Making 5G a reality for Africa

A CSIR & Ericsson Collaboration

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Contents

This position paper is a collaborative effort between the Council for Science and Industrial Research (CSIR), a world-class organisation that undertakes directed, multidisciplinary research and technological innovation that contributes to the improved quality of life of South Africans, and Ericsson, a global leader in telecommunications equipment and service provision, to indicate and initiate a discussion on what can be achieved in the short term by the ICT sector and by fully exploiting the enabling capacity of emerging ICT technologies.

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1. Executive Summary

Africa has become a home to over a billion people and the population is expected to grow in the coming years. It is also a continent with the most growing economies and many from a low base. To leap frog, the continent will have to take advantage of the new technologies to improve the government, business environment and society.

Technology has the potential to fundamentally transform countries through digital transformation, enable rapid improvements to industrial production, societal services and of the way we live and interact with our environment. In the Networked Society, Information Communication and Technology (ICT) allows people, knowledge and devices to be networked in new ways, and countries that embrace its ICT's potential can create new value, operate efficiently and benefit from significant return on investment.

The South African population has grown from 37.8 million to 55 million between 1993 and 2016 and in that time household's numbers increased exponentially. These are consumers of services that must be reached, which will require the extension of infrastructure. Interestingly, mobile phone access across population and income groups is high.

ICT and broadband are becoming central to the society developments. As these digital infrastructures and interactions become increasingly central to the functioning of our societies and economies, affordable broadband access will need to be extended to billions of individuals who remain economically excluded. Broadband is further enabling new technologies environment like cloud, big data, artificial intelligence and internet of things

If the Internet of Things (IoT) period we are now entering is to be more inclusive and empowering, we need to start by examining the fundamental nature of the physical world fuelled by digital connectivity. ICT is essential for development and no developing society can hope to achieve economic sustainability without adequate ICT service deployment and digital connectivity.

Modernising technological innovation towards the challenges countries are experiencing, will help Africa emerge from the economic challenges in a more sustainable manner. If well managed, ICT can provide inclusive socio-economic development and has the potential for rapid service improvements and digital readiness across societies, governments and industries.

What is now needed is a framework that embeds ICT's squarely in the efforts to address inclusive socio-economic development in Africa. Africa is able to leapfrog by delivering such a framework and the challenge is to grab the opportunity with emerging ICT and networking technologies which the 5th generation ICT eco-system provides.

This paper provides a perspective by the CSIR and Ericsson on how 5G can be realised in Africa. Furthermore, it looks at some of the use cases that could be early drivers of 5G in Africa and the degree of relevance on the cases will vary per country. Finally, the paper provides a look into how policy is being approached in the changing environment in which 5G becomes an enabler for other industries.

2. Introduction

The ICT sector in Africa continues to demonstrate dynamic growth, particularly driven by the mobile sector. The growth has not met the national objectives of affordable access to the full range of communication services. Access to mobile services continues to grow, however, broadband access remains very low in comparison to other lower-middle-income countries.

Even though consumers with access to broadband services are benefitting from stiff price competition between mobile operators seeking to attract and retain data customers, it should not be assumed that the uptake of mobile broadband services – and the price competitiveness of these services in this more liberalised segment of the market – means that issues of affordable access have been fully addressed. Affordability and quality will be critical factors in generating faster diffusion of internet. The entry of new technologies provides opportunity for positive impact in getting more broadband and internet users.

The impact of the current broadband realities on the cost of communications in South Africa requires regulatory assessment. Policy and regulatory bottlenecks that constrain operators and potential players from responding dynamically to the changing nature of communication require policy and regulatory attention. Major policy challenges thus remain for South Africa and Africa if it is to create the conditions for large-scale investment to deal with demand for stable, high-speed broadband.

Such investments will require more capital than government alone can be expected to provide. Governments across Africa need to create an environment conducive to investment, through credible commitments and a predictable regulatory environment, and it is not only capital that is required. The creation of an infrastructure that is wholly integrated, requires a clear delivery strategy which includes demand-creation strategies in the areas such as education and e-literacy; entry-level prices for devices and services; the removal or reduction of taxes for internet-enabled devices (e.g. when part of education initiatives).

3. The African Market & Trends

Sub-Saharan Africa remains the region with the highest growth rate in mobile subscriptions globally. Looking forward to 2023, we foresee mobile subscriptions to exceed 900 million, total mobile data traffic growing 11x (compared to today), and 75 million cellular IoT devices being connected. In 2018, Sub-Saharan Africa is forecast to have 40 million net additions. Between 2017 and 2023, mobile subscriptions in the region will grow at a compound annual growth rate (CAGR) of 5%, to over 900 million subscriptions – leading to a penetration rate of 105%.

Though LTE subscriptions show strong year-on-year growth, WCDMA/HSPA will remain the dominant mobile broadband access technology in SSA through 2023. Combined LTE and WCDMA/HSPA will comprise 90% of total subscriptions in 2023. GSM/EDGE will still have 12% of the total connections in 2023 and allocation of low band spectrum will enable wider LTE coverage in a more cost-effective manner, as today most LTE deployments are re-farmed from allocated bands.

The Sub-Saharan Africa economy is forecast to grow by around 3% in 2018 driven by higher commodity prices and solid domestic demand. Growth is expected to improve due to an improvement in macro-economic conditions. The region's middle class will continue to rise, leading to an increase in purchasing power, and stimulating demand for a wide range of products and services in the market. Projected population growth will put a strain on the existing general infrastructure, and the growing urbanization trend will drive service provider investment in key areas. Furthermore, rising youth population will drive the uptake of mobile broadband services and affordability is also driving the increase in mobile broadband uptake in Sub-Saharan Africa. Declining data prices, and an increase in the accessibility of smartphones due to lower prices is also driving growth.

Mobile Traffic Growth

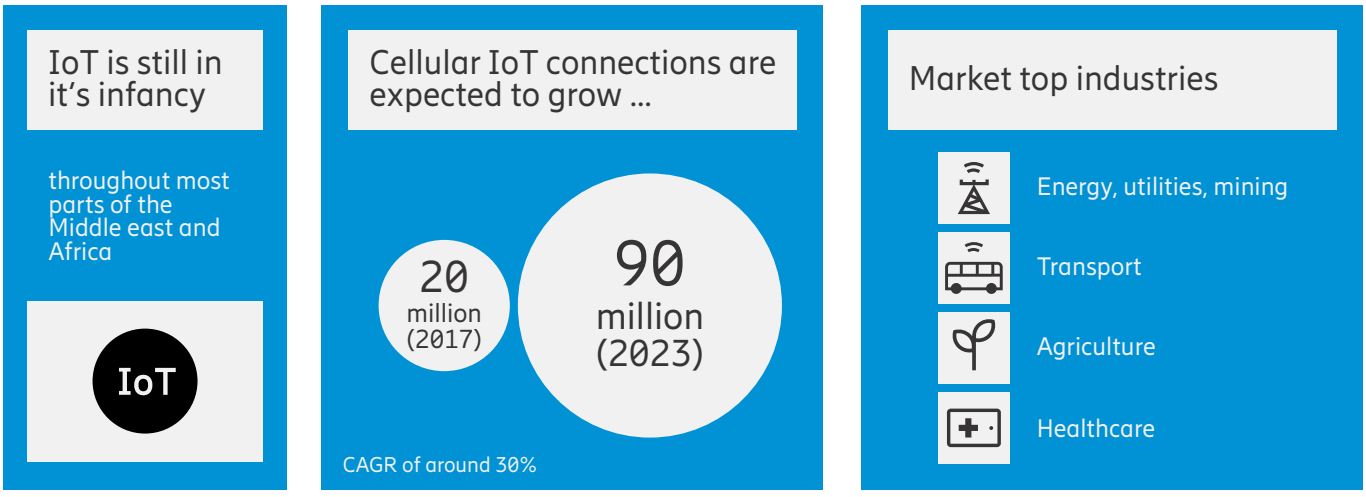
The forecast is that mobile data traffic will grow by around 50% annually between 2017 and 2023 (11 times growth). Key drivers will be extensive network coverage and the reduction in prices of both devices and services. Also, driven by the rapid rise in access to relevant video content, with new players who provide and aggregate local content finding initial success in larger markets including Nigeria and South Africa. The increase of mobile data traffic in Africa is driving operators to look at opportunities to optimize their network capacities, including complementing capacity via Wi-Fi networks.

Internet of Things

The Internet of Things (IoT) will provide the means for delivering innovative solutions to meet the socio-economic challenges and will transform businesses to enable more growth in Africa. Whilst Nigeria and South Africa will continue to increase the number of connected devices, IoT initiatives are seeing to advance in the rest of the region, especially East Africa. IoT is of increasing value to cities in Africa, with at least 55% of the urban population in the region living in informal settlements, and urbanization is rising. Smart City solutions, such as using IoT to curtail water scarcity in large informal settlements, to intelligent transport solutions, are increasingly being investigated to find answers to the challenge of urbanization. In agriculture, micro-insurance companies have deployed IoT devices to monitor weather patterns, e.g. providing small-scale farmers with insurance in Kenya.

Unlocking the potential of IoT in Africa

IoT provides an opportunity for mobile operators to bring new products and services to underserved markets, opening new possibilities for growth within the region. In order to unlock IoT's potential in Africa, Regulatory authorities, mobile operators and stakeholders will need to work together. Failure to understand and fully develop the links across the various stakeholders in the ecosystem could stunt the growth of IoT in the region.



Source: Ericsson Mobility Report 2017

Figure 1: IoT and Industry digitalization

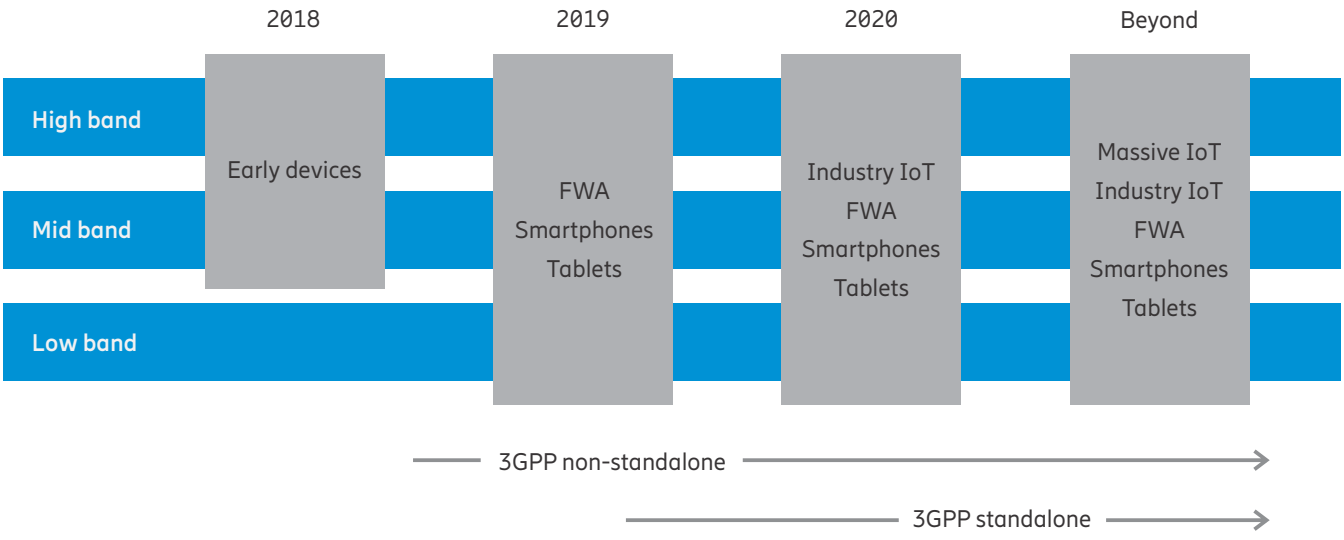
4. Defining 5G

(Benefits and the Technology Roadmap)

Delivering the full 5G experience will involve enhancing many existing use cases and creating new ones that cannot be fulfilled using current technologies. Decisions on where, when and how operators deploy 5G are not only driven by commercial considerations but also on the availability of spectrum, network equipment and devices. Furthermore development of expert human capacity to innovate on services and creation of awareness in the consumer domain to new and innovative services should be undertaken by the 5G eco-system stakeholders.

The first 5G standard (Release 15, NSA - non stand-alone - mode, Option 3) was finalized at the end of 2017. Fully standard-compliant radio systems will likely be available at the end of 2018 in fact, Ericsson Radio System delivered since 2015 is compliant, and enabled by a smooth software upgrade. Which means that 5G will become the mainstream ecosystem by 2022, still, we can expect to see 5G start being deployed by global leading operators during 2019, addressing specific use cases. As 5G will need to coexist with 4G, we-re likely to see the early deployments as non stand-alone (NSA) initially, as a way of reducing time to market and ensuring good coverage and mobility. The 5G standard for stand-alone (SA) was released mid-2018. This deployment mode will enable the full 5G potential, and expected to see volumes by late entrants. This requires a new (service-based) core network architecture (known as 5G Core, or 5GC), which will enable deployments of 5G as an overlay to or independent of 4G coverage.

Concurrently, the ITU chose IMT-2020 as its official designation for what will be specified as 5G. The work that is currently being done by the 3GPP will be submitted into the ITU efforts ahead of the release of the formal IMT-2020 specifications, which will be finalised in 2020. It is important to note that while these specifications are being finalised, there will be pre-standard 5G commercial deployments starting earlier.



FWA - Fixed Wireless Access

Figure 2: 5G device availability

Source: Ericsson "5G Deployment Considerations" 2018

5. Spectrum considerations

5.1. Spectrum needs

There are several indications that despite spectrum that are currently allocated to mobile, there will be an increased demand for more spectrum for 5G. To ensure investment in Africa, Regulators will have to make sure that spectrum is available in a timely manner to enable innovation and competition as well as to ensure 5G services benefits consumers, businesses and industries.

The view is that it's not only about the release of new spectrum but also the re-farming and or the re-use of current spectrum to provide for the various frequencies bands, 5G will need to have access too. Regulators will have to determine the process that they'll follow to ensure that mobile data growth and early 5G deployment is not hampered by spectrum requirements.

Modern mobile networks need a variety of spectrum with different frequencies providing different key components. Low frequency spectrum tends to offer better coverage, travelling distances and giving in building coverage, at the expense of data rates (i.e. speed). High frequency spectrum offers shorter coverage distances but substantially higher data rates. We expect that 5G will need a mix of low, medium and high frequency spectrum, some of which will be 'new' spectrum and some will be 're-farmed' spectrum, previously used by other services or even shared with existing services.

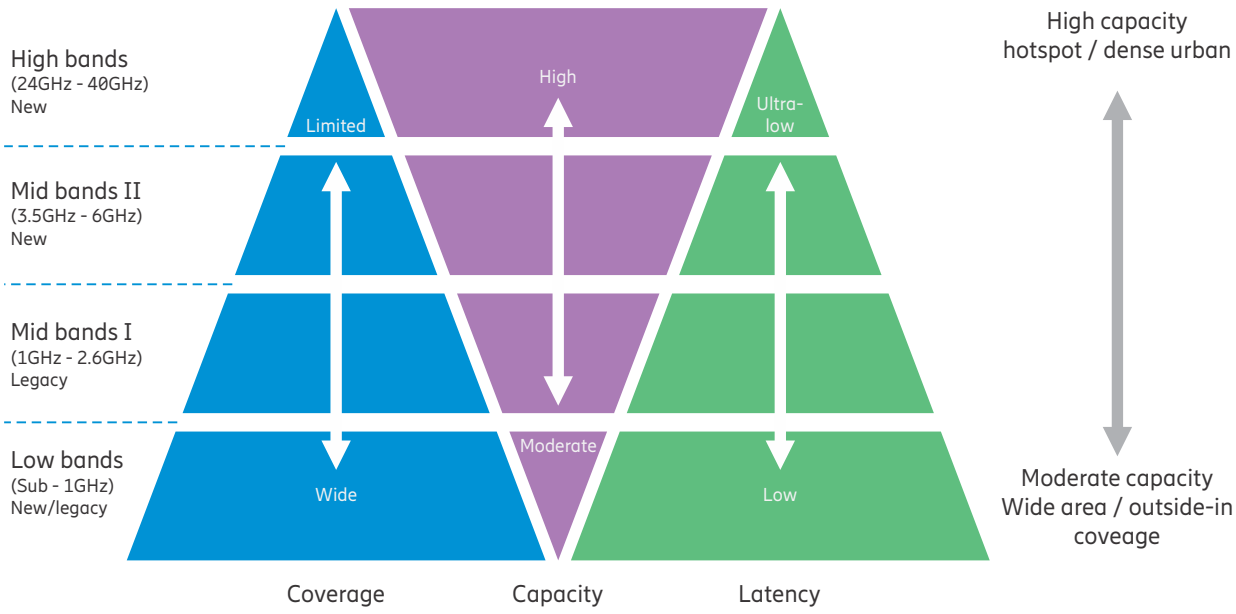


Figure 3: 5G spectrum trade-offs

Source: IEEE - A survey on low latency towards 5G RAN, Core network and Cashing solutions

5.2. Possible candidate bands for 5G

As the use of spectrum is a global phenomenon, the spectrum bands available in Africa should not be different from that of other administrations within Region 1, as it would be expensive to use without the economies of scale for network equipment and device manufacturers that come from harmonised bands. Therefore, there is a need to ensure the necessary outcomes that are favourable to African administrations from international negotiations (regionally, within ATU and globally at the International Telecommunications Union's World Radio Conferences (ITU's WRC).

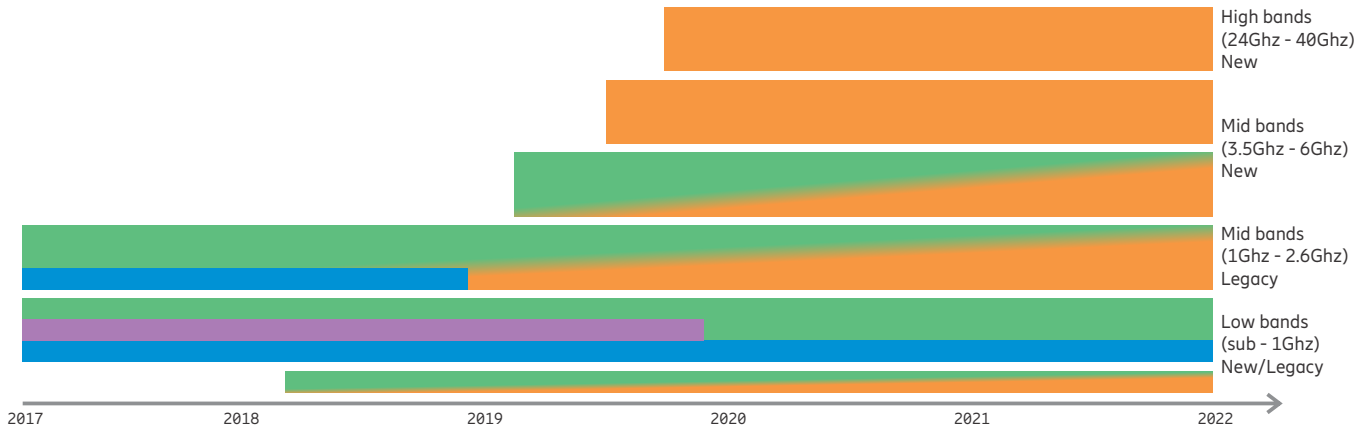
Given this, the view is that the spectrum bands that will become available and suitable for 5G will include (but will not be limited to):

- 700MHz;
- 800MHz
- 2600MHz;
- 3.5GHz;
- 26GHz - are being looked at within Region 1 as a harmonised 5G band (the possibility to move or co-exist with other sector users in this band); and
- 40GHz

Due to the strong outlook of harmonisation of the bands in Region 1 (Africa and Europe) and its potential for global harmonisation, Governments in Africa should support 700MHz, 800MHz, 2600MHz, 3.5GHz, 26GHz and 40GHz bands as 5G pioneer bands. The spectrum available for 5G will vary from market to market, according to whether it is already in use and the timing of auctions and licensing processes.

Each spectrum band has different physical characteristics, which means that there are trade-offs between capacity, coverage and latency, as well as reliability and spectral efficiency. These trade-offs need to be taken into consideration when planning 5G deployments, especially with regard to the Mobile Network Operators (MNO's) service focus, whether this is enhanced mobile broadband, massive IoT, critical IoT or Fixed Wireless Access (FWA). The New High-band spectrum (mmWave) provides the quantum leap in performance promised by 5G. These new spectrum bands are typically in the 24–40 GHz range, with bandwidths of 100 MHz (or higher) blocks. Such large bandwidth enables ultra-high capacity networks (5–10 times higher than today), with latency as low as 1ms.

Additionally, MNO's will be able to "re-farm" their existing spectrum for 5G adoption. These licences issued by Regulators are generally technology-neutral or unified licences where MNO's can move one technology from a spectrum band and deploy a different technology, in that same band.



FWA - Fixed Wireless Access

Figure 4: Spectrum allocation over time

Source: Ericsson "5G Deployment Considerations" 2018

5.3. Spectrum Sharing

Spectrum sharing is one of the techniques for improving spectrum availability in the realm of 5G. Recent research and innovation in spectrum resource utilization has resulted in the development of several techniques, tools and dynamic spectrum sharing models to make possible a non-interfering sharing of spectrum resources lying idle in space, time and power domains. This is mostly motivated by the need to promote efficient utilization of national radio-frequency spectrum resources, and development of new dynamic spectrum network technologies in solving the affordable broadband connectivity of underserved communities.

This at the same time will address the high 5G spectrum demand and development of the spectrum toolboxes, that will make sure 5G networks are equipped with technologies that can utilize and share spectrum lying idle in several bands. Several telecom regulatory authorities are planning to introduce dynamic spectrum sharing regulations. The CSIR working with partners such as ICASA, FCC & Ofcom has developed a tutorial to address the technical and regulatory frameworks for dynamic spectrum sharing for existing and future wireless 5G systems.

5.4. Spectrum Pricing

In the developing markets, spectrum pricing has been influenced by policies that seek to maximise revenues. MNO's in such countries have often paid similar prices for spectrum as those in developed countries, even though consumer incomes and expected mobile service profits are substantially lower. This directly affects return on investment and may also impose financial constraints on operators, which likely lead to reduced investment and higher consumer prices.

High spectrum prices in developing countries are influenced by various factors which are often linked to expensive and low quality mobile broadband services. This highlights the trade-offs between spectrum policy and trying to deliver greater welfare for consumer by achieving the country's digital inclusion objectives.

With the adoption of 5G, MNO's will require an increased amount of spectrum and therefore it is important that a country develop spectrum policies that will enable the fast adoption of innovative technologies and sustainable development of the mobile industry. This will help to realise maximum benefit for its citizens, particularly those that are unconnected.

6. The potential economic benefits of 5G

There are overwhelming evidence linking ICT investment in infrastructure and economic growth. Access to high-quality broadband services are based on networks that supports rapid growth in internet traffic as well as competitive pricing. There is supporting evidence that proves that a rise in mobile broadband penetration can be linked to economic growth and job creation. Although these supporting evidences may vary in its estimation on the exact contribution to the economy, there are enough to support these claims in that an increase in broadband penetration are associated with increases in Gross Domestic Product (GDP), creating jobs, increase of educational opportunities, and enhancing service delivery and rural development.

If the relevant frameworks are put in place, an assessment on the impact of broadband investment indicates that over a 10-year period, more than 400 000 jobs can be created with over USD 8 billion contributed to a country's GDP. However, there are key requirements needed to be addressed to establish the link between broadband penetration and economic growth:

- broadband must reach a critical mass of a country's citizens;
- broadband access must be affordable;
- demand-side skills must be developed to optimise broadband services for personal and business use; and
- supply-side skills need to be developed in order to exploit the innovative potential of broadband.

As wireless connectivity enables business to be done on the go, it allows information and services to be access anywhere, and will create new services and industries. It has been stated that the mobile industry in African, is a key contributor to a country's economy and enables new economic activity in other sectors with the adoption of IoT. The GSMA has estimated that an increase in penetration of mobile data, can be linked to an increase in annual GDP growth of a minimum of 0.5%.

As an augmentation of current mobile technologies, 5G could consequently ensure significant economic advantages for a country's citizens. However, the characteristics in speed, reliability and latency means that 5G can potentially be a technology which will enable new markets, develop and transform current industries, as well as support socio-economic benefits. The economic impact of 5G is difficult to be determined for now, but there are views that 5G will enable new applications and services in several different sectors.

The view is that the majority of infrastructure investment will be done by the mobile industry. Mobile Network Operators (MNO's), infrastructure manufacturers and ICT service providers, will have to play a crucial part in deploying 5G networks in Africa. Contrary to previous mobile technologies generations and, the fact of the potential of the 5G ecosystem, the view is that investment needed will not only come from MNO's but also from other industry players.

MNO's are faced with multiple challenges such as an increase demand from consumers and tough pricing competition, which are only a few of the factors causing market stagnation for the industry. However, despite the high growth in both mobile subscriptions and mobile data traffic, overall mobile service revenue growth has flattened out, compared to the 10 to 15 percent annual growth a decade ago. This means that MNO's can benefit from an additional 36 percent revenue from 5G-enabled industry digitalization market opportunities by 2026.

5G enabled revenues per industry

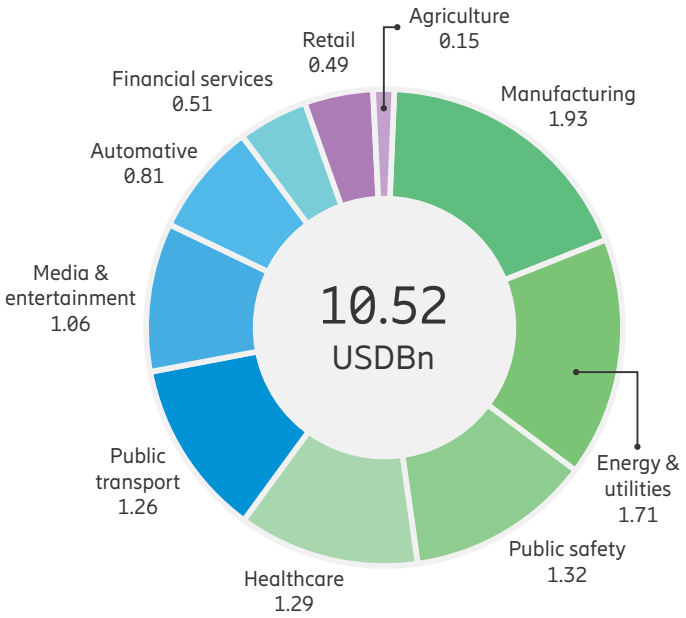


Figure 6: 5G enabled revenues

Source: Ericsson "The 5G Business Potential 2nd Edition" 2017, for Africa

Digitalization has risen industrywide across the globe, and it is predicted that digital revenue for ICT players will be worth around USD 10.5 billion by 2026 across the key industries in Africa. Industry digitalization revenues for ICT players come from adopting or integrating digital technologies into a specific industry.

As 5G is a technology that evolves, the development of the technology and deployment criteria on commercial level are being determined. The development and deployment of new technologies and its uses typically consists of the following stages:

- stage 1 - research and development - here technologies and use cases are identified and defined;
- stage 2 - testbeds and trials – further development, testing and changes to the solutions are made with the assistance of industry players for the implementation of use cases;
- stage 3 - early deployment - commercial trials can start and allow early deployment of infrastructure as well as having the relevant regulatory and policy frameworks in place; and
- stage 4 - full commercialisation.

The National initiatives on 5G will have to be focused primarily on 'phases 2' related activities. These stages include projects that focuses, for example, on smart cities and Internet of Things, which will help to shape the 5G narrative and help to build the relevant skills and requirements for the digital economy. Stages 3 & 4 will have to be done through Public Private Partnership with industry leadership.

Everyone must be empowered through digital literacy in how to use the services which will be enabled by 5G applications to reap the financial inclusion, health, social and other benefits it will offer. Governments in Africa should work with industry, businesses, and Non-governmental organisations (NGO's) to increase digital inclusion, through the creation of a digital training and support frameworks to enable the growth of digital small medium enterprises (SME's) and ensure support for its citizens who might not have the required digital skills, confidence or access to these digital services.

7. Selected emerging market use cases in 5G

7.1. Benefits of use cases

A widespread data gathering, and analysis exercise must be carried out by a country, to assess the potential role of ICT in meeting its targets. There are several challenges and enabled lines of action to be identified.

As the use of ICT equipment in the delivery of services and its penetration increases, the overall ICT use is growing. This is where the enabling capacity of ICT is expected to make the greatest contribution to facilitate an integrated increase to access, improve performance through improved revenue assurance as well as cost savings.

The goals set by countries, though sometimes ambitious, varies and there is little basis for the sector to determine where the opportunities for greater effectiveness lies and where efforts should be focused. Furthermore, measurable data on the benefits achievable through ICT is often inconsistent or lacking.

Removing these inconsistencies, will require a harmonised methodology by all the role-players for measuring and quantifying the ICT performance. This will provide reliable data for adopting, implementing and evaluating new strategies.

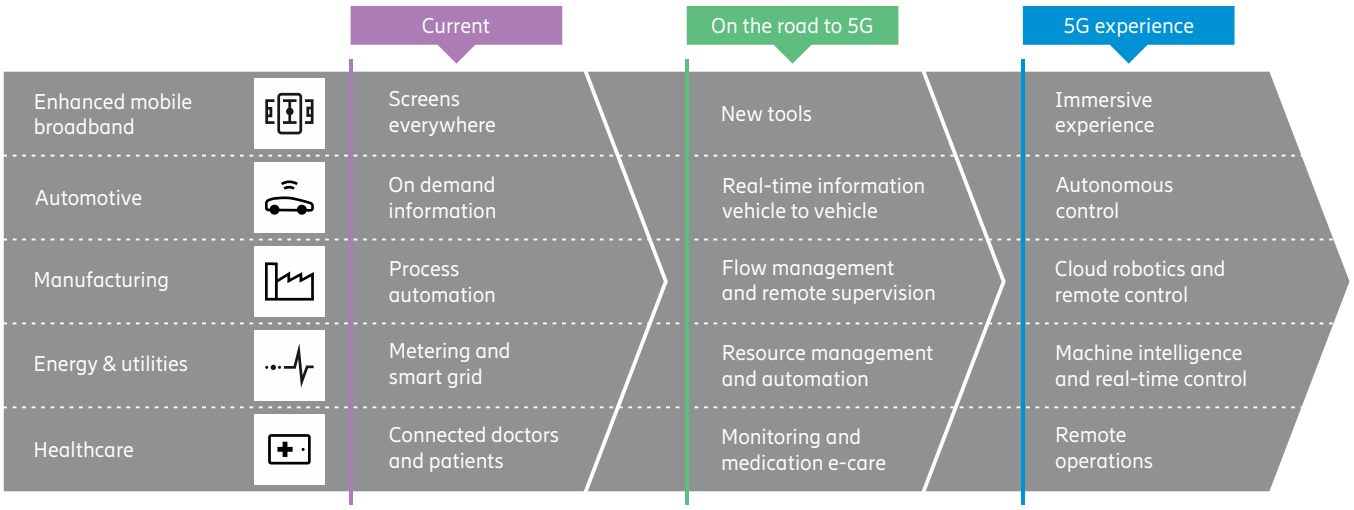


Figure 5: Use case evolution

Source: Ericsson "5G Deployment Considerations" 2018

7.2. Affordable Broadband for Societal ICT Services (ABSIS)

Affordable broadband is a critical component of the 5G ICT eco-system in Africa and developing markets. Most of the use cases relevant and useful in emerging economy countries are dependent on the development of affordable network technologies, enabling spectrum policy and regulatory frameworks for 5G. The integration of an affordable broadband standard for 5G and accelerated development of innovative ICT services for developing market use cases in e-agriculture, e-education, e-health, mining, including the use cases listed below is of paramount importance.

7.3. Integrated and Intelligent Transportation Solutions (IITS)

One of the important sectors expected to benefit from the 5G ICT eco-system are road, rail or air; mass transit operators, transport hubs. Transport authorities are reshaping the movement of people and goods with a range of Intelligent Transport Systems that allow the exchange of information in a safe, structured manner and improve safety, efficiency and sustainability.

Technologies such as ticketing systems to make payments seamless across all modes of transport, publishing real-time schedules and alerts to commuters and integrating data into traffic management systems to improve decision making, outreach to drivers and commuters and to facilitate long term planning.

7.4. Public Safety and Security (PSS)

5G will provide advanced technologies for the deployment of smart public safety and security systems. Disaster and Emergency Management (DEM) solutions can support Public Safety agencies in achieving their aims of effectively managing natural or man-made emergencies by providing multimedia-based information over a reliable and high bandwidth 5G network, thereby preventing harm and providing protection to life, property, and nations. DEM offerings include National Level Emergency Response control rooms and Civil Warning solutions that ensure the right information gets to the right person at the right time, i.e.

- Emergency Response – Managing 112/911/999 calls & alarms from the public & connected systems and providing actionable intelligence to field force agencies
- Civil Warning – Providing multi-media warning to the population in event of crisis or emergency using integrated sensor, analysis, communications and systems.
- Situation Awareness – alarm/sensor fusion, management and sharing as a decision and response support aid.

7.5. Energy & Water

Smart and green energy and water supply management systems are two of the critical Industry 4.0 services that will be enhanced by the 5G ICT eco-system technologies. Transformation of the Utility sector and public services must be done in a manner to promote smart and effective utilization of the energy resources of a nation.

For example in the Energy Sector, in order to increase the integration of renewable green energy solutions into the grid, and to help manage peak demand, utilities and municipalities are turning to smart energy solutions such as revenue and customer management, detecting technical and non-technical losses, smart metering and smart grid communications, as smart management of the consolidated multi-sourced energy supply of a country is becoming critical to the sustainable development of a nation.

Another key critical sector is Water Supply Management. In South Africa and the rest of Africa, water has already become a serious scarce and critical resource. This is evident by the recent strict water implementation measures that were experienced by the City of Cape Town. Hence, the use case of monitoring of the water collection at the reservoirs and the monitoring of the water leaks in the distribution network through smart sensor networks and smart metering has also become a critical 5G IoT vertical use case in the African emerging market.

7.6. Healthcare

Limiting the cost of healthcare and providing more effective care are the main challenges in this vertical. 5G is expected to bring new efficiencies, particularly in creating self-management capabilities and facilitating access to healthcare to minimize costs. This will partly be accomplished via m-Health, a general term used for the application of mobile phones and other wireless technology in medical care. The most common application of m-Health today is the use of mobile phones and communication devices to educate consumers about preventative healthcare services. There are also many m-Health devices (for blood sugar testing, cholesterol, etc) that can be utilised remotely, and uploaded via the mobile app to a clinic and/or hospital. This particular application is very useful for patients in rural areas where the distance to the clinic and/or hospital are very far and can take them hours to get there.

Another key application is eHealth, which broadly refers to the use of information and communications technologies in healthcare. eHealth is an emerging field at the intersection of medical informatics, public health, and business, that aims to deliver health services and information through the Internet to reach people via mobile wireless technologies and broadband connections. 5G is expected to boost m-Health and eHealth applications in a major way to enable the introduction of additional services such as personalized or precision medicine initiatives with distributed, patient-centric approaches.

The integration of data across different networks and the aggregation of services across different domains will support various care models that include billing and care accounts where patients can better control their care and allocate financial resources as needed. 5G also has huge potential to enhance the capabilities of the surgeons by utilizing robots for remote applications. This will improve healthcare in locations lacking trained specialists and impact people that do not have the means or capability to travel to the top hospitals for care. 5G technology requirements include ultra-low latencies and real-time sensing and perceptions for audio, vision, and haptics to enable these augmented or virtual reality applications

The following healthcare areas will be strongly impacted by 5G technology:

a) Remote Health Monitoring;
b) Remote Healthcare; and
c) Remote Surgery

7.7. Agriculture

5G technology will expand business opportunities and business models through monitoring, tracking and automation control of environmental data and production information such as humidity, soil analysis, animal and vegetal feeding, rain, sun and others. From connected farms and agriculture, 5G technology will reduces costs, improves efficiency and provides real-time data in amazing new ways.

The benefits will be that 5G will provide new ways to customize performance and eliminate inefficiencies by providing prompt reactions according to retrieved data and custom algorithms. For instance, sensors will be able to be implemented throughout farms allowing for crops to communicate moisture and fertilization needs. The potential productivity gains, along with the ability to customize what, where and how to plant down to areas of just a few square meters, could have huge implications for future sustainability.

8. The regulatory & policy implications

5G standards must still be ratified by ITU and relevant organisations, however, the industry has produced an expansive 5G vision, and whilst the limits of that vision are a matter for industry, the speed of technological progress means that a flexible regulatory framework is needed to keep pace with developments and innovations. Governments will have to create a regulatory framework that accelerates investment in infrastructure and helps to create opportunities.

The deployment of 5G will require a significant increase in the number of small radio cells – likely to be located on street furniture, the sides of buildings etc. - in order to facilitate the requirements of 5G networks. Therefore, flexible and fit for purpose planning regulations will be required to support the deployment of 5G networks.

However, given the sheer scale of infrastructure envisaged within 5G networks, there may still be a case for going further. Where Governments are of the view that further changes are needed to the planning and regulatory system, amendments to legislation will have be made to meet the unique challenges of 5G infrastructure deployment. Governments will have to review legislation on a regular basis, as its understanding of these issues improves through the implementation of 5G.

Governments will have to consider much needed reforms to the telecoms legislation that will directly address investment barriers, lower the cost of infrastructure deployment and encourage long-term investment in digital infrastructure.

Governments should actively explore further ways to reduce the cost of deployment and operation of network and other related digital infrastructure, working closely with all spheres of government and industry in order to maximise the commercial case for early, rapid and widespread deployment of 5G.

5G will enable the creation of many new applications and technologies across a range of different industries. Some of these new applications will be created for use in regulated industries, and as they develop, it will be important to ensure that the regulatory frameworks in which they operate do not inhibit their development unnecessarily. Achieving this will require a balance between supporting innovation and providing adequate protections for businesses and consumers.

Governments will have to use the 5G use case trials to improve its understanding of the different regulatory regimes in which 5G applications and services will operate, work with those regulatory authorities to develop appropriate regulatory frameworks.

9. Recommendations

5G is one of the crucial network technology standards that will pave the way for the 4th Industrial revolution (4IR). Investment in research, development and innovations with expert human capital development in 5G network technology standards and regulatory frameworks will accelerate and grow the market potential. Service and industry creations in the 4IR fields will lead the move from an emerging market to a developed market where short term to long-term goals are being set and thus can determine the present and future socio-economic impact and digital inclusion. To kick-start ICT-enabled transformation and realize its benefits, policymakers need to take a broader, more coherent ICT policymaking approach. There are six key areas where governments can act to trigger ICT-enabled transformation:

- Broadband for all: This determination should set a timeline for broadband connectivity by 2020. It is recommended that ICT infrastructure be put in place in all regions as soon as possible whereby public institutions be connected to a high-speed broadband network. By providing incentives, operators will participate to fund much of the needed infrastructure, addressing both urban and rural requirements. The telecoms industry has grown rapidly over the past years, where fair competition, global standards and economies of scale have driven down prices, secured investments and improved accessibility and affordability.
- Enable ICT policy framework: Develop an enabling regulatory landscape that address the supply- and demand-side considerations. These policies will have to promote the ICT policy implementation framework for the Sustainable Development Goals (SDG's) of the United Nations (UN). Policies should encourage the development of new business models that will emanate from deployment of 5G technologies.
- ICT rollout: Drive adoption of ICT throughout the public-sector value chain. E-governments and online ICT-enabled public services. This will lower the cost of public services, reduce opportunities for corruption and create a flow of big data that can be collected and analysed to improve resource utilisation and support evidence-based policymaking.
- Public-Private Partnerships (PPP): These partnerships are needed between government, international organizations and industry, to establish sustainable business models that support wide scale ICT deployment. For example, to enable connectivity in rural or unconnected areas, or accelerate the creation of innovation hubs, skills development, sufficient public and private investment needs to be actively targeted towards ICT. This will include capacity building on policy and technical regulation with ICT regulatory bodies, to ensure 5G technologies are adequately catered for and is an area where the CSIR & Ericsson can work together to assist Governments across Africa.
- Accelerate innovation to develop new ICT applications: National policies should encourage the development of small scale ICT industries, both locally and internationally, to operate within the country to provide solutions and applications designed for the local context. To facilitate the quick distribution of ICT-based solutions, governments must work with ICT companies through PPP's.
- Harness big data and analytics: Develop national online and open access databases using big data from mobile networks, sensors and other devices which can be connected to the Internet of Things. This real-time online data will be a critical resource for monitoring and evaluating achievements by a country, for forecasting different scenarios, and promoting investment by the private sector.

10. Conclusion

With connectivity at the heart of industry transformation, 5G technologies have a significant role to play – not just in the evolution of communication but in the transformation of businesses and societies as a whole. 5G will build on and extend the public network, making it viable for any type of applications. Therefore, 5G will be an enabler of IoT and the Networked Society. As a natural evolution of current network architecture, broken up into building blocks through access, transport, cloud (including SDN and NFV), network applications and management (including orchestration and automation), 5G systems will provide a higher level of abstraction that will simplify its management. The architecture of 5G systems, will not only be cost-efficient to operate, but will also have the agility and flexibility in place for the rapid introduction of services. These solutions will be required to enable new business models that can rapidly generate new revenue opportunities.

For that reason, 5G systems will be built in the form of programmable platforms that provide functionality on an "as-a-service" basis. Network slices are key to delivering differentiated offerings, as they can provide a complete solution environment that is adapted for specific application usage – and they do this in a way that uses network resources efficiently. The 5G transformation has already started with NB-IoT, NFV and management automation, for example. It is an incremental process, enhancing the current network in a step-by-step fashion. As the process unfolds, global partnerships will prove essential to enabling a cross-industry engagement in defining and building the 5G ecosystem.

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This paper provides a perspective by the CSIR and Ericsson on how 5G can be realised in Africa. Furthermore, it looks at some of the use cases that could be early drivers of 5G in Africa and the degree of relevance on the cases will vary per country. It suggests the possible spectrum bands to be assigned for 5G and the potential economic benefits thereof. Finally, the paper provides a look into how policy is being approached in the changing environment in which 5G becomes an enabler for other industries.

The Council for Scientific and Industrial Research, commonly known as the CSIR, is a world-class organisation that undertakes directed, multidisciplinary research and technological innovation that contributes to the improved quality of life of South Africans. We draw expertise from diverse research fields, such as the built environment, defence and security, energy, health, industry and the natural environment to provide integrated solutions and interventions to support public and private sector programmes. Our scientists, engineers and technologists are enabled by our state-of-the-art research infrastructure and share a passion for shaping a better future through science and technology innovation. It is this combination of excellence in research, competent staff and world-class infrastructure that puts the CSIR at the cutting edge of research and technological innovation to improve the quality of life of South Africans.

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