integrate 5G technology into the development of these cities will be an effective way to ensure innovative technology is utilised to its maximum potential.

5. It is vital that governments find efficient ways to improve the quality of life for this increasing number of city dwellers. Cities already face huge challenges relating to job pools, economic development, sustainable environments, welfare, and social resilience. These existing challenges are only going to be exasperated by ongoing increases in urban populations. Smart Cities, and the utilisation of 5G technology, can help provide some solutions to help tackle some of these challenges. For instance, IBM believe that 5G will spur a period of innovation, the greatest since microprocessors came out in the early 1970's and cities will see an incredible plethora of benefits.

6. To enable future economic development, cities need successful businesses to provide jobs. Technology already has a dramatic effect on what it means to be a successful business and future technological innovations will help businesses grow. Over the last two decades, the internet, mobile phone and social media have redefined the boundaries of the communications, technology, media, publishing, and technology industries. The companies that thrived through those changes were those who best understood how to use technology to merge capabilities from across those industries into new business models.

7. In the near future, digitisation will extend to further industries such as manufacturing through technologies such as 3D printing and smart materials, transport, retail and leisure through informed choices, and also healthcare using assistive technologies. 5G will play a major role in the implementation of this advanced technology.

8. Mobile connectivity can have a considerable positive impact on the UK economy. 5G connectivity is expected to generate £198 billion per annum by 2030 which is expected to be 5.7% of GDP. Major savings can be generated through Smart City solutions applied to the management of vehicle traffic and electrical grids through reductions in energy usage, traffic congestion, and fuel costs.

9. 5G enables such technological benefits to become a reality by providing greater bandwidth, reliable connectivity, and ultra-low latency. Former generations of mobile connectivity, such as 4G, do not have the technical capability to allow many of the applications needed for a Smart City. 5G will provide the speed, reliability and data capacity for Smart Cities to roll out the required innovative applications detailed in the next section of this paper.

5G Benefits for Smart Cities

Smart Devices and New Innovations

10. With the constantly increasing world population, the quality of life of billions of people will depend on the capability of cities to save energy, reduce harmful emissions, provide smart mobility, improve health services, living conditions, and improve safety. 5G communications network can provide this by enabling access to information, broadband and other critical services.

11. Smart Cities depend on smart devices and sensors installed throughout the city. These devices rely on internet connectivity to function; with the current 4G technology, slow internet speeds and high latency limits the use of smart device technology. 5G can help alleviate these problems by providing higher data transfer speeds and low latency. This is critical to ensure the functionality of smart device related innovations, for example, healthcare services need to have a reliable, uninterrupted connection in place to ensure the safety of the system. 5G promises speeds up to 100 times faster than 4G, as a result, more technological benefits can be realised through the utilisation of 5G.

12. Current technology services are designed to focus on personal communications such as voice, instant messaging, social networking, multimedia streaming and internet browsing. In the near future, these will evolve to provide new 5G macro-applications such as:

    - Industrial automation: the use of sensors, robotics and remote control
    - Transport: assisted and autonomous driving, smart sensors on vehicles, and instant information on traffic and potential dangers
    - Public safety services: information systems for the police and fire services, and benefits for healthcare. More information on these benefits can be found in our accompanying document: '5G – Benefits for Health and Emergency Services'.
    - Tele-presence services: virtual reality, holograms, and virtual offices
    - Systems of public utility: education and civic participation

    These new macro-applications will provide new opportunities for businesses, service providers, and city dwellers. The main benefits these new applications will bring are improved efficiency, reliability and accessibility.

13. Improved digital connectivity can help provide improved automated services. The advent of 5G means cities will be able to use artificial intelligence to analyse the massive amounts of data being collected in a city. This data can then be used to automate processes that are currently done manually. The end result is that a city can become more efficient and mundane tasks can be automated, leaving more complex tasks to city employees and citizens.

14. An example of this is being used in the city of Hull. Using sensors distributed around the city to provide real time data, Hull City Council will be able to better control street lighting, refuse collection, parking and traffic congestion. The overall aim is to provide better, efficient services at a reduced cost. For example, sensors installed inside bins can monitor waste levels, and the data is used to determine optimal times for waste collection or to determine more efficient collection routes.

15. Local governments are also looking to digitise their public services. Improved connectivity will be vital in ensuring the delivery of these services and promoting public participation. The Government Digital Service (GDS) endeavours to help people interact with the government and supports the government to enabling them to operate more effectively and efficiently. From 2020-2021, the GDS will prioritise delivering user-focussed services by supporting

government digital transformation, this will be done by providing vital information and services through online platforms, help the government use innovative technology and grow the Govtech sector, and support departments by strengthening their digital capability and providing direct support for major digital projects. Put simply, public sector departments will be able to provide a more efficient service with their finite resources.

16. One of the government services being increasingly digitised is the planning system which is providing cost savings and improved public engagement. In Scotland, innovative use of technology is being utilised in the planning system by launching the eDevelopment service which enables the submission of planning applications online since its creation in 2016. The Digital Strategy for Scotland plan explains that the Scottish Public Sector is committed to simplifying public services, improving service delivery and sharing public sector data. Huge strides have been made in digitising public services; people can now pay bills online, report needed repairs and access a range of personal and common information online. This online system will only be possible if people have reliable access to high levels of connectivity

Smart Utility Conservation

17. As a result of increasing population figures, there is an ever increasing strain on vital resources. Cities need to find ingenious ways to combat these challenges through providing better services at an affordable cost and to a reliable standard. 5G technology, through its ultra-fast speed and low bandwidth, can help provide smart solutions for the provisions of utilities to urban settlers.

18. 5G can help provide benefits for energy distribution. A Smart Grid is a modernised power grid which uses communication technologies to collect information from the power grid, this information is then analysed to adjust the production and distribution of electricity, or to adjust power consumption in order to save energy and enhance reliability. A report by O2 predicts that 5G driven Smart Grids could save up to 12% in energy consumption in the UK whilst a government research paper, 'The Smart City Market: Opportunities for the UK', estimates that the UK Smart Grid market will be worth $500 billion by 2030.

19. The Smart Grid system deploys different sensors installed on selected electrical grids to monitor the network and predictive maintenance and ensure infrastructure security. The outcome will be a more efficient, cost effective, and reliable energy system. Additionally, due to increased levels of energy conservation, the Smart Grid system will also have positive benefits for tackling climate change. These benefits can only be realised with the existence of reliable, ultra-fast connectivity, to standards that are not possible with current 4G technology. 5G technology can provide the required connectivity to make Smart Grids a reality.

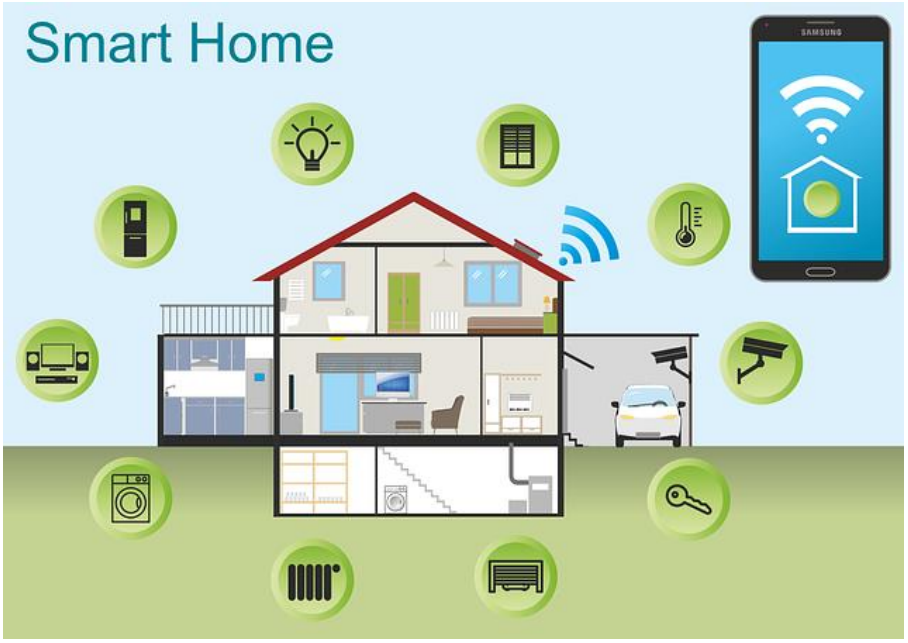
20. Improved digital technology can also help cities implement Smart Water management. In the UK, utilities companies are experiencing losses of up to 27% of treated water due to poor conditions of the water network. 5G powered Smart Water management solutions are a way in which water companies can use technology to optimise performance and improve efficiency by minimising disruptions and conserving water. A fully integrated Smart Water network system can enable utility companies to:

    - Remotely and continuously monitor and diagnose problems to then take pre-emptive measures to manage maintenance
    - Use remote sensors to optimise performance
    - Reduce supply disruptions and improve customer service
    - Comply with waste water regulation and conserve water
    - Provide users with intelligent information which allows them to make choices regarding their water usage

Smart Homes

21. 5G can have numerous benefits for home life by creating Smart Homes. These homes can be managed by using smart devices capable of carrying out various tasks. Smart devices in the home could range from smart speakers, smart electricity solutions, to smart security solutions. Using 5G technology, these devices can transfer data instantaneously between each other and to data servers with low latency. This will improve the responsiveness and the output of each device. A specific example would be 5G technology providing a higher level of home security. This could be achieved if more homes adopt a smarter security system, the surrounding area could be warned immediately if a break-in occurs or if some suspicious behaviour is detected.

22. 5G will also enable Smart Homes to save on energy costs. By supporting more services on one network, the technology will allow people to add smart home devices that work automatically to manage power usage without manual programming. With 5G technology, service meters can be connected to a central network which means energy suppliers can detect and respond to fluctuation in energy usage. This network also has the ability to quickly detect gas leaks and send an emergency call, therefore also improving safety. Benefits like these can only be implemented if 5G technology becomes more widespread because it relies on devices being connected to each other.



Benefits for the Education Sector

23. Technology can provide benefits for the education sector through digitised Smart Education. Edtech relies on technologies like machine vision, artificial intelligence, and large quantities of data for improving the current quality of education provided. The data generated by smart devices can be analysed and processed much faster in comparison to 4G technology meaning there are more digital possibilities. For instance, 5G technology will enable immersive lessons with virtual reality making learning more engaging and enjoyable. 5G technology can also improve access to education, especially for higher education students, and allows part-time students to become better integrated. By improving connectivity, long distance learning can become accessible to a wider audience; education will not only be limited to those that are within commuting distance of educational facilities but would now be available to remote students who could access materials online with improved connectivity, therefore opening the door to people who would not have previously had access to these forms of education.

24. Additionally, there are no intrinsic age-based restrictions on difficulty level, therefore, students can work at their own pace at levels that are best suited to their ability. Within a traditional classroom, this is more difficult because the class are forced to work at the pace and level the teacher sets.

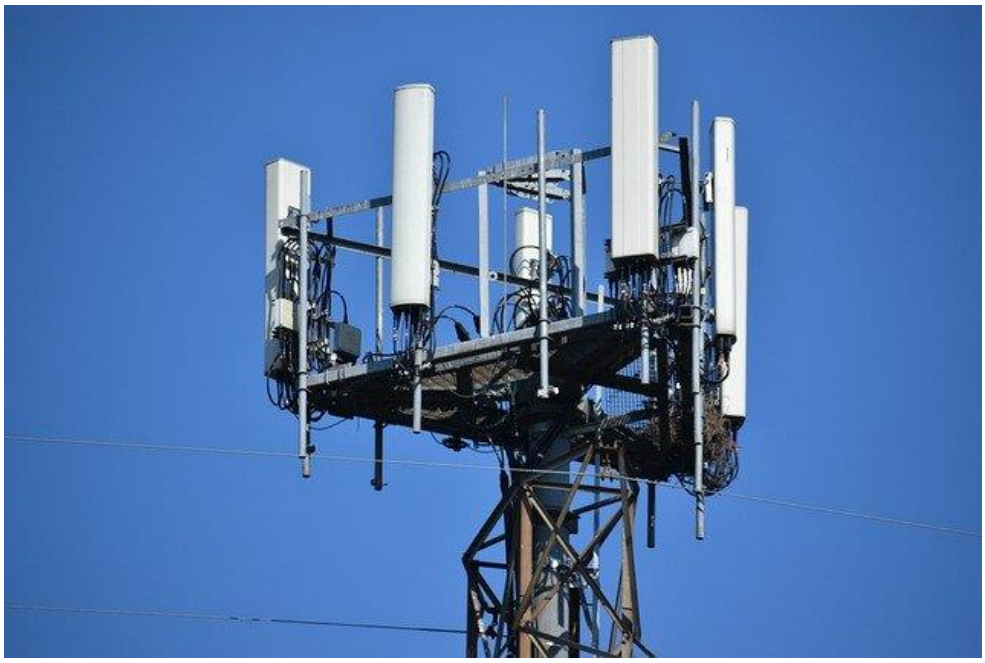
Tourism and Cultural Asset Conservation

25. Many UK cities have important tourist assets and 5G technology can bring significant digital benefits to the tourism industry. For instance, an estimated thirty million people visit London each year, their visiting experience can be enhanced by innovations enabled through 5G technology. Such innovations could include immersive 360-degree visits of churches, museums, historic buildings, and archaeological sites. Digital content supplied by 5G powered virtual reality and augmented reality can be used to enhance guided visits around cultural heritage sites.

26. The 5G tourism project has shown how immersive technologies and the latest advanced digital technologies can be used to extend the reach of immersive cultural experiences. Through combining advanced connectivity and new innovative technologies, the UK's

culture, tourism, and heritage sectors can be opened up to wider audiences and can provide a better visiting experience.

27. British cities are full of important cultural and historical buildings, many of which are fragile and need routine restoration work. 5G sensors can provide structural monitoring of buildings and infrastructures. Sensors installed into buildings can provide rapid, efficient, and precise collection of data regarding the current state of health of a building. If a building is becoming structurally inadequate, these sensors can indicate restorative works need to take place. This is a particularly useful innovation for culturally important, historic, and fragile buildings. The ability for 5G to gather large amounts of data and instantly process this information makes this digital protection of important historical assets a reality.



Benefits for Transport

28. Increasing urbanisation means cities are facing high levels of congestion and associated carbon emissions, in the UK, congestion costs the economy €24.5Bn a year in lost production. The development of transportation systems is rapidly evolving due to improvements in communication technology and transport technology. These advancements are enabling cities to provide more seamless movement of people and goods, many of these benefits are can be made possible by 5G technology.

29. Transportation is a vital aspect of city life and cities are constantly attempting to tackle problems relating to traffic and congestion. Underpinned by the speed and data flexibility of 5G, cities can completely transform their traffic systems. 5G enhanced roads will have a large number of sensors and smart devices which, when combined, will enable real time interaction between the infrastructure and the vehicles that use it.

30. Transport bodies will be able to manage a road network in real time, controlling traffic lights, traffic flows and congestion through automated systems. Alongside weather warnings and traffic updates, 5G will also enable users to receive alerts from other smart road users which will allow motorists to receive information about incidents elsewhere on the road. Drivers or authorities can also monitor road conditions for accidents or congestions in real time using 5G technology. The overall result will be a safer and more efficient driving experience.

31. With the future of transportation being autonomous and internet connected, the use of advanced connectivity technologies like 5G will become imperative. The implementation of 5G devices will not only be limited to vehicles alone but also deployed on junctions, roads, pavements, and traffic lights. These devices can communicate with each other to create a safer, more efficient transport system. Carnegie Mellon University's recent test of Smart Traffic Lights indicated a 26% faster commute time and a 40% reduction in vehicle wait times. More information on the benefits of 5G on the transport sector can be found in our accompanying document – '5G Connected Vehicles and 5G Ecosystem'.

Environmentally Friendly Smart Cities

32. A major component of a Smart City's identity is to be environmentally sustainable. 5G can help tackle climate change and the environmental burden expanding cities are enabling. Many of the methods for reducing greenhouse gas emissions in smart cities rely on sensors to record and relay real time consumption information or to detect the activities of residents. For effective use, these sensors need to be connected back to a central processing system to allow for data analysis and process automation. Telecommunications networks are ideally suited for a lot of these tasks and relying on these networks will be far cheaper than building bespoke networks from scratch.

33. A specific example which shows the role 5G can play in tackling climate change is in the transport sector. Cities are reliant on transport networks, these networks are major contributors of greenhouse gases; the transport sector accounts for 14% of global greenhouse gas emissions. By utilising 5G technology, new use cases and apps will contribute to the battle against global warming, some of which have been discussed in the 'Benefits for Transport' section of this paper.

34. Another particular way 5G can help tackle climate change in cities is through Smart Energy Conservation. This process uses data gathered through vehicular and pedestrian movements to allow smart traffic lights to be dimmed or even switched of in low traffic areas and quickly turned on if sensors detect any activity within a fraction of a second. Residential and commercial building can also work on the same principle with lighting and heating which will contribute to energy conservation. As well as being environmentally friendly, this system will also be cost efficient.

Connectivity and Society Function with COVID19

35. COVID19 has had devastating impacts around the globe and has resulted in the closure of offices, schools and commercial outlets. The global pandemic has highlighted the importance of digital connectivity, in order for society to carry on functioning, it has highlighted how important it is to be able to work online from home and this can only be done by having fast and reliable mobile connectivity. The virus has created a 'new normal' which we now live in; a society which has adapted to the effects of the global pandemic and there's now an expectation that people can remotely work from home. Even after the worst

effects of the virus are behind us, continued remote working will be seen as an attractive option for many businesses who look to cut office rent costs, especially as it's now been proven that society is capable of continuing to function without office-based work.

36. Home based working requires access to high standards of connectivity including a larger network capacity. The implementation of 5G technology, and the ultra-fast, reliable and secure connectivity this will bring, will allow these high standards of connectivity to be available to more people. This will enable more people to work from home and therefore make remote working a viable option for businesses to function.

Planning and Government Support:

37. The UK Government aims to create 5G powered Smart Cities and this is reflected in national and local policy documents. The 5G Testbeds and Trials Programme forms part of the government's Industrial Strategy, aimed at continually driving the UK's connectivity, telecommunications and digital sectors, and investing in the skills, industries and infrastructure of the future.

38. The National Planning Policy Framework (NPPF) explains that local planning authorities should encourage the implementation of 5G networks. Paragraph 113 States:

"Supporting High Quality Communications: The number of radio and electronic communications masts, and the sites for such installations, should be kept to a minimum consistent with the needs of consumers, the efficient operation of the network and providing reasonable capacity for future expansion. Use of existing masts, buildings and other structures for new electronic communications capability (including wireless) should be encouraged. Where new sites are required (such as for new 5G networks, or for connected transport and smart city applications), equipment should be sympathetically designed and camouflaged where appropriate."

39. At a local level, Councils in major UK cities have recognised the importance of 5G technology and the positive impacts Smart Cities can bring to communities. As a result, many cities have produced plans to try and help implement the digital technology required to make Smart Cities a reality.

40. One of these plans has been made for London, The Smart London Plan, which explains that:

"Digital technology is making massive changes to the way we experience the city – from traffic lights changing as CCTV logs congestion, to knowing exactly what time your bus will arrive and paying for it with the touch of your credit card. 'Smart London' is about harnessing new technology and data so that businesses, Londoners and visitors experience the city in a better way, and have time free from bureaucratic hassle and congestion."

This plan explains how the council plans to create a Smart City by:

- Pledging to promote the use of smart grid technologies to better manage demand and supply of energy and water.
- Stimulating the use of data and technology to inform the development of new markets for London's waste that brings efficiencies and scale to the utilisation of waste as a resource.
- Demonstrating how technology can reduce traffic collision and trial new technologies that can reduce the risk of collisions with cyclists and other vulnerable road users.
- Finding new ways of reducing light freight traffic by using open data technology to tackle the increase in white van deliveries associated with e-commerce.

41. Many of these proposed plans are reliant on improved digital connectivity in order to function properly. The implementation of 5G infrastructure can help make these proposed plans a reality and Council's should encourage the development of 5G proposals.

42. Another Smart City plan has been created for Birmingham. To try and enable the city to evolve into a Smart City, Birmingham City Council have created the 'Birmingham Smart City Blueprint – Best Practice Note'. This document identifies that the city of Birmingham will strive to create a 'sustainable environment which will enable businesses, communities and citizens to learn, create and prosper in an open and collaborative way, through the provision of city governance, platforms and spaces, which integrate and leverage intelligence across our communities'. The aim is to evolve Birmingham into a Smart City by harnessing technology and using information to deliver sustainable benefits. The council recognises that Birmingham will have to exploit new technologies, such as 5G, to solve its challenges and compete for wealth creation, environmental sustainability, and improvements to quality of life.

43. London and Birmingham have both recognised the importance of developing Smart Cities using digital technology, much of which requires modern infrastructure in place such as 5G. Naturally, since these two cities are the largest urban areas in England, they are leading the way on digitised Smart City development, but other UK cities will also be embracing the benefits of 5G and creating Smart City blueprints of their own. With the challenges faced by modern cities, a digitally connected Smart City will soon become a necessity to solve these ever growing problems. To combat these challenges, the correct digital infrastructure needs

to be in place and Council's need to encourage the development of 5G infrastructure to help create these Smart Cities.

Digitalisation of Services in Scotland

44. In 2017, the Scottish Government published a strategic plan to digitise society entitled: *'Realising Scotland's Full Potential in a Digital World: A Digital Strategy for Scotland'.* This document emphasises the Scottish Government's aim to provide digital connectivity to the country, the opportunity to develop new products and services, and the chance to reduce costs whilst also increasing the quality of public service delivery. This document explains that the digitisation of public services has already generated huge savings, The Scottish Wide Area Network has already enabled savings of over £30 million to public service costs and this figure is predicted to increase as more services are digitised and new innovations are implemented. The Digital Strategy explains:

"The changes that technology brings to our society are every bit as significant as the changes that it brings to our economy. Digital allow information to be transmitted faster and further than ever before, enabling us to develop new communities of interest and opening up new opportunities for education, commerce, creativity, friendship and leisure."

45. 5G technology can provide the digital platform to bring these benefits detailed in the Digital Strategy for Scotland. It is important to encourage the implementation of 5G infrastructure to provide these digital opportunities for society.

46. Glasgow City Council has launched its own Smart City Project, the Future City Glasgow project. This project has helped raise productivity, create jobs, improve safety, provide environmental benefits, and make public services more efficient and accessible. According to official government statistics included in research briefings, an initial £24m outlay of public funding in 2013 has seen an initial return on this investment of £144m in 2017 and benefits are expected to be substantially larger in the future.

47. Investing in 5G infrastructure helps cities unlock the full potential of Smart City Projects, and as explained throughout tis document, many of the innovations related to Smart Cities can only be realised with the deployment of 5G technology.