White paper on 5G policy implications in Sub-Sahara Africa

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He has a strong track record working in the ICT and telecommunication industry with expertise in mobile telecommunication technologies (3G/4G/5G), global and regional spectrum policy, as well as governmental ICT policies across Africa.

Before joining Intel Corporation, Dr Agbokponto Soglo worked at Qualcomm for more than 10 years, first as Staff Engineer then as Government Affairs Director for West and Central Africa. Prior to that, he worked at Huawei Technologies as Wireless Product Manager.

He has published several technical papers on Network Control Systems in International Journals and Conferences, including in the European Journal of Control. He has also presented at many international forums, conferences and meetings across the globe including at the WTO and the ITU; and held leadership positions in ITU-R Working Party 5D.

Dr. Agbokponto Soglo holds a Ph.D. degree in Control Science & Engineering from Beijing Tsinghua University (2005), an MSc in Control Theory & Control Engineering from Dalian University of Technology (2002), and a BSc in Automatic Control from Dalian Maritime University (1999), China. He has excellent proficiency in English, French and Mandarin.

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Scope

One primary objective of this white paper is to provide suggestions and recommendations on the policy and regulatory implications for Sub-Sahara Africa (SSA) in the context of 5G, taking into account the standardization, ecosystem development and current status of broadband in SSA. This white paper also provides recommendations for the development of a regional, national, or continental 5G action plan as well as recommendations for regional economic communities, governments, policy makers, regulators, and stakeholders in the ecosystem for 5G readiness in order to take advantage of addressable 5G opportunities for the digital transformation of the continent.

Executive Summary

With a population of ~ 1 billion[1] in 48 countries, 40% of the population in Sub-Sahara Africa (SSA) are under the age of 16, a demographic segment that has significantly lower levels of mobile ownership than the population as a whole according to the World Bank data. The International Monetary Fund (IMF) shows that the macroeconomic outlook for SSA continues to strengthen with growth expected to increase from 2.9% in 2018 to 3.5% in 2019.[2] According to the GSM Association (GSMA), the mobile industry made a total contribution of 110 billion USD to the SSA economy, in value added terms, which is equivalent to 7.1% of the region's gross domestic product (GDP) in 2017 and, that by 2022, the mobile economy in the region will generate more than 150 billion USD (or 7.9% of GDP).[3]

There are different studies on the economic and social benefits of 5G. In particular, a 5G study report for the Gulf Cooperation Council (GCC) region prepared by Analysis Mason indicated that 5G will provide a new income of 273 billion USD to the GCC region within the next 10 years.[4] According to the European Union's study, socio-economic benefits from the introduction of 5G capabilities in Europe could reach 113.1 billion Euro per year in four key sectors: automotive, health, transportation and energy.[5] In Africa, an Ericsson report[6] indicated that the estimated 5G business potential is in the order of 10.52 billion USD by 2026 in sectors such as healthcare, agriculture, energy and utility, public transport etc. Furthermore, a GSMA report[7] indicated that the GDP impact (socio-economic benefits) of mmWave 5G in SSA is around 5.2 billion USD by 2034 - in areas such as high-speed broadband, next-generation transport connectivity and industrial automation etc. A recent report commissioned by the Wi-Fi Alliance, "Global economic value of Wi-Fi® nears $2 trillion in 2018",[8] estimated the current annual global economic value of Wi-Fi® at 1.96 trillion USD in 2018 and projected that number to surpass 3.47 trillion USD by 2023.

Broadband subscription penetration in SSA (41%) is low compared to the world average, which is 74%.[9] More needs to be done to improve broadband penetration in SSA, and 5G provides an opportunity for an increase in broadband penetration on the continent.

5G is more than just another step in the evolution of wireless; it is the convergence of wireless with computing and the cloud. Intel technologies power and enable 5G across network, cloud, edge and devices.

Intel believes that both 3GPP-based and IEEE-based technologies play an important role in 5G. 3GPP standards (e.g. Release 15 and beyond, IMT-2020) and IEEE-based standards (Wi-Fi 6 and beyond, and WiGig) will deliver wireless broadband to consumers and businesses worldwide.

Within ITU-R, work has begun on the development of IMT-2020, the next generation of cellular technology, which will be backwards compatible with IMT-Advanced (e.g. LTE) and IMT-2000. IMT-2020 will also interoperate with Wi-Fi and WiGig technologies in license-exempt spectrum. Wi-Fi connectivity is a critical component of overall 5G connectivity and, as expected, the increase in 5G data throughput will further increase the demand for Wi-Fi connectivity.

To enable 5G and unlock the full potential of broadband in SSA, current and next wave connectivity will provide an optimal platform for the near-and long-term. It is therefore critical for countries in SSA to make spectrum available for 5G. Specifically, licensed spectrum in low-band, mid-band and high-band as well as license-exempt spectrum should

be made available to enable 5G. Relevant 5G use cases such as fixed wireless broadband, digital government, education, healthcare, agriculture, smart cities and industrial IoT will also be necessary to take advantage of the full potential of 5G in SSA.

Based on progress made on 5G standardization, regulations, trials, deployments, product readiness and launches, as well as 5G's potential contributions to the increase of broadband access and business potential for the continent, now is the right time for regulators and policy makers in the region to prepare for 5G deployments.

It is therefore recommended for Sub-Sahara African countries to consider the following:

- Develop a 5G action plan including a spectrum roadmap.
- Call for studies on 5G use cases/applications relevant to Africa (SSA).
- Review/update their national ICT policy, broadband plan/strategy, and/or digital economy strategy to incorporate the needs for new technological development i.e. 5G.
- Review and modernize existing regulations to adapt to new technological developments (i.e. 5G), including the elimination of regulations that have outlived their original purpose, or that create unnecessary burdens which negatively impact deployment and adoption.

From a continental and regional perspective, it is recommended for the relevant continental and regional organizations to consider the following:

- Development of an African/Regional Digital Strategy.
- Development of a Continental/Regional broadband infrastructure strategy/action plan.
- Development of a Continental/Regional 5G action plan.

A 5G action plan should include the following:

1) **A 5G spectrum roadmap** that consists of:

- Licensed spectrum: in low-band – below ~1 GHz (e.g. 700 MHz band); mid-band – between ~2 – 6 GHz (e.g. 3300 – 3600 MHz); and high-band – above 24 GHz (e.g. within 24.25-29.5 GHz and 37-43.5 GHz)
- License-exempt spectrum: unlicensed spectrum in the 6 GHz band (within 5925 – 7125 MHz); and unlicensed spectrum accessed in the 60 GHz range (e.g. 57 – 66 GHz and 66 – 71 GHz)

The 5G spectrum roadmap should also include recommendations on timeline for the release of 5G spectrum in the mid-term, especially spectrum for low-band (700 MHz), mid-band (3.5 GHz), the mmWave band (~26 GHz, ~40 GHz) and additional spectrum for Wi-Fi in the 5 GHz and/or 6 GHz bands.

Regulators/Administrations should also be considering additional spectrum that can be made available in the mid-to-long term for licensed and license-exempt use.

2) Call for the **deployment of infrastructure** that will facilitate 5G such as fibre, data centres, edge compute and transformed networks.
3) **A call for studies on 5G use cases/applications** relevant to Africa in areas such as fixed wireless broadband, digital government, education, smart agriculture and smart cities.

1. INTRODUCTION

In a mere 20 years, we have moved from voice centric communications (2G), to the data and app revolution with 3G, to ever-increasing data rates with 4G. The fifth generation wireless technologies, referred to as 5G, represent more than just another step in the evolution of wireless. It is the convergence of wireless with computing and the cloud. 5G is a new paradigm, where everything is smart, because everything is connected.

5G addresses existing, emerging and future uses delivering diverse services with usage scenarios such as: 1) Enhanced Mobile Broadband (eMBB) with immersive experiences (e.g. Virtual Reality, Augmented Reality); 2) Internet of Things (IoT)/Massive Machine Type Communication (mMTC) with applications such as smart home, smart cities, sensors; and 3) Ultra Reliable Low Latency Communications (URLLC) with applications such as mission critical type communication including autonomous driving or industrial IoT.

5G has the potential to transform industries from a wide variety of business sectors, initiating ripples of impact that could spur market growth and the global economy.

The mobile, computing and networking ecosystem has been addressing 5G standardization and 5G trials for several years. Initial commercial 5G networks are now being deployed with many more expected to come online in the near future.

Topics discussed in this white paper include:

- ICT trends and developments in Africa (Sub-Sahara Africa)
- 5G ecosystem
- 5G Technologies
- 5G Standardization efforts
- Policy and Regulatory implications for 5G
- Recent developments on 5G in Sub-Sahara Africa
- 5G use cases.

2. ICT TRENDS AND DEVELOPMENTS IN AFRICA (SUB-SAHARA AFRICA)

2.1 Brief Introduction to Sub-Sahara Africa

With a population of ~1 billion people[10] in 48 Countries (see Figure 1 below), around 40% of the population in SSA are under the age of 16. According to World Bank data this demographic segment has significantly lower levels of mobile ownership than the population as a whole.

According to the IMF, the macroeconomic outlook for SSA continues to strengthen with growth expected to increase from 2.9% in 2018 to 3.5% in 2019.[11]

The mobile industry made a total contribution of 110 billion USD to the SSA economy in value added terms which is equivalent to 7.1% of the region's GDP in 2017. By 2022, the mobile economy in the region will generate more than 150 billion USD (or 7.9% of GDP) of economic value added as countries continue to benefit from improvements in productivity and efficiency brought about by increased adoption of mobile internet in particular.[12]

Some of the key continental organizations, regional economic communities and regulatory associations are described as follows:

- **Continental Organizations:** e.g. African Union Commission (AUC); African Telecommunications Union (ATU); Smart Africa; Francophonie Numérique (International).
- **Sub-Regional Organizations:** e.g. ECOWAS - Economic Community of West African States / WATRA – West Africa Telecommunications Regulators

Figure 1: Map of Sub-Sahara Africa

Assembly; SADC - Southern African Development Community / CRASA – Communications Regulator's Association of Southern Africa; EAC – East African Community / EACO - East African Communications Organization; ECCAS – Economic Community of Central African States / ARTAC - Assembly of Telecommunication Regulators of Central Africa.

2.2 ICT Trends and developments in Africa – Sub-Sahara Africa

Some key indicators in terms of mobile subscriptions, mobile broadband subscription and fixed broadband subscriptions for Africa/SSA compared to the world average are provided in Table 1 below. From this table, it can be seen that broadband subscription penetration is low compared to the world average.

According to Ovum, Nigeria is Africa's largest mobile market in terms of subscriptions, with 150.3 million mobile subscriptions in June 2018, followed by South Africa with 99 million and Ethiopia with 64 million. (See Figure 2 below)

According to the GSMA, 4G and 5G as percentage of connections in SSA are predicted to be around 23% and 3% respectively by the year 2025 (see Figure 3).

3. 5G VALUE PROPOSITION FOR SUB-SAHARA AFRICA

5G is expected to support billions of connected devices with differing requirements and expand flexibility and agility beyond purpose-built LTE Networks. It will also provide the infrastructure for much Artificial Intelligence (AI) especially real time analytics through edge compute. In addition 5G will facilitate rapid access to cloud resources and therefore the cloudification of the telecom network. GSMA Intelligence forecasts that the first commercial 5G services will be launched in the region by 2021, with 5G connections accounting for 2.6% of the total connections base by 2025. [15]

In SSA, 5G and transformed networks can enable use cases in areas such as fixed wireless broadband, digital government, smart education, healthcare, agriculture, smart cities, and industrial IoT.

There are different studies on the economic and social benefits of 5G. In particular, a 5G study report for the Gulf Cooperation Council (GCC) region prepared by Analysis Mason indicated that 5G will provide a new income of 273 billion USD to the GCC region within the next 10 years.

Table 1: Key indicators for Sub-Sahara Africa / Africa

Key indicators	Africa/SSA	World
Mobile subs. (%)	82 / 71	104
Mobile Broadband sub. (%)	43.5* / 41	74
Fixed broadband Subs. (%)	< 7.5*	~ 52*

Source: Ericsson mobility report, November 2018;
*Africa Digital Outlook 2019; Ovum, June 2018

Figure 2: Sub-Sahara Africa's largest mobile markets by subscriptions, 2Q18[13]

Sub-Sahara Africa largest mobile markets by subscriptions, 2Q 2018

Country	Mobile Subscriptions (millions)	Mobile subscription penetration (% of population)	Mobile broadband penetration (% of subscriptions)
Nigeria	150.3	77.4	52.2
South Africa	99	177.9	74.2
Ethiopia	64	60.6	16
Kenya	43.3	88.3	50.1
Tanzania	41.7	72.2	44.4
Ghana	39.2	135.4	47.4
DR Congo	35.5	42.5	35.1
Africa Total	1038.1	82.3	43.5

Figure 3: Mobile broadband Technology penetration in Sub-Sahara Africa[14]

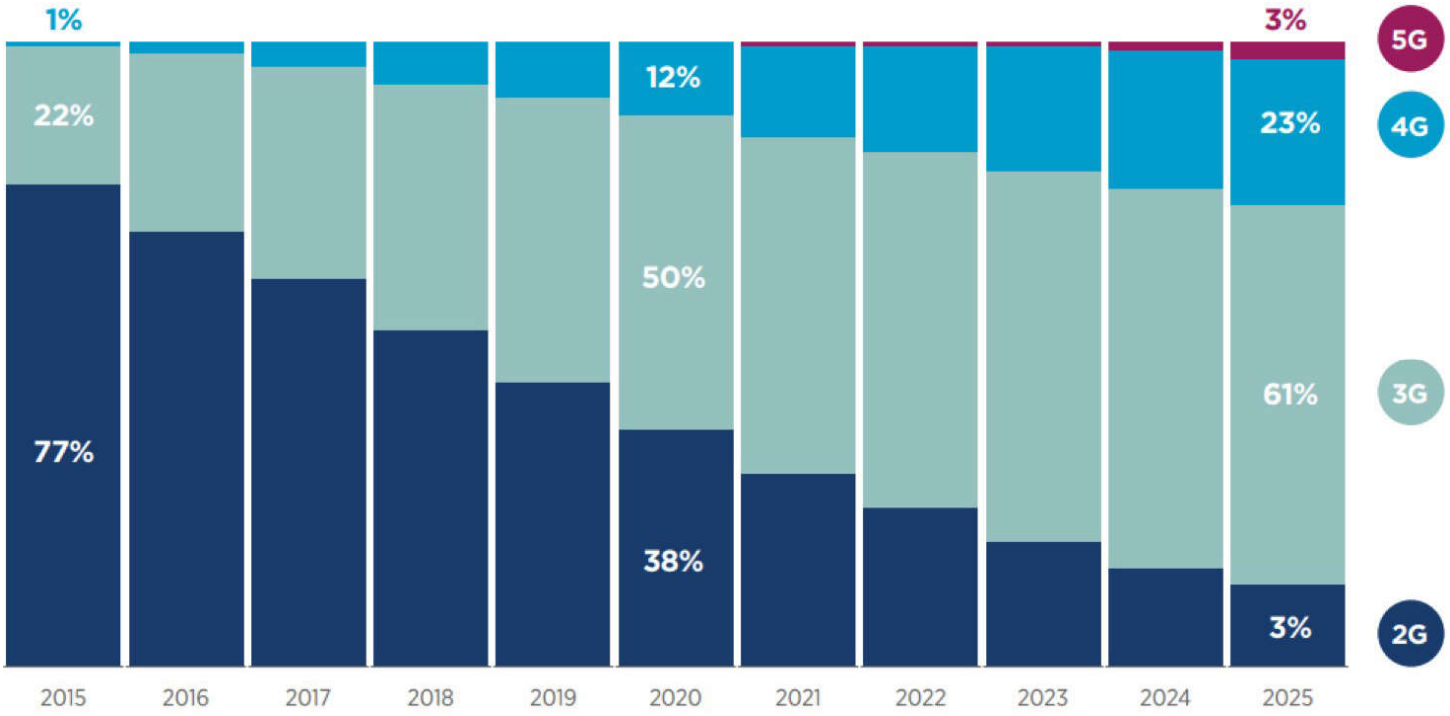
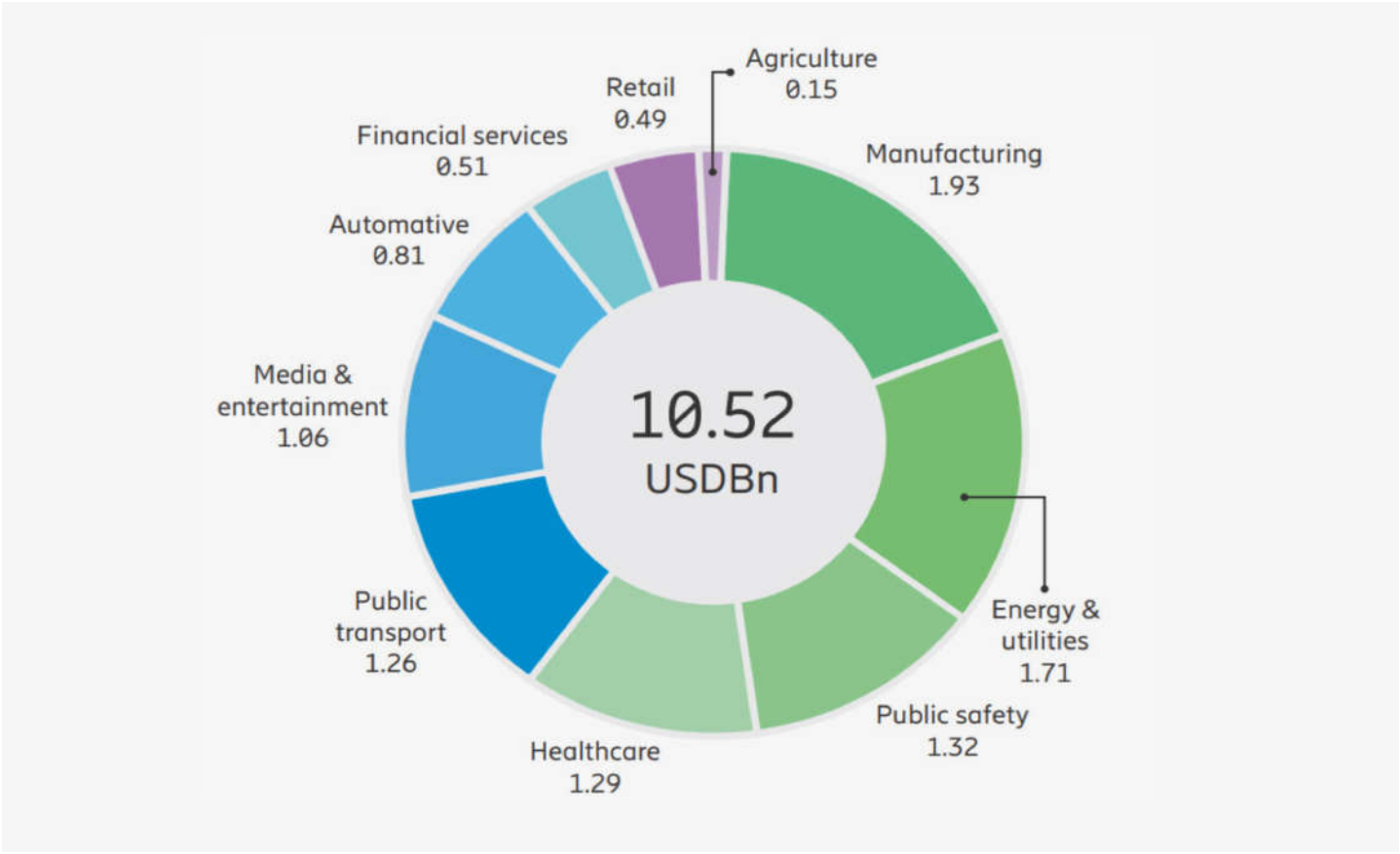


Figure 4: 5G enabled revenues for Africa



According to a European Union study, socio-economic benefits from the introduction of 5G capabilities in Europe could reach 113.1 billion Euro per year in four key sectors: automotive, health, transportation and energy.

In Africa, an Ericsson report estimated that the 5G business potential for Africa will be on the order of 10.52 Billion USD by 2026 in sectors such as healthcare, agriculture, energy and utility, public transportation etc. as shown in Figure 4 above.

Furthermore, a GSMA report[16] indicated that the GDP impact (socio-economic benefits) of mmWave 5G in SSA is around 5.2 billion USD by 2034 in areas such as high-speed broadband, next-generation transport connectivity and industrial automation etc.

Wi-Fi connectivity is also a critical component of overall 5G connectivity and it is expected that the increase in 5G data throughput will further increase the demand for Wi-Fi connectivity. A recent report commissioned by the Wi-Fi Alliance "Global economic value of Wi-Fi® nears $2 trillion in 2018"[17] estimated the current annual global economic value of Wi-Fi® at 1.96 trillion USD in 2018, and projected that number to surpass 3.47 trillion USD by 2023.

3.1 Global 5G Ecosystem

As a leader in the 5G ecosystem, Intel participates in many standards, regulatory, and industry groups worldwide, including holding leadership positions in the ITU-R, ITU-D, CEPT, 3GPP, ETSI, IEEE, GSMA, GSA, and Wi-Fi Alliance (WFA) as well as key vertical industry associations.[18] Intel is also very active in the World Radiocommunication Conference 2019 (WRC-19) preparatory process.

Some of the 5G collaborators in the ecosystem are mobile network operators, network equipment providers, device manufacturers, standards and regulatory bodies and industry verticals as shown in Figure 5 below.

3.2 5G Technologies

Intel technologies power and enable 5G across network, cloud, edge and devices and it is one of the only companies with such broad capabilities in 5G in both compute and connectivity. (See Figure 6).

Intel is already helping to build 5G's future, collaborating with others to accelerate 5G technology, standards and spectrum. And the top infrastructure vendors for radio access networks (RAN) are already utilizing Intel technologies and products to power the next generation transformed networks.

Critical wireless technologies for 5G in the mmWave bands, such as massive antennae arrays, narrowband IoT

Figure 5: Global 5G Collaborators

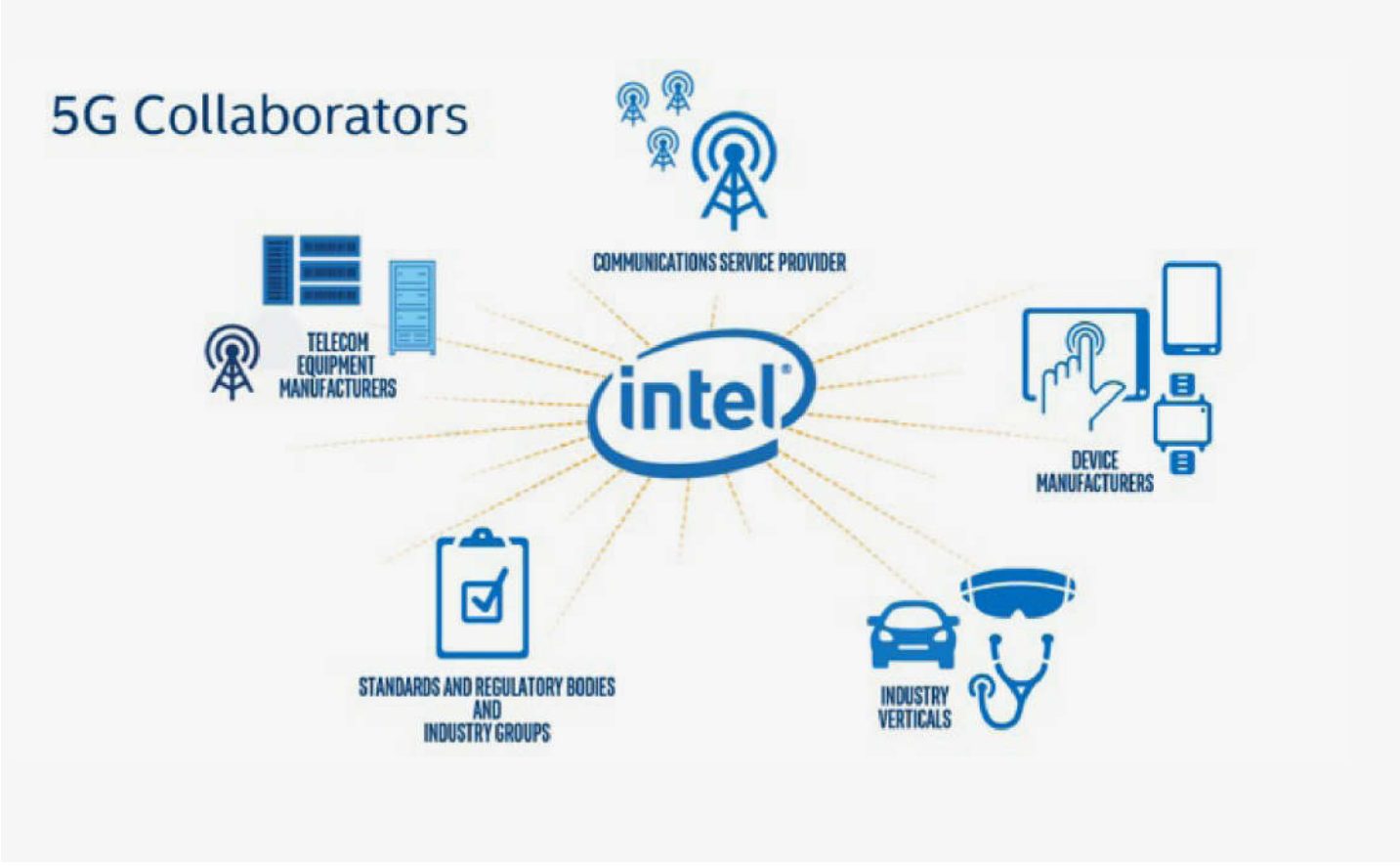


Figure 6: Intel's 5G End-to-End

and LTE-Wi-Fi Evolution are being developed, enabling Intel to deliver products for 5G radios. Intel is already delivering Gigabit+ modems (Intel® XMM™ 7660) with multi-technology and multi-mode operation supporting more than 45 frequency bands (incl. 3.5 GHz and 5 GHz) and aggregation of up to 7 carriers resulting in 1.6 Gbps peak data rates. Intel is also starting to deliver 5G modems (Intel® XMM™ 8160) supporting 5G New Radio (NR) (Non Standalone – NSA and Standalone - SA) as well as LTE and other legacy technologies with LTE-NR dual connectivity operating both in low/mid band spectrum in the 600 MHz to 6 GHz range as well as 26/28/39 GHz mmWave bands targeting 6 Gbps peak data rates.

Intel believes that both 3GPP-based and IEEE-based technologies play an important role in 5G. 3GPP standards (e.g. Release 15 and beyond, IMT-2020) and IEEE-based standards (Wi-Fi 6 and beyond, and WiGig) will deliver wireless broadband to consumers and businesses worldwide.

Within ITU-R, work has begun on the development of IMT-2020, the next generation of cellular technology, which will be backwards compatible with IMT-Advanced (e.g. LTE) and IMT-2000. IMT-2020 will also interoperate with Wi-Fi and WiGig technologies in license-exempt spectrum.

Therefore, to enable 5G and mobile broadband in SSA, current and next wave connectivity will provide an optimal platform for the near and long-term.

The first wave of 5G service deployments are using various frequencies (e.g. 3300 – 3600 MHz; 26/28 GHz) for improved data throughput, leveraging existing 4G deployments for smoother migration to 5G. The first release of the 5G standard, which was approved in June 2018, simplified network infrastructure, lowered costs and is ideal for use cases such as ultra-reliable and low latency communications. Initial 5G deployments are expected to use spectrum within the 3.3-3.8 GHz and 26.5-29.5 GHz (28 GHz), which will be expanded to spectrum within 3.3-5 GHz for mid-band spectrum and 24.25-29.5 GHz and 37-43.5 GHz for high-band spectrum.

3.2.1 International Mobile Telecommunications (IMT)

International Mobile Telecommunications (IMT) encompasses IMT-2000, IMT-Advanced and IMT-2020. The capabilities of IMT systems are being continuously enhanced in line with user trends and technology developments.

Recommendations ITU-R M.1457, ITU-R M.2012 and ITU-R M. [IMT-2020.SPECS] (to be finalized by ITU-R Working Party 5D in October 2020) contain, respectively, the detailed specifications of the terrestrial radio interfaces of IMT-2000, IMT-Advanced and IMT-2020. Within ITU-R,

work has begun on the development of IMT-2020, the next generation of cellular technology, which will be backwards compatible with IMT-Advanced (e.g. LTE) and IMT-2000.

3.2.1.1 IMT-2000

IMT-2000 third generation mobile systems started service around the year 2000. Objectives of IMT-2000 are defined in Recommendation ITU-R M.687 "IMT-2000", and were finally revised in 1997, including general objectives, technical objectives, and operational objectives.

3.2.1.2 IMT- Advanced

International Mobile Telecommunications – Advanced (IMT-Advanced) is a mobile system that includes the new capabilities of IMT that go beyond those of IMT-2000.

The term "IMT Advanced" is applied to those systems, system components, and related aspects that include new radio interface(s) that support the new capabilities of systems beyond IMT 2000. IMT-Advanced systems provide enhanced peak data rates to support advanced services and applications (100 Mbit/s for high and 1 Gbit/s for low mobility were established as targets for research).

3.2.1.3 IMT-2020

IMT for 2020 and beyond is envisaged to expand and support diverse usage scenarios and applications that will continue beyond the current IMT. These intended different usage scenarios and applications for IMT for 2020 and beyond include[19] (see Figure 7 below):

- Enhanced Mobile Broadband (eMBB): Applications include immersive experiences (e.g. virtual reality, augmented reality).
- Massive machine type communications (mMTC): Applications include smart home, smart cities, and sensors.
- Ultra-Reliable Low Latency Communications (URLLC): Applications include mission critical type communication (e.g. autonomous driving, industrial automation).

The capabilities of IMT-2020 technologies are enhanced and backward compatible with those of IMT-Advanced as indicated in Figure 8 below. The peak data rate for enhanced Mobile Broadband features up to 20 Gbps which is 20 times higher than the data rates of IMT-Advanced, the area traffic capacity is 100 times higher than that of IMT-Advanced, a spectral efficiency 3x more efficient than IMT-Advanced for enhanced Mobile Broadband, and a sub- 1 millisecond end-to-end delay for low latency applications.

Figure 7: Usage scenarios of IMT for 2020 and beyond

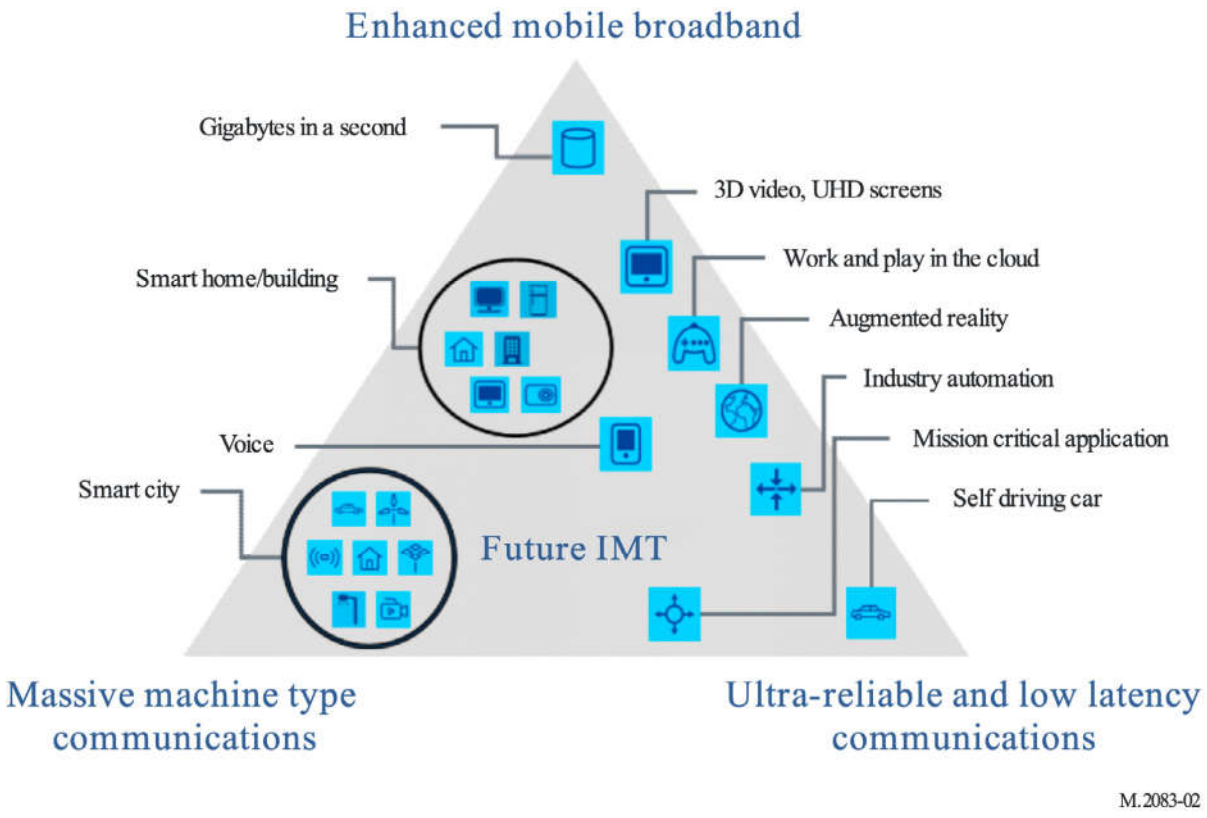
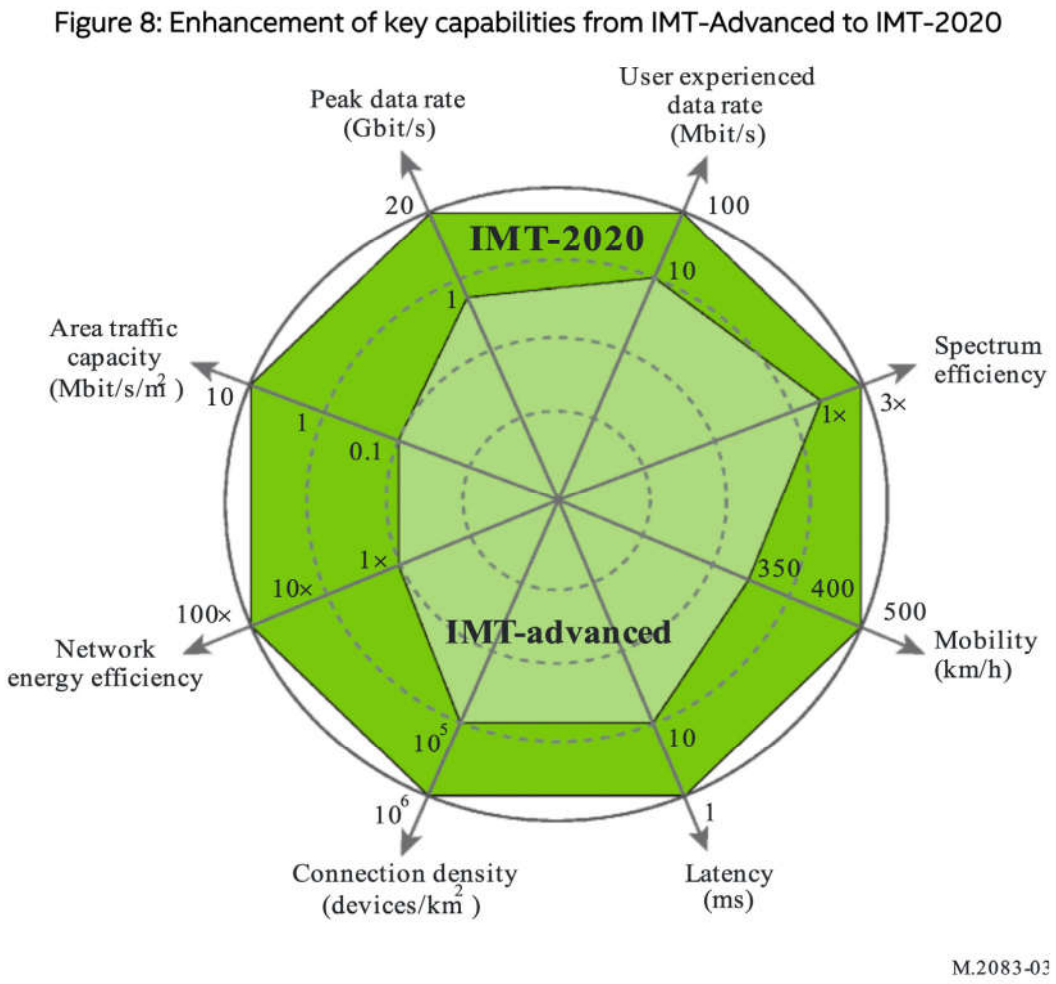


Figure 8: Enhancement of key capabilities from IMT-Advanced to IMT-2020



3.2.2 Current and next generation Wi-Fi Technologies

Today Wi-Fi supports high-resolution video streaming, Wi-Fi calling, smart home monitoring, hotspot access, automation of city-wide services, residential, augmented reality (AR) / virtual reality (VR) applications, and seamless roaming. Wi-Fi's role will only increase in the future, since Wi-Fi technology is expected to play an important role in supporting 5G networks, with ultra-dense, high-speed connections to wireless and wired networks, making end-to-end communications seamless.[20] Wi-Fi will continue to deliver connectivity and will carry a bulk of the world's data traffic as 5G networks are deployed. Wi-Fi 6, based on the IEEE 802.11ax standard, will bring increased access and capabilities. Meanwhile WiGig enhancements, based on the IEEE 802.11ad/ay standards and operating within the 57 – 71 GHz band, will deliver faster speeds and longer ranges for WiGig, providing connectivity for many advanced use cases in connected homes, connected enterprises, IoT, smart cities and public venues.[21]

3.2.3 Intel Technology Leadership

Intel is unique in its ability to **deliver integrated, complete platforms** across a range of markets and use cases. Intel processors power computing in connected devices such as personal computers (PCs), autonomous cars, and Internet-of-Things products, through edge devices like gateways, and across massive-scale networking infrastructure to hyper scale cloud data centers. These processors are combined with Intel's 5G technology, revolutionary memory products, and seamless software solutions to deliver true end-to-end platforms. Please see Figure 9.

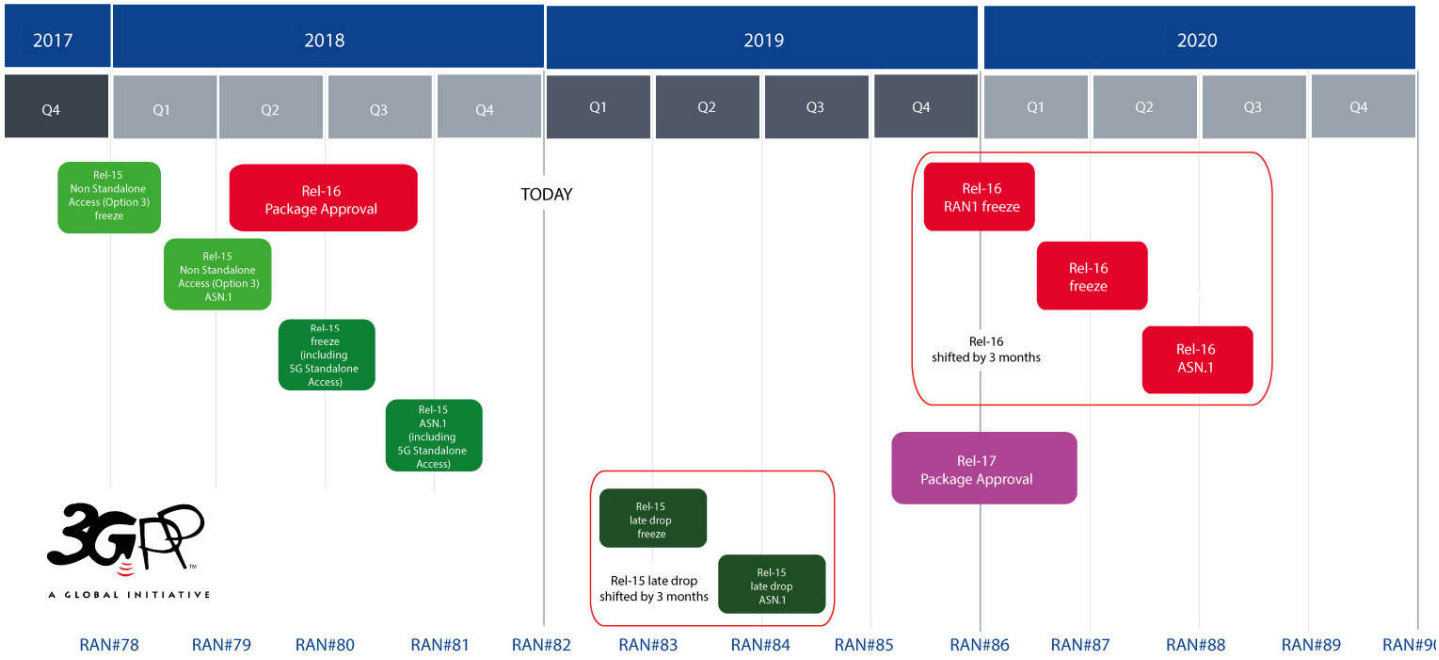
3.3 5G Standardization efforts

3.3.1 5G Standardization - 3GPP

In June 2018, 3GPP RAN completed the 1st version of all 5G New Radio (NR) specifications for key deployment scenarios, Non-Standalone (NSA) and Standalone (SA), for use cases of Mobile Broadband (MBB) and Ultra Reliable Low Latency Communication (URLLC). The 3GPP RAN-adjusted schedule for the 2nd wave of 5G specifications is shown in Figure

Figure 9: Intel End-to-End Platforms

Figure 10: Adjusted overall schedule for 2nd wave of 5G specifications[22]



10 above. The primary focus of the 3GPP Release-15 5G NR standard completed in June 2018 is enhanced mobile broadband (eMBB) services. Commercial deployments are already available starting from 2019. The 3GPP Release-16 5G NR standard, planned to be completed in June 2019, incorporates features supporting the Internet of Things (IoT).

3.3.2 5G Standardization - ITU

The process and activities identified for the development of the IMT-2020 terrestrial components radio interface Recommendations are described in Doc. IMT-2020/2(Rev1) - Submission, evaluation process and consensus building for IMT-2020.[23] The detailed timeline and process for the development of IMT-2020 in ITU-R[24] is shown in Figure 11.

3.4 Policy and Regulatory implications for 5G

3.4.1 Regulatory policy

Any broadband strategy or policy plan should include the following key elements/items to facilitate 5G deployment/use:

- Spectrum allocation – affordable access to licensed spectrum and timely access to additional license-exempt spectrum.
- Technology neutrality.
- Right of way and permit process.

Other aspects that might be included in national ICT policy or digital economy strategies are privacy, data protection, and cybersecurity considerations.

In SSA, many of the countries' national master plans/ICT policies/digital economy strategies or broadband plans/strategies were developed years ago. Taking into account new technological development (i.e. 5G and current broadband penetration), it is recommended that Sub-Sahara African Countries:

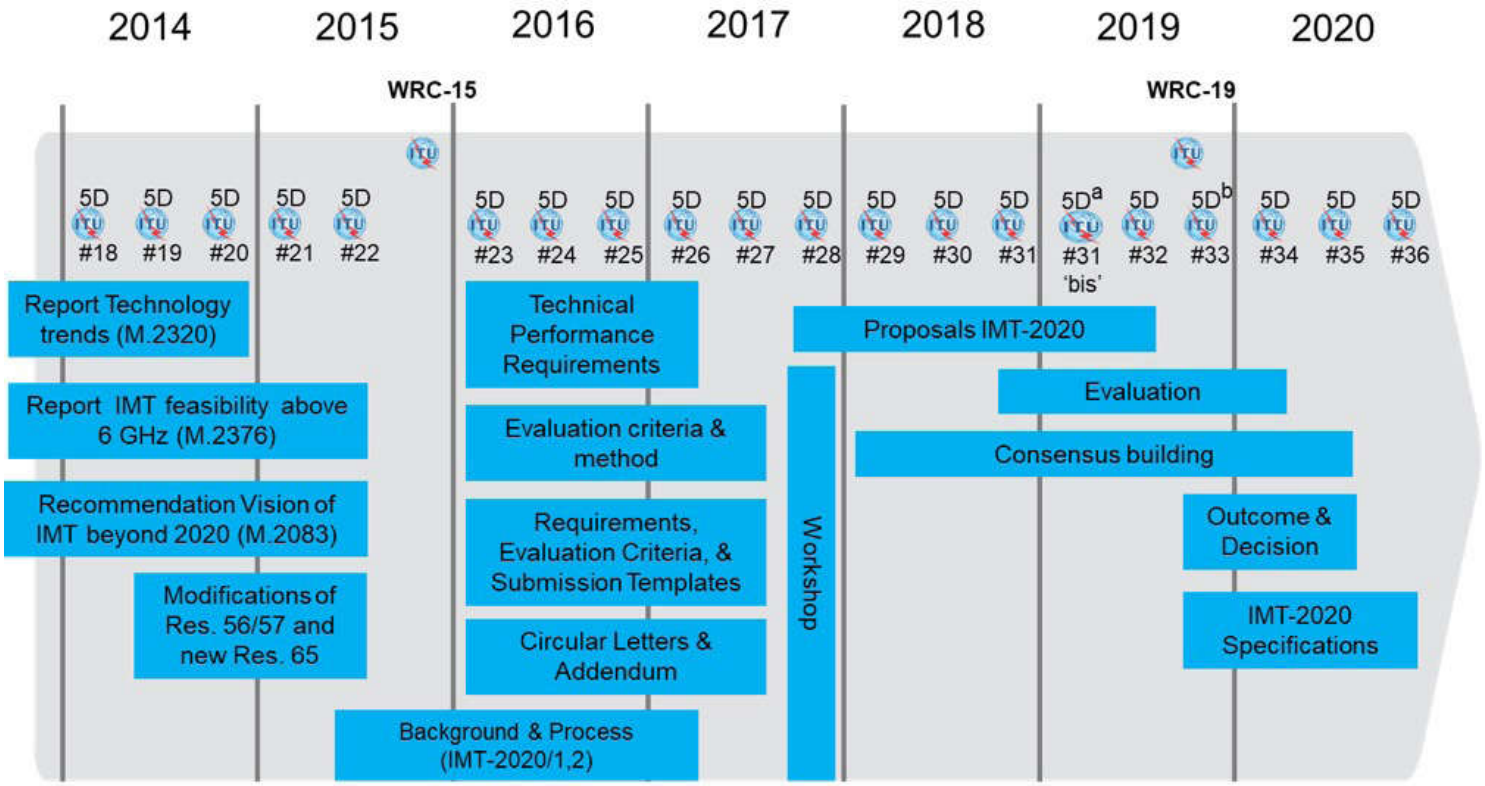
- Review and update their national broadband plans/strategies to incorporate the needs for new technological development e.g. 5G, new broadband targets, etc.
- Review and modernize existing regulations to adapt to new technological developments i.e. 5G, including the elimination of regulations that have outlived their original purpose, or that create unnecessary burdens which negatively impact deployment and adoption.

3.4.2 Spectrum policy

5G will enable a diverse set of use cases and applications. In order to fulfil these usage scenarios, access to spectrum within low, mid and high bands is needed. As the global community continues to make decisions on which spectrum will be used for 5G services, Intel is working with industry groups (e.g. GSMA/GSA/WFA), governments and regulators around the world - including in SSA - to ensure there is adequate spectrum to fulfil the potential of 5G.

5G NR supports a variety of frequency bands including high-band spectrum with far greater bandwidth. To enable 5G, access to licensed and license-exempt spectrum is essential.

Figure 11: Detailed Timeline & Process for IMT-2020 in ITU-R



(a) – five day meeting, (b) – focus meeting on Evaluation (Technology)

Note: While not expected to change, details may be adjusted if warranted.

3.4.2.1 Licensed Spectrum

For licensed spectrum, which is traditionally used for cellular communication with exclusive rights granted to the network operators, there will be a need for:

- Low-band spectrum (below ~1GHz) which provides coverage across a wide area including indoors and outdoors for low bandwidth uses. The 700 MHz band (3GPP Band 28a: UL- 703 – 733 MHz / DL- 758 – 788 MHz) and 800 MHz band (3GPP Band 20: DL – 791 – 821 MHz / UL- 832 – 862 MHz) are excellent for wide area coverage of LTE and also 5G in regional and rural environments, for in-building coverage, and represent an important digital dividend arising from the shift by TV broadcasters to digital transmissions. According to the GSA,[25] 1348 LTE FDD user devices and 5211 LTE FDD user devices are on the market globally in 700 MHz and 800 MHz respectively. In some countries, operators are also using the 600 MHz band for 5G.
- Mid-band spectrum (between ~2 – 5 GHz) delivers mobile broadband e.g. TDD 3.5 GHz. The 3 400 – 3 600 MHz band is globally harmonized. At WRC-15, the frequency band 3 300 - 3 400 MHz was also allocated to the mobile, except aeronautical service, through various footnotes, and is identified for IMT in forty-five (45) countries across the three regions of the ITU, with thirty-three (33) in Africa (Region 1), six (6) in the Americas (Region 2) and six (6) in Asia (Region 3).

Considering that the 3 300 – 3 400 MHz band is adjacent to the near-globally harmonised 3 400 – 3 600 MHz band, the frequency arrangement under consideration in the revision of recommendation ITU-R M.1036 is F3 (TDD: 3 300 – 3 700 MHz) which could provide the possibility for administrations to implement IMT in the whole or parts of the bands identified in the Radio Regulations (3 300 - 3 400 MHz, 3 400 – 3 600 MHz and 3 600 - 3 700 MHz).

From 5G trials, deployments and launches perspectives, the 3.5 GHz band (3 300 – 3 800 MHz) has been the most frequently used band and is emerging as a core 5G band. In Europe, 3.4 - 3.8 GHz is identified as the first primary band for 5G, which can be used to provide high capacity and coverage.

The 3.5 GHz band will benefit from harmonisation of equipment if TDD band plans are adopted globally. With the use of TDD technology, a single device will be able to operate in the entire range (3 300 – 3 800 GHz: 3GPP band n78) and adjust to only using portions of the band licensed in any given country. More information at Considerations for the 3.5 GHz IMT range.

In SSA therefore, the 3 300 – 3 600 MHz TDD (3GPP band n78) band could be designated as one of the core bands for 5G.

In addition, countries are making different portions of spectrum available for 5G within the 3 300 – 5 000 MHz band. For example, the USA has initiated a Notice of Proposed Rulemaking to permit mobile broadband use within the 3.7 – 4.2 GHz spectrum range.[26] China has reserved the 3 300 – 3 600 MHz and 4 800 – 5 000 MHz bands for 5G services, and Russia issued the 4 800 – 4 990 MHz frequencies for pilot 5G projects.[27] Japan has made the 3 600 – 4 100 MHz frequencies available for 5G, and Korea has already completed auction for the 3 420 – 3 700 MHz frequencies in mid-2018 for 5G, with the commercial launch there expected to start in April 2019. For more information, please refer to the "5G mid-band spectrum global update" report[28] by Analysis Mason.

These various frequencies being made available for 5G in leading markets will be supported by a 5G "tuning range" which will cover 3.3 - 5 GHz. The relevant 3GPP band classes are as follows:

n77	**3 300 MHz – 4 200 MHz**
n78	**3 300 MHz – 3 800 MHz**
n79	**4 400 MHz – 5 000 MHz**

- High-band spectrum (above 24 GHz) transmits massive amounts of data. New advancements will allow extended reach for outdoor coverage e.g. TDD 26 GHz and 40 GHz bands (WRC-19 Agenda Item 1.13). The 26 GHz band (24.25 - 27.5 GHz) is identified as a key band to enable 5G and is gaining momentum for IMT identification globally. It has also been designated as the pioneer band for 5G deployment in the mmWave band in Europe. Initial 5G deployments are occurring within the 28 GHz band (26.5-29.5 GHz). The 26/28 GHz tuning range approach, which will include both the 26 GHz and the 28 GHz bands, will enable terminals to select any sub-band within this frequency range which is available in the country it is used in. Sub-Sahara African countries could take advantage of the early ecosystem development and uptake in the 28 GHz band for future 5G deployments in the 26 GHz when the band becomes available.

  The 40 GHz band (37.0 - 43.5 GHz) is also an important band for 5G. Therefore, the identification of the entire 37.0 - 43.5 GHz frequency range (37 - 40.5 GHz, 40.5 - 42.5 GHz and 42.5 - 43.5 GHz) i.e. 40 GHz band for IMT at WRC-19 would enable Sub-Sahara African countries to select the most appropriate portions for the national implementation of IMT-2020. As these three bands are part of the same tuning range, they enable the widest possible harmonization. For more information, please see section 3.4.2.4 WRC-19 Agenda Item 1.13: high-band spectrum (above 24 GHz) below.

For additional information on licensed spectrum, please refer to Annex 4, GSA reports on 5G developments.

3.4.2.2 License-exempt spectrum

For license-exempt spectrum, which is spectrum used collectively by a number of independent users without registration or individual permission, there is a need for spectrum within the:

- 5 GHz band which is used by Wi-Fi and other devices: For more information, please see section 3.4.2.5 WRC-19 Agenda Items 1.16 and Agenda Item 9.1/ Issue 9.1.5.
- 6 GHz band under the existing Mobile Allocation, which is under consideration by the US and Europe.
- 60 GHz band (57-71 GHz), which is used by WiGig devices among others, noting an IMT identification for 66-71 GHz is not needed (WRC-19 Agenda Item 1.13). For more information, please see section 3.4.2.4 WRC-19 Agenda Item 1.13: high-band spectrum (above 24 GHz) below.

For additional information on license-exempt spectrum, please refer to Annex 5, Spectrum for License-Exempt Component of 5G.

3.4.2.3 License-shared spectrum

In addition, license-shared spectrum (shared exclusive use) is a new complementary model to licensed spectrum, allowing use by another licensee when not being used by an incumbent operator.

3.4.2.4 WRC-19 Agenda Item 1.13: high band spectrum (above 24 GHz)

WRC-19 Agenda Item 1.13 is "*to consider identification of frequency bands for the future development of International Mobile Telecommunications (IMT), including possible additional allocations to the mobile service on a primary basis, in accordance with Resolution 238 (WRC-15).*"

The frequency bands under consideration are 24.25-27.5 GHz; 31.8-33.4 GHz; 37-43.5 GHz; 45.5-50.2 GHz; 50.4-52.6 GHz; 66-71 GHz; 71-76 GHz; and 81-86 GHz.

The following frequency ranges are identified as key bands to enable 5G:

26 GHz:

- 24.25 – 27.5 GHz is one of the bands under consideration for 5G under Agenda Item 1.13 for WRC-19. This band is identified as a key band to enable 5G and is gaining momentum for IMT identification globally. It has also been designated as the pioneer band for 5G deployment in the mmWave band in Europe.

  Studies in ITU Task Group 5-1, indicate that sharing with in-band services is feasible with large margin. For the

out-of-band-emission (OOBE) limit required from IMT-2020 to protect the Earth Exploration Satellite Services (EESS) in the adjacent 23.6 – 24 GHz band, the African Telecommunication Union (ATU) has proposed limits of -32 to -37 dBW/200 MHz for the base station and -28 to -30 dBW/200 MHz for the user equipment. Europe / CEPT has decided to implement more restrictive and very conservative limits for the protection of EESS applications. The Arab Spectrum Management Group (ASMG) has recently decided to support limits of -32 dBW/200 MHz for the base station and -28 dBW/200 MHz for the user equipment based on an assessment of the coexistence situation. The US and Korea support -20 dBW/200 MHz for the base station and for the user equipment.

3GPP has defined the frequency range 2 (FR2) above 24 GHz with 3GPP band n258 referring to the frequency range between 24.25 - 27.5 GHz (26 GHz) and 3GPP band n257 which refers to 26.5 - 29.5 GHz (28 GHz). Initial 5G deployments are occurring within the 26.5-29.5 GHz.

Taking into account the fact that there is 1 GHz of overlap (26.5 – 27.5 GHz) between the 26 GHz and the 28 GHz band, Sub-Sahara African countries could take advantage of the early ecosystem development and uptake in the 28 GHz band for future 5G deployments in the 26 GHz when the band becomes available. This will be possible due to the prospect of the 26/28 GHz tuning range approach, which will include both 26 GHz and 28 GHz, enabling terminals to select any sub-band within this frequency range which is available in the country it is used in. For more information on new development on the 28 GHz please refer to: http://5g-28frontier.org/.

37 - 43.5 GHz:

- The 37.0 – 43.5 GHz frequency range includes the following three bands under consideration for IMT-2020 under Agenda Item 1.13 for WRC-19: 37 - 40.5 GHz, 40.5 - 42.5 GHz and 42.5 - 43.5 GHz. The identification of the entire 37.0 - 43.5 GHz frequency range for IMT at WRC-19 would enable Sub-Sahara African countries to select the most appropriate portions for the national implementation of IMT-2020. As these three bands are part of the same tuning range, they enable widest possible harmonization.

  At the 3rd African Preparatory Meeting for WRC-19 (APM19-3) meeting, the African Telecommunication Union decided to support the full 37- 43.5 GHz frequency range for IMT identification at WRC-19. The 40.5 - 43.5 GHz frequency range is a priority band for CEPT and is already identified for future harmonisation in Europe. CEPT considers that this band has good potential for future harmonisation in Europe. Furthermore, CEPT has recognized the harmonization potential of a global IMT tuning range across the 37- 43.5 GHz band at WRC-19 and, whilst CEPT has currently no intention to use the 37 - 40 GHz portion for IMT, CEPT has indicated that they would not oppose a global IMT identification of the entire 37 - 43.5 GHz frequency range. We see similar trends also in the Asia-Pacific and Americas regions, noting that, among others, the US has already allowed 5G in 37-40 GHz and China is interested in portions of the 37 - 43.5 GHz frequency range.

66 - 71GHz band:

- The 66 - 71 GHz and 57 - 66 GHz bands are important bands for license-exempt multiple-gigabit systems as part of the overall 5G ecosystem. The existing co-primary mobile allocation is sufficient to enable both IMT and non-IMT technologies to develop on an equal basis. In Europe, support for an identification of the 66 – 71 GHz frequency band for IMT does not establish priority in the Radio Regulations and does not preclude the use of the frequency band by any application of the services to which it is allocated. IMT and Multiple Gigabit Wireless Systems (MGWS)/ Wireless Access Systems (WAS) should have equal access to the frequency band 66 - 71 GHz and an identification should not confer any priority to IMT. IEEE-based and 3GPP-based technologies both successfully utilize 5 GHz spectrum without any identification to IMT. Therefore, similar to 5 GHz, an IMT identification for 66 - 71 GHz is actually not needed to facilitate use of this spectrum by both types of technologies. On the contrary, an IMT identification could be seen as putting priority on the IMT technologies and thus disadvantaging or even excluding non-IMT technologies and therefore an IMT identification would pose a risk to non-IMT technologies not being able to use this band in the future.

3.4.2.5 WRC-19 Agenda Item 1.16 and Agenda Item 9.1/Issue 9.1.5

WRC-19 Agenda Item 1.16:

This agenda item is being pursued to consider issues related to wireless access systems, including radio local area networks (WAS/RLAN), in the frequency bands between 5 150 MHz and 5 925 MHz, and take the appropriate regulatory actions, including additional spectrum allocations to the mobile service, in accordance with Resolution 239 (WRC-15).

Radio local area networks (RLANs) have proven to be a tremendous success in providing affordable and ubiquitous broadband connectivity. Introduced by some administrations in limited spectrum in the 2.4 GHz band and subsequently expanded into the 5 GHz band, RLANs (e.g. Wi-Fi devices), now are an integral component of the world's connectivity infrastructure. According to the latest statistics, more than half of all global IP traffic will be delivered over Wi-Fi,[29] and forecasts suggest that with the introduction of

5G and gigabit wireless technologies, the demand will continue to grow rapidly in the coming years. In spite of the tremendously growing demand, however, no additional spectrum has been made available globally for RLAN since World Radiocommunication Conference 2003 (WRC-03). This lack of adequate spectrum threatens to degrade RLAN performance and limit connectivity for billions of consumers worldwide. This problem is particularly acute for RLAN outdoor deployments.[30]

5 150 – 5 250 MHz:

The problem of inadequate spectrum access for RLANs is exacerbated further by the fact that except for the band 5 150 - 5 250 MHz, other spectrum in the 5 GHz range harmonized for RLANs on a world-wide basis is subject to technical constraints such as the dynamic frequency selection (DFS). The DFS constraint, albeit necessary, reduces spectrum access and raises equipment cost and complexity for RLAN implementation.

Thus, relaxing some of the operational constraints on RLANs in the 5 150 – 5 250 MHz band offers unique advantages in addressing the growing need for RLAN outdoor access. Recognizing this fact, in 2014, the United States adopted regulations that protect other services while allowing limited RLAN operations outdoors in the 5 150 – 5 250 MHz band.

Since the United States adoption of these more permissive regulations for 5 150 – 5 250 MHz, other countries such as Canada, Korea, Japan etc. authorized outdoor RLAN deployments.

There is a need therefore to enable much needed RLAN outdoor deployments while ensuring protection of other operations in the 5 150 - 5 250 MHz.

5 725 - 5 850 MHz:

The 5 725 - 5 850 MHz frequency band is allocated to various services as contained in the Radio Regulation Table of Frequency Allocations including associated footnotes. In Region 1, a number of systems/applications such as road transport and traffic telematics (RTTT), wireless industrial applications (WIA), broadband fixed wireless access (BFWA) and short-range devices (SRD) in addition to the designation of this band worldwide as an industrial, scientific and medical (ISM) band operate in this band in several countries. Some of these applications use WAS/RLAN technologies. In Nigeria for example, the Nigerian Communications Commission (NCC) has developed guidelines indicating that this band is available for WAS of the many types that are or will become available in the world markets; and that both indoor and outdoor operations are permitted, with an output power (e.i.r.p) of up to 4W with no DFS restriction.[31] In South Africa, this band is also used for WAS/RLAN with a maximum of 4W e.i.r.p for which relevant standards are FCC 15.247 and FCC 15.249.[32]

Given the fact that WAS/RLAN already operate in various countries throughout the world, including in some countries in Sub-Sahara Africa within this frequency band, there should be no new conditions and therefore there should be no change to the radio regulation for the 5 725 - 5 850 MHz frequency band. See approach D1 in CPM19-2 CPM text (https://www.itu.int/md/R15-CPM19.02-R-0001/en) on page 348.

WRC-19 Agenda Item 9.1/ Issue 9.1.5:

This issue is being pursued for consideration of the technical and regulatory impacts of referencing Recommendations ITU R M.1638 1 and ITU R M.1849 1 in Nos. 5.447F and 5.450A of the Radio Regulations in accordance with Resolution 764 (WRC 15).

WRC-03 allocated the 5 150 - 5 350 MHz and 5 470 - 5 725 MHz frequency bands to the mobile service on a primary basis for the implementation of WAS including RLANs subject to **Resolution 229 (Rev. WRC-12)**. WRC-03 also decided that the radiolocation service, the Earth exploration-satellite service (active), the space research service (active) (**No. 5.447F**), and the radiodetermination service (**No. 5.450A**) shall not impose on the mobile service more stringent protection criteria, based on system characteristics and interference criteria, than those stated in Recommendations ITU-R M.1638-0 and ITU-R RS.1632-0, which are incorporated in the Radio Regulations by reference.

Since WRC-03, millions of RLAN devices have been deployed worldwide. ITU-R revised Recommendation M.1638-0 during the WRC-15 study cycle. The revised recommendation (M.1638-1) included several new radars with different system characteristics and removed the technical characteristics and protection criteria for ground-based meteorological radars, which were placed in Recommendation ITU-R M.1849-1 instead. Several new meteorological radars were also added to Recommendation ITU-R M.1849-1 during this revision process. The protection requirements for some of these new radars would mean that Wi-Fi would have to stop operating in the band 16 years after it was opening for Wi-Fi.

The proposal therefore is to update footnotes Nos. **5.447F** and **5.450A** to remove the references to Recommendations ITU-R M.1638-1 and M.1849-1 while not imposing more stringent technical conditions. See approach B in CPM19-2 CPM text (https://www.itu.int/md/R15-CPM19.02-R-0001/en) on page 385.

3.5 Recent developments on 5G in Sub-Sahara Africa

Comsol, a layer 2 open access solution provider in South Africa, is collaborating with both Verizon and Samsung to launch 5G fixed wireless trials in South Africa, and says it plans to launch commercial 5G-based Fixed Wireless Broadband (FWB) services in 2019.

MTN has announced partnerships with both Huawei and Ericsson, while Vodacom has signed a memorandum of understanding (MOU) with Nokia.

In August 2018, Vodacom said that it had already launched Africa's first commercial 5G service for two enterprise customers in Lesotho.[33]

Recently, MTN undertook what the company claimed to be the first 5G field trial in the region, using Huawei's 5G 28 GHz millimetre-wave technology. The trial focuses on the fixed wireless use case, a key potential opportunity for 5G in South Africa to facilitate an increase in the availability of broadband connectivity.[34]

3.6 5G Use cases for Sub-Sahara Africa

5G can be a catalyst for a connected society and economic transformation in SSA. The future society and economy on the continent will strongly rely on its communications infrastructure to contribute to the digitalization of vertical markets such as education, city management, agriculture, government, healthcare, and transportation etc.

Intel has driven dozens of 5G trials worldwide with the top operators and with key use cases, and demonstrated the value of 5G in use cases across industrial, media, retail, smart cities with top global industrial partners.[35]

Some of the 5G use cases that we envisioned in the context of SSA are 1) Fixed Wireless Broadband (FWB); 2) Digital government; 3) Smart education; 4) Healthcare; 5) Agriculture; 6) Smart Cities and 7) Industrial IoT.

For additional information on 5G use cases, please also refer to the ITU-R Report M.2441 on Emerging usage of terrestrial component of International Mobile Telecommunication (IMT) which provides detailed information in section 5 - Use Cases or Applications.

3.6.1 Fixed Wireless Broadband

The fixed wireless broadband use case would provide fixed 5G services with fibre-like speeds for enterprises and homes, and could be used to provide last mile connectivity (5G as a backhaul).

According to the GSMA, MTN and a number of other operators appear set to focus initially on the fixed wireless opportunity. Investment to increase fibre backhaul as a replacement for microwave has resulted in significant capacity at cell sites for backhaul. Therefore, with 5G, there is the opportunity to address the last-mile opportunity and connect households more cost-effectively, similar to a Verizon initial deployment in the USA.

3.6.2 Digital government

5G technology can improve network connectivity by delivering lower latency, improved battery life, and the ability for networks to handle more data. It is expected that 5G could positively impact government agencies in areas such as facilitating the digitization of public services (e.g. Smart ID), increasing citizen engagement, and helping make public institutions more inclusive and effective.

3.6.3 Education

5G can play an important role in enhancing education, extending our experience of learning and teaching far beyond what we have had over last decades. New mobile technology and connected devices can give students the opportunity to learn mostly through exploration, discovery and peer coaching. [36]

3.6.4 Healthcare

5G can enable real time health services with a boom in next-generation 'telehealth' treatment options, commanding unwavering connectivity and data intelligence. Evolution in healthcare will encourage health-tracking, proactive patient care, comprehensive data analytics and distance training and treatment. Mission-critical medical functions require an end-to-end virtualized network boasting high reliability, low latency and a wireless structure with enhanced capabilities. Connected medicine will provide quality care by allowing physicians to uncover actionable insights, learn in real-time and tap into accumulated data to determine best treatment options.

3.6.5 Agriculture

5G can facilitate agricultural applications. Precision farming can drive African farmers to unprecedented levels of productivity. Smart farming applications can deliver around-the-clock visibility into soil and crop health, machinery usage, storage conditions, animal behaviour and energy consumption. Real-time data analysis, lower operational costs, data sent back to the cloud and other assets remaining operational even when one malfunctions will only be realized through 5G's edge computing model and gateway networking devices. Not only does smart farming cut costs and boost food production, but the use of sensors can also improve animal welfare and reduce the use of resources, such as water.

3.6.6 Smart cities

Urban cities are transforming into 'smart cities,' powered by a 5G network enabling smarter, cleaner and safer places to live. Disparate modern devices and facilities will soon communicate seamlessly, boosting efficiency and minimizing hazards, including congestion, pollution and excessive energy consumption. Connected devices will deliver intelligent data to facilitate real-time adaptability and advancements in traffic control and remote systems management. 5G will provide the transformative technologies to meet the demands of a skyrocketing population, while reducing its environmental impact, improving public safety and optimizing efficiency.

3.6.7 Industrial IoT

With 5G, industrial environments are experiencing revolution in development and application of manufacturing intelligence to every aspect of business. Industrial IoT enables technologies that fuel innovation; vastly improve operational efficiency, safety and security; and transform workforces. Software-driven services provide increased visibility into products,

processes, customers and partners. Huge data sets collected will result in actionable insights to reduce downtime, increase output, use assets better, and develop new revenue streams.

4. CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

With a population of ~1 billion[37] in 48 countries, 40% of the population in SSA are under the age of 16, a demographic segment that has significantly lower levels of mobile ownership than the population as a whole according to the World Bank data. The International Monetary Fund (IMF) shows that the macroeconomic outlook for SSA continues to strengthen with growth expected to increase from 2.9% in 2018 to 3.5% in 2019.[38] According to the GSM Association (GSMA), the mobile industry made a total contribution of 110 billion USD to the SSA economy in value added terms, which is equivalent to 7.1% of the region's gross domestic product (GDP) in 2017 and that by 2022, the mobile economy in the region will generate more than 150 billion USD (or 7.9% of GDP).[39]

There are different studies on the economic and social benefits of 5G. In particular, a 5G study report for the Gulf Cooperation Council (GCC) region prepared by Analysis Mason indicated that 5G will provide a new income of 273 billion USD to the GCC region within the next 10 years.[40] According to the European Union's study, socio-economic benefits from the introduction of 5G capabilities in Europe could reach 113.1 billion Euro per year in four key sectors: automotive, health, transportation and energy.[41] In Africa, an Ericsson report[42] indicated that the estimated 5G business potential is in the order of 10.52 billion USD by 2026 in sectors such as healthcare, agriculture, energy and utility, public transport etc. Furthermore, a GSMA report[43] indicated that the GDP impact (socio-economic benefits) of mmWave 5G in SSA is around 5.2 billion USD by 2034 - in areas such as high-speed broadband, next-generation transport connectivity and industrial automation etc. A recent report commissioned by the Wi-Fi Alliance "Global economic value of Wi-Fi® nears $2 trillion in 2018"[44] estimated the current annual global economic value of Wi-Fi® at 1.96 trillion USD in 2018, and projected that number to surpass 3.47 trillion USD by 2023.

Broadband subscription penetration in SSA (41%) is low compared to the world average which is 74%.[45] More needs to be done to improve broadband penetration in SSA, and 5G provides an opportunity for an increase in broadband penetration on the continent.

5G is more than just another step in the evolution of wireless; it is the convergence of wireless with computing and the cloud. Intel technologies power and enable 5G across network, cloud, edge and devices.

Intel believes that both 3GPP-based and IEEE-based technologies play an important role in 5G. 3GPP standards (e.g. Release 15 and beyond, IMT-2020) and IEEE-based standards (Wi-Fi 6 and beyond, and WiGig) will deliver wireless broadband to consumers and businesses worldwide.

Within ITU-R, work has begun on the development of IMT-2020, the next generation of cellular technology, which will be backwards compatible with IMT-Advanced (e.g. LTE) and IMT-2000. IMT-2020 will also interoperate with Wi-Fi and WiGig technologies in license-exempt spectrum. Wi-Fi connectivity is also a critical component of overall 5G connectivity and as expected, the increase in 5G data throughput will further increase the demand for Wi-Fi connectivity.

To enable 5G and unlock the full potential of broadband in SSA, current and next wave connectivity will provide an optimal platform for the near-and long-term. It is therefore critical for countries in SSA to make spectrum available for 5G. Specifically licensed spectrum in low band, mid-band and high-band as well as license-exempt spectrum should be made available to enable 5G. Relevant 5G use cases such as fixed wireless broadband, digital government, education, healthcare, agriculture, smart cities and industrial IoT will also be necessary to take advantage of the full potential of 5G in Sub-Sahara Africa.

4.2 Recommendations

Intel believes that both 3GPP-based and IEEE-based technologies play an important role in 5G. 3GPP standards (e.g. Release 15 and beyond, IMT-2020) and IEEE-based standards (Wi-Fi 6 and beyond, and WiGig) will deliver wireless broadband to consumers and businesses worldwide.

Based on progress made on 5G standardization, regulations, trials, deployments, product readiness and launches, as well as 5G's potential contributions to the increase of broadband access and business potential for the continent, now is the right time for regulators and policy makers in the region to prepare for 5G deployments.

It is therefore recommended for Sub-Sahara African countries to consider the following:

- Develop a 5G action plan including a spectrum roadmap.
- Call for studies on 5G use cases/applications relevant to Africa (SSA).
- Review/update their national ICT policy, broadband plan / strategy, and/or digital economy strategy to incorporate the needs for new technological development i.e. 5G.
- Review and modernize existing regulations to adapt to new technological developments (i.e. 5G), including the elimination of regulations that have outlived their original purpose, or that create unnecessary burdens which negatively impact deployment and adoption.

From a continental and regional perspective, it is recommended for the relevant continental and regional organizations to consider the following:

- Development of an African/Regional Digital Strategy.
- Development of a Continental/Regional broadband infrastructure strategy/action plan.
- Development of a Continental/Regional 5G action plan.

For more information on the development of a 5G action plan, please refer to Annex 3.

ANNEX 1-5

Annex 1. Abbreviations and Acronyms

APM19	African Preparatory Meeting for WRC-19
AR	Augmented Reality
ARTAC	Assembly of Telecommunication Regulators of Central Africa
ATU	African Telecommunications Union
AUC	African Union Commission
BFWA	Broadband fixed wireless access
CEPT	European Conference of Postal and Telecommunications Administrations
CRASA	Communications Regulator's Association of Southern Africa
EAC	East African Community
EACO	East African Communications Organization
ECCAS	Economic Community of Central African States
ECOWAS	Economic Community of West African States
eMBB	Enhanced Mobile Broadband
ETSI	European Telecommunications Standards Institute
FWB	Fixed Wireless Broadband
GDP	Gross domestic product
GSA	Global Mobile Suppliers Association
GSMA	GSM Association
ICT	Information and Communications Technology
IEEE	The Institute of Electrical and Electronics Engineers
IMF	International Monetary Fund
IMT	International Mobile Telecommunication
IoT	Internet of Things
ISM	Industrial, scientific and medical
ITU	International Telecommunication Union
ITU-D	ITU Telecommunication Development Sector
ITU-R	ITU Radiocommunication Sector
mMTC	Massive Machine Type Communication
MGWS	Multiple Gigabit Wireless Systems
NR	New Radio
NSA	Non Standalone
RLAN	Radio Local Area Networks
RTTT	Road transport and traffic telematics
SA	Standalone
SADC	Southern African Development Community
SRD	Short-range devices
SSA	Sub-Sahara Africa
TDD	Time Division Duplex
URLLC	Ultra Reliable Low Latency Communications
VR	Virtual Reality
WAS	Wireless Access Systems
WATRA	West Africa Telecommunications Regulators Assembly
WFA	Wi-Fi Alliance
WIA	Wireless industrial applications
WiGig	Multi-gigabit speed Wi-Fi
WRC	World Radiocommunication Conference
3GPP	3rd Generation Partnership Project

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Annex 3. Development of a 5G action plan

To unlock the full potential of broadband in Africa and take advantage of the economic potential of 5G, Intel is looking forward to working with relevant continental organization/ regional organizations and Administrations in SSA for the development of a 5G action plan which would include:

1) **A 5G spectrum roadmap** that consist of

- Licensed spectrum: in low band – below ~1 GHz (e.g. 700 MHz band); mid-band – between ~2 – 6 GHz (e.g. 3 300 – 3 600 MHz); and high band – above 24 GHz (e.g. within 24.25 - 29.5 GHz and 37 - 43.5 GHz)
- License-exempt spectrum: unlicensed spectrum in the 6 GHz band (within 5 925 – 7 125 MHz) and unlicensed spectrum accessed in the 60 GHz range (e.g. 57 – 66 GHz and 66 – 71 GHz)

The 5G spectrum roadmap should also include recommendations on timeline for the release of 5G spectrum in the mid-term; especially spectrum for low-band (700 MHz), mid-band (3.5 GHz), the mmWave band (~26 GHz, ~40 GHz) and additional spectrum for Wi-Fi in the 5 GHz and/or 6 GHz bands.

Regulators/Administrations should also be thinking about additional spectrum that can be made available in the mid-to-long term for licensed and license-exempt use.

2) Call for the **deployment of infrastructure** that will facilitate 5G such as fibre, data centres, edge compute and transformed networks.

3) **A call for studies on 5G use cases/applications** relevant to Africa in areas such as fixed wireless broadband, digital government, education, smart agriculture and smart cities.

Annex 4. GSA reports on 5G developments

According to the GSA (Global mobile Suppliers Association), 201 operators in 83 countries have launched (limited availability or non-3GPP networks), demonstrated, are testing or trialling, or have been licensed to conduct field trials of 5G-enabling and candidate technologies (up from 182 operators in November 2018).[46]

In it recently published report - Spectrum for Terrestrial 5G Networks: Licensing Developments Worldwide, January 2019[47] - the GSA indicated that 50 countries/territories are formally considering introducing certain spectrum bands for terrestrial 5G services, are holding consultations regarding suitable spectrum allocations for 5G, have reserved spectrum for 5G, and have announced plans to auction frequencies or have already allocated spectrum for 5G use. For example, in Europe, six countries have already completed auctions of 5G spectrum with another seven having recently completed auctions of spectrum that could potentially be used for 5G.

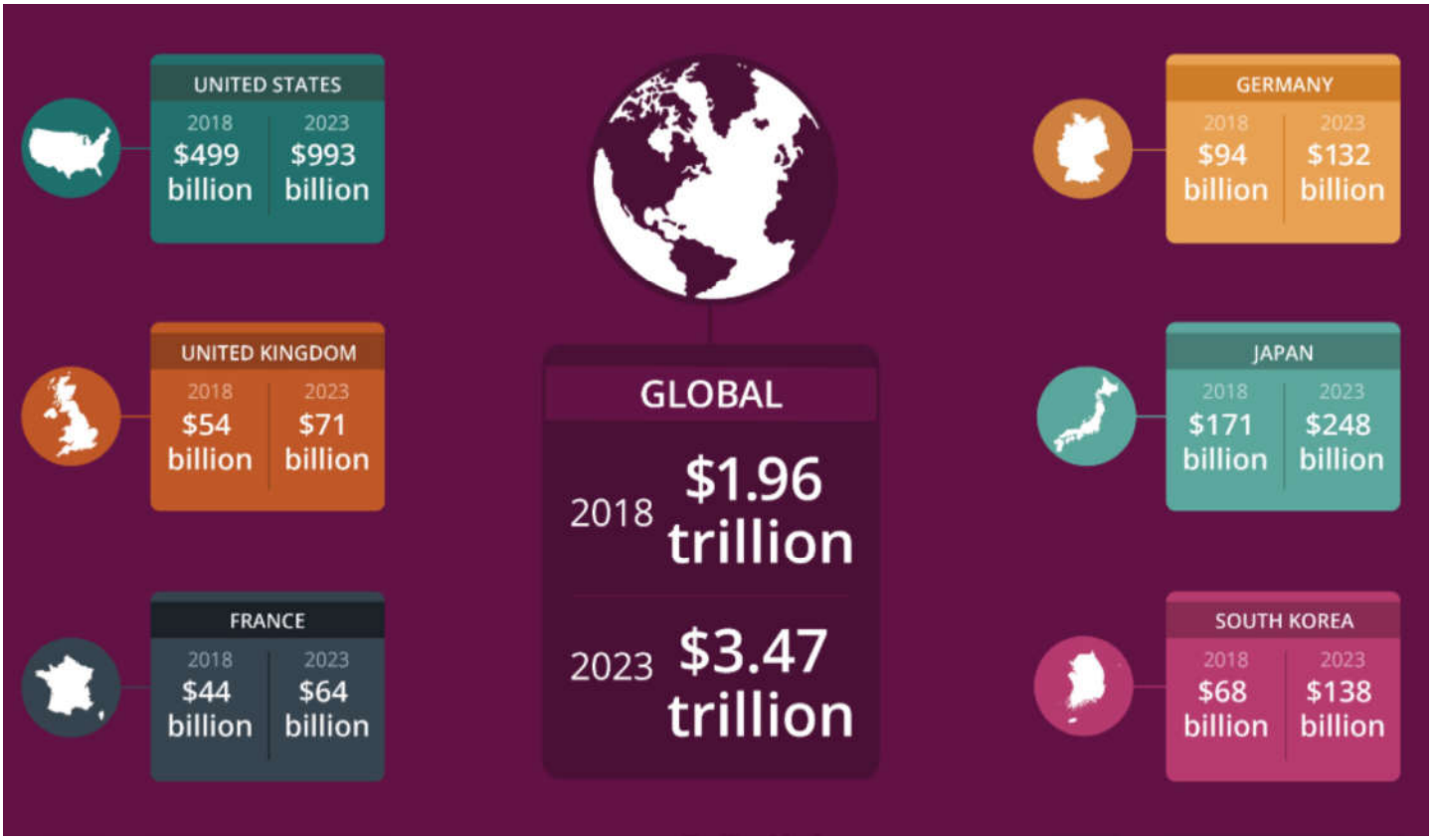
Furthermore, the GSA report on Global Progress to 5G - Trials, Deployments and Launches published in February 2019, indicated that band n78 (ranging from 3 300 MHz to 3 800 MHz) has been the most frequently used band in trials and tests, followed by band n257 (ranging from 26.5 GHz to 29.5 GHz) which is the next most used.[48]

Additional information on 5G spectrum activity observed by GSA can be found in the GSA report Spectrum for Terrestrial 5G Networks: Licensing Developments Worldwide, January 2019

Annex 5. Spectrum for License-Exempt Component of 5G

Expected increase in 5G data throughput will further increase the demand for Wi-Fi connectivity. It's important for African regulators to understand that Wi-Fi connectivity is a critical component of overall 5G connectivity.

The Wi-Fi Alliance commissioned a spectrum needs study that analysed current and future Wi-Fi spectrum requirements.[49] Based on projected growth in demand for use of spectrum on which Wi-Fi devices operate, by 2025, up to 1 500 megahertz of additional mid-band spectrum may be needed to sustain the Wi-Fi ecosystem.[50]



In Europe, for example, it is estimated that there will be a spectrum shortfall of around 5 00 MHz by 2020, and a short fall of around 1 000 MHz by the year 2025.

A recent report commissioned by the Wi-Fi Alliance "Global economic value of Wi-Fi® nears $2 trillion in 2018"[51] estimated the current annual global economic value of Wi-Fi® at 1.96 trillion USD and projected that number to surpass 3.47 trillion USD by 2023.

Wi-Fi brings the greatest impact to the economy in four key categories: developing alternative technologies to expand consumer choice, creating innovative business models to deliver unique services, expanding access to communications services for fixed and mobile networks, and complementing wireline and cellular technologies to enhance their effectiveness. In addition to determining Wi-Fi's global impact, the study evaluates individual economies of six countries, highlighting the incredible value of Wi-Fi and underscoring the need for adequate unlicensed spectrum to ensure Wi-Fi continues to deliver benefits to consumers, business, and economies.

Key findings of the report include:

- **United States**: Wi-Fi contributes 499 billion USD in economic value today, 993 billion USD by 2023
- **United Kingdom**: Wi-Fi contributes 54 billion USD in economic value today, 71 billion USD by 2023
- **France**: Wi-Fi contributes 44 billion USD in economic value today, 64 billion USD by 2023
- **Germany**: Wi-Fi contributes 94 billion USD in economic value today, 132 billion USD by 2023
- **Japan**: Wi-Fi contributes 171 billion USD in economic value today, 248 billion USD by 2023
- **South Korea**: Wi-Fi contributes 68 billion USD in economic value today, 138 billion USD by 2023

Consumers and business depend on Wi-Fi for connectivity, productivity, and critical operations each day, but the true economic value of Wi-Fi has been difficult to define due to diverse unlicensed spectrum environments. The study defines economic value by looking at the tangible, economic gains that Wi-Fi provides consumers and producers, and net contribution to GDP. The study also estimates Wi-Fi's role in job creation in each country through a valuation of its impact on different categories of employment.

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