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"5G & BEYOND": GOVERNANCE, GLOBAL POLICY PERSPECTIVES, AND SOCIETAL BENEFITS

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ABSTRACT
The aim of this research is to confabulate "5G & Beyond" wireless technologies trends,innovations and development, network deployment, governance and geopolitics, global spectrum policy perspectives for policy-makers, and societal benefits fueling a new generation of applications disrupting markets globally making the products, processes, and services superior during the next decades accelerating economic growth and security. Ultimately, whether it's with 5G, 6G, 7G, 7.5G, or another "G", the speeds will be incredibly fast with low latency as the key driver of empowering machine to machine communications (MMC), Internet of Everything (IoE), Smart Wearable, Quantum Smart Wearable, and eXtended Reality (XR – Augmented Reality, Virtual Reality and Mixed Reality) services for pervasive immersive experience. The exhaustive literature review explores the keywords broadly. The sequential methodology approach provides a perspective on the "5G & Beyond" exploratory scenario, strategies, geotypes, infrastructure sharing, cost modeling, network dimensioning and related inputs. The findings suggest that the rollout of "5G & Beyond" networks is increasingly vital to achieve the productivity benefits desired by industrial policy and digital divide issues. The contribution of this research provides policy recommendations to policy makers, non-government organizations (NGOs), academia, entrepreneurs, and telecommunication industry stakeholders to assuage composite thinking and socioeconomic benefits.

Keywords: 5G & Beyond, Governance, Global Spectrum Policy Perspective, Innovations, Societal Benefits

INTRODUCTION

International Telecommunications Union (ITU) headquartered in Geneva, Switzerland, founded in 1865, is committed to connecting everyone in the world – wherever they live and whatever their means. ITU is a unique platform for global public-private partnerships has been created global governance undertaking for the wireless industry to compare the development of the wireless markets globally facilitating insights as to how standards are set in a free market without regulatory designations. World Telecommunication Policy Forum (WTPF) provides a venue for exchanging information and views to create a shared vision among policy makers globally related to policy issues on wireless technologies, networks and services that would benefit the society at large.

In this study "5G & Beyond" means whether it's with 5G, 6G, 7G/7.5G, or another "G" wireless technologies and/or networks, the speeds will be incredibly fast with ultra-low latency as the key driver of empowering the Internet of Everything (IoE), and eXtended Reality (XR - Augmented Reality(AR), Virtual Reality(VR) and Mixed Reality(MR)) services for telemedicine, haptics, brain-computer interfaces, intelligent robotics, smart cities, smart buildings and flying autonomous vehicles [1].

The use of radio-frequency communication-- referred to as wireless communication--is becoming pervasive, more economical and socially important. Over many decades technological innovation and progress has enabled the deployment of successive generations of wireless technology used by billions of people worldwide opened opportunities for examining the policy framework that governs the management and appropriation of the spectrum. The wireless industry regulations are montage and regulators seek to ensure the efficient use of spectrum to maximize the benefits of spectrum use for the society. By adopting to international standards and regulatory best practices, regulators create an environment for the mobile sector that fosters innovation, and fair competition that serves the interests of consumers.

The key drivers from business, and society will shape "5G & Beyond" networks. The move towards a data market economy will pose issues with data ownership and the need to ever higher frequencies with smaller radio ranges and the expanding role of networks that will boost network sharing, particularly driving the

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telecomoperator's paradigm. "5G & Beyond" stakeholder's role will unceasingly change compared to the current wireless ecosystem and new roles are going to transpire in the course of time.

5G is up to 100 times faster than 4G connecting 1000 times more Internet of Things (IoT), Internet of Medical Things (IoMT) devices and five times more responsive. Autonomous vehicles for ecological logistics and transport are being possible by "5G & Beyond" wireless networks with distributed artificial intelligence (AI). Always on ubiquitous connectivity will unlock innovation across every part of society empowering all industries improving safety, reducing waste and enhancing our environment.The following emerging issues need special attention in the context of "5G & Beyond" always-on ubiquitous connectivity : (i) consumer trust and protection, (ii) content regulation, (iii) data and privacy protection, (iv) freedom of expression, (v) digital identity and divide, and (vi) human rights, and (vii) the socio-ethical impacts.

6G is in the embryonic stage. At present, research efforts are aimed at the quantum realm to intersect with 6G. The race to roll out 6G paradigm will be the most tectonic fight for global technological preeminence. The 6G archetype can offer backward and forward compatibility with 5G and 7G/7.5G respectively integrating terrestrial wireless with satellite communication systems as well as space roaming for global ubiquitous mobile network coverage creating strategic competitive advantage offering virtually Internet of Everything (IoE) for everybody.

7G/7.5GWireless would leapfrog the technical capabilities of 5G and 6G and will characterize satellite and space roaming functionalities in remote portable correspondence providing numerous elements to deal with every one of the downsides of past era frameworks.

This study shines a spotlight on 21st-century wireless trends, innovations, governance, the global policy perspective and societal benefits of emerging next generation wireless network (NGWN) technologies for future spectrum management.

JUSTIFICATION OF THE STUDY

Globally, to date, governments and their relevant telecommunication agencies, academia, corporations, multi-national mobile operators (MNOs), and NGOs have not yet adopted to think holistically to apply the unique strength of comprehensive policy implementation to "5G & Beyond" applications for the societal benefits. Since other eye-catching technologies such as quantum computing have the interplay to create quantum computing communication and quantum internet, the "5G & Beyond" concept as a holistic thinking is still largely undiscovered areas in the governance of wireless technologies and network policy perspective. The 5G network and technology forward and backward compatibility to 6G, 7G/7.5G has not received its fair share of scholarly attention in the wireless policy and governance literature. Projects in practice devoted to 5Gemerging new applications is not yet pursued by the stakeholders of the mobile industry. There is a knowledge vacuum in the literature with respect to synthesis approach of the spectrum policy execution in the next generation of applications of "5G & Beyond" for the societal benefits. Hence, the author has ventured to investigate the influence of holistic thinking approach in the "5G & Beyond" applications to establish the policy opportunities and recommendations for the societal benefits.

RESEARCH BACKGROUND

Historical perspective of the "Gs"

A new wireless generation(G) appears every decade. During 1970s wireless communications began with the absence of global standards resulted in regional standardization and as an offshoot of wireline telephony. Wireless technology (1G- First Generation, 2G-Second Generation, 3G-Third Generation, 4G-Fourth Generation, 5G-Fifth Generation, 6G- Sixth Generation, 7G-Seventh Generation, and so on)has been continuously evolving and will evolve to meet increasing consumer demands and higher specification requirements for next generation applications as shown in table 1.There were more than ten analog standards established worldwide for the first (1G) generation wireless systems. Four architectures for digital wireless were established for the second (2G) generation digital wireless system. Two major mobile communications 2G standards have dominated the global wireless market, namely, TDMA/CDMA developed by the Telecommunications Industry of America (TIA) and Global System for Mobile Communication (GSM)

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developed by the European Telecommunications Standards Institute (ETSI). The third generation (3G) wireless standards were relatively more global and collaborative creating 3G wireless radio technologies that met the International Mobile Telecommunications – 2000 (IMT-2000) requirements.https://web.sonoma.edu/users/f/farahman/sonoma/courses/cet543/resources/hostoryof%20wireless.pdf

Table 1: Wireless (1G to 7G/7.5G) Technology Evolution & Applications

Generation	Speed (Data Rates)	Technology	Key Features/Applications
1G (1970-1980s), Analog	14.4Kbps	AMPS, NMT, TACS	Voice only services
2G (1990-2000) - Digital 2.5G to 2.75G (2001-2004)	9.6/14.4KBPS 171.2Kbps 20-40Kbps	TDMA, CDMA GPRS	Voice and Data Services Voice, Data, Web Mobile Internet, Low Speed Streaming, Email Services
3G (2004-2005)	3.1 Mbps 500 – 700 Kbps	CDMA 2000 (1xRTT/EVDO) UMTS AND EDGE	Voice, Data, Multimedia, Support for Smart Phone, Faster Web Browsing, Video Calling, TV Streaming
3.5G (2006-2010)	14.4 Mbps Up to 3 Mbps	HSPA	All the services mentioned in 3G network with enhanced speed and more mobility
4G (2010 Onwards)	100 – 300 Mbps, 100 Mbps Wi-Fi	WiMAX, LTE & Wi-Fi	High Speed, High Quality Voice over IP, HD Multi-media Streaming, 3D programming, HD Video Conferencing and Global Roaming
5G (2020)	1Gbps & Higher	LTE Advanced PRO, OMA, NOMA	Superfast Mobile Internet, Low Latency Network for Mission Critical Applications, IoTs & IoMT, HD Multi-media Streaming, Autonomous Driving, Smart Health Care Applications
6G (2030 Onwards)	100 Gbps	Quadrature Amplitude Modulation (QAM) and Orthogonal Frequency Division Multiplexing (OFDM). Radio technology including IAB Plus Satellite technology. Mobile Edge Computing integral to 6G.	Ultrafast Internet, XR immersive experience, IoE, Machine to Machine Interaction, Smart Cities, Smart Buildings. eMBB- enhanced mobile broadband URLLC – ultra-reliable low latency communications, MMC.
7G or 7.5G (2040 Onwards)	100 times faster than 6G speed, Tera Hz (THz) Based	6G QAM and OFDM PLUS Modulation at THz frequencies	6G applications plus Space roaming, supported by the global navigation satellite system, the earth image satellite system, the telecommunication satellite system, and the 6G cellular system.

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The third (3G) generation of wireless attempted to create a single globally unified standard but two different standards were competing for the 3G standards involving Qualcomm (USA)'s proposal Code Division Multiple Access - 2000 (CDMA-2000), and the European Telecommunications Standards Institute (ETSI)'s endorsement to Universal Mobile Telecommunication System (UMTS).

Based on the dominant global installed base of the Global System for Mobile (GSM) Communication subscribers, ITU adopted a modified version of the UMTS proposal - backward compatible with GSM rather than CDMA-2000. Qualcomm did pursue the endorsement of 3G through lobbying efforts, legal action, and tactics to manage the market perception to uphold its CDMA- 2000 intellectual property rights (IPR).

The fourth generation (4G) Long Term Evolution-Advanced (LTE-A) standard is forlocal- and wide-area mobile platforms supporting high peak data rates; handover between wireless bearer technologies; Internet Protocol (IP) core, radio transport networks for voice, video and data services.There are many 4G service providers currently on the market claiming, "what is called 4G?" The first-release versions of "4G" networks did not meet the standards set out by the ITU-Radiocommunication Sector (ITU-R). These almost-4G networks were often called "3.9G" because they differ significantly from what is available on the market but do not quite meet ITU-R standards. Furthermore, these 3.9G wireless systems were based on new radio-interface paradigms, use different frequency bands than existing networks and are not backward compatible with 3G solutions. Two technologies that have been submitted to the ITU as viable 4G wireless standards: LTE and LTE Advanced. The standardized versions of these two technologies are the closest to "true 4G" as defined.4G wireless standard is a significant evolution over the 3G standards, most notably in the removal of IP address limitations, increased data transfer rates. The advanced capabilities of LTE networks of the major carriers are quickly utilizing the speeds promised by 4G and became commercially available since 2010.

5G - A GLOBAL STANDARD

European Union - USA

5G policy issues are regularly discussed as part of the EU-US Information Communication Technologies (ICT) dialogues. A first call was launched in 2018, aiming at common transatlantic experiments linking platforms and testbeds, fostering common scientific roadmap, developing new tools and potential options for standards.

European Union - China

In 2015, a joint declaration on developing 5G networks technology was signed to strengthen cooperation to promote global standardization for 5G.

European Union – India

In 2018, a memorandum of understanding signed between India and EU on technological approaches towards 5G standardization. At this stage India has taken the decision to distribute the 2.6 GHz spectrum based on the mode similarly to China, USA, Japan. In addition, the EU commission cooperates with India on digital issues including 5G.

European Union - Japan

A joint declaration on developing 5G was signed, in May 2015, to strongly support and seek a global consensus and cooperation on 5G. EU and Japan has set up a close cooperation on ICT policy issues since 2008. Their cooperation is to design network and computing technologies for the next generation of telecommunications and cloud-based services beyond 2020.The two latest joint calls had a focus on 5G, and beyond.

European Union - South Korea

A joint declaration on strategic cooperation on ICT and 5G, was signed in June 2014. This declaration was instrumental to develop joint research cooperation actions in the areas of 5G, Cloud Computing and Internet of Things (IoTs).

European Union – Brazil Partnership

Since 2008, the EU commission has been cooperating with Brazil on ICT in the context of an agreement for scientific and technological agreement. In 2016, joint declaration on developing 5G was signed to develop a global definition of 5G identifying the services especially in the framework of the ITU.

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New Zealand - Having already been laying the groundwork (including trail) for 5G in 2018, New Zealand's plans to have a full 5G network ready to go in 2020.
Australia's Telstra launched 5G in 2018, and Optus, second largest telecommunications company, launched 5G in 2019.

Africa 5G – Vodacom group, which was the first to release of a 5G trail in 2018. Rain is another South African telecom operator that's rolled out 5G in 2019.

Latin American countries with the greatest populations began to see 5G come out in spurts beginning in 2020.

5G stands for fifth-generation wireless and commercially deployed starting 2019 in some parts of the world offering a wide range of features that are mentioned below in comparison to the previous technologies:

- Speed - 1 to 10 Gbps.
- Latency will be 1 millisecond (end-to-end round trip).
- 1,000x bandwidth per unit area.
- Feasibility to connect to 100 number of devices.
- Global coverage with global 5G standard.
- 90% reduction in network energy usage.
- Battery life to be much longer.
- The whole world to be in Wi-Fi zone.

5G will be the “eyes and ears” of the AI systems as it will provide real-time data collection and analysis. Smartphone application is the tip of the iceberg for 5G. At the same time, it will bring the “cloud” to a new dimension by enabling the distribution of computing and storage throughout the infrastructure (edge cloud, mobile edge computing).5G smartphone applications are the tip of the ice-berg.

The 3rd Generation Partnership Project (3GPP) – the international group that governs wireless standards- is an organization (consortium) which develops protocols for wireless officially signed off on the standalone 5G New Radio (NR) specification and finally a finished 5G standard by late 2018 and met the requirements of the ITU IMT-2020.Unlike previous generations (1G to 4G) of mobile networks, the fifth generation (5G) technology will transform the role that telecommunications technology plays in contemporary society. It should be noted that 5G will aim to provide up to 100 times the peak data rate (speed), 10 times lower latency (responsiveness) and 3 times more spectral efficiency than 4G long term evolution (LTE). The development and deployment of 5G will spur innovation, enable cutting - edge technological advancements bringing the benefits of connectivity globally.5G network is expected, by 2021, to support 50 billion connected devices and 212 billion connected sensors ranging from smartphones and tablets to smartwatches, cars, machinery, appliances, and remote monitoring devices generating a massive amount of “useful data” that can be analyzed. Researchers estimate that the 5G connected ecosystem will utilize a higher percentage of digital data (35%) than before (5%). The 5G wireless communication services will transform the way people live, work, travel, and play and will dramatically reduce costs per Gigabit per second (Gbps) of service. 5G will unleash new ideas and applications in areas like mobile virtual reality, supercharging the Internet of Things. Global Wireless Service Providers have for years said the fifth (5G) generation network will provide not only hyper-fast mobile phone speeds, but breakthroughs for data-heavy technologies like autonomous vehicles, robotics and artificial intelligence.
https://www.qualcomm.com/news/onq/2018/03/21/first-5g-standard-complete-so-whats-next

The 5G action Plan is a strategic initiative which concerns all stakeholders, private and public. 5G will be a key asset for the world with worldwide 5G revenues for MNOs expected to reach 225 Billion Euro by 2025. EU commission launched 5G plan, in 2016, to boost the deployment of 5G infrastructures and services by 2020 outlining a clear roadmap for public and private investment on 5G infrastructure in the EU. To achieve the goals, the EU Commission proposed the following measures:

- Align roadmaps and priorities for a coordinated 5G deployment across all EU Member states, targeting to move towards commercial introduction by the end of 2020.
- Make provisional spectrum bands available for 5G ahead of the 2019 World Radio Communication(WRC-19) conference
- Promote early deployment in major urban areas and along major transport paths.
- Facilitate the implementation of an industry-led venture fund in support of 5G-based innovation.

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- Unite leading actors in working towards the promotion of global 5G standards.
- 5G subscriptions to top 2.6 billion by end of 2025
- 5G to cover up to 65 percent of the world's population by the end of 2025.
- Globally smartphone users to consume 24 GB per month in 2025 using 5G. Currently it is 7.2 GB.
- Total number of cellular IoT connections estimated at five billion by the end of 2025.
- 3GPP (releases 15/16/17) - plans 5G wearable, public safety multicasting, and 60Ghz standards for 2021.

5G – EXPLORING THE SAFETY LIMITS

5G safety questions sometimes arise when new technology is brought to the market, hence important to address some of the safety misunderstandings. 5G wireless technologies covered by national and international guidelines protect public and the environment. Initial 5G deployments are at frequencies close to 3.5 GHz, like existing 3G/4G mobile networks. To achieve higher capacity 5G use frequencies are known as millimeter-waves (mmWave) and are covered by safety guidelines. 5G uses smart antenna technologies (massive multiple input multiple output – mMIMO) that deliver radio signals where they are needed. Digitization of cities can only be realized through a greater density of mobile network sites through increased use of small cells mounted on streetlights or inside buildings for both 4G and 5G with exist harmonized principles for small cell compliance with safety limits.https://www.gsma.com/publicpolicy/5g-exploring-the-safety-limits-and-addressing-the-myths

A 2018 ITU report suggests that adoption of more restrictive limits increases public concern and potentially severely affects the ability to deploy mobile infrastructure to address the growing data traffic demand. The Australian Health Regulator has alerted against '*misinformation*' about 5G networks. *Contrary to some claims, there are no established health effects from the radio waves that the 5G network uses.*This has been confirmed from authorities in many countries, including USA, France, Germany and the United Kingdom. 5G trials demonstrate that the overall levels of radio signals in the community remain low and well below international safety guidelines.

Research shows that there are no established health effects. Policymakers should take steps to streamline the conditions for efficient 5G deployment by setting a national mobile network deployment policy that simplifies planning procedures for small cells, improves operator access to public sites for antenna siting, and establishing uniform radiofrequency exposure rules based on the international safety guidelines.

TOWARDS A 6G GLOBAL STANDARD

The author suggests 6G specification synopsis, as shown in Table 2, that includes increased demands for machine-to-machine communications, including IoE, robotics, autonomous drone delivery, smart cities,and transport systems.

Currently, ITU is studying what a 6G world might look like. Globally, research scholars at various universities are pursuing new technology research that could become the basis for "6G and Beyond". S. K Telecom (South Korea) partnering with Ericsson and Nokia is pursuing 6G wireless research and development. Qualcomm and Samsung have started working on 6G and exact capabilities are still in the speculation phase.

Concepts and functions of 6G technology is at the nascent stage of research. 6G networks can offer speeds of up to 1 Terabyte per second (Tbps). To put that into perspective, broadcasting Netflix in the highest definition requires 56 gigabits of data per hour. With 6G, one would be able to download just over 142 hours of high-quality video every second.6G's higher frequencies will enable much faster sampling rates providing substantial better throughput.

Other future trends for 6G include ultra-dense cell networks, reconfigurable hardware, mm Waves for user access, enhanced optical-wireless interface, and intelligent networking to enable a fully immersive experience for users. Users will demand greater global coverage, higher capacities with always-on connectivity for QI services and applications. The drive towards 6G is the growing trend of Software Defined Radio (SDR), Software Defined Networking (SDN) and Inter-Vendor Operability (IVO) enabling the user's easier way to upgrade to cloud-based resources endowing numerous applications.

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NTT Docomo (Japan) plans by 2030 to provide 6G transmission speeds of up to 100Gbps. 6G will have a new network topology technology instead of the traditional coverage extension of terrestrial networks including larger-scale MIMO and ultra-lower latency, much more reliable communication, and even cooperation with artificial intelligence (AI). The expansion of 6G communication coverage should be in the sky, at sea, and in space.It will continue its research into and development of 5G evolution towards 6G technology, aiming to realize technological advances including:

(i) the pioneering of a new frequency bands, including terahertz frequencies
(ii) the provision of ultra-low-energy and ultra-low-cost communications
(iii) the capability of massive device-connectivity and sensing

https://www.gizchina.com/2020/01/24/ntt-docomo-6g-will-provide-transmission-speeds-of-up-to-100gbps/, https://www.nttdocomo.co.jp/english/info/media_center/pr/2020/0124_00.html

Table 2: 6G Specification synopsis proposal

	6G
Generation	Sixth
World Wide Web (WWW) Support	Wireless WWW (WWWW)
Architecture	Open Wireless Architecture (OWA)
Data Rates	1 Tera bits per second user
Transmission Speed	Terabit Range, THz frequencies
Useable Format	Mobile Internet Packet (IP)
Multiple Mobile and Network Access	Yes
Integration of Satellite Communication Networks	Yes (Satellite to Satellite Communications)
Applications	Futuristic – Autonomous System, Network Mix Reality, 3D Internet concept, Space technology and defense applications, home based ATM systems and Natural Calamities will be controlled by 6G. Mind to Mind communication is possible. Machine to Machine Communications, Internet of Everything (IoE), Smart Buildings, Smart Cities, Software Defined Radio (SDR) & Software Defined Network (SDN), Ultra – dense Cell Networks, Millimeter Wave for user access, Multiple services for applications such as XR, Brain Computer Interactions (BCI), Connected Robotics Autonomous System (CRAS), and Digital Ledger Technology (DLT) where tracking, control, localization, Reconfigurable Hardware, Enhanced Optical-Wireless Interface, Intelligent Networking for full immersive experience for users, greater global coverage consist earth imaging and navigation satellite networks with higher capacities and always-on connectivity for new and future internet services , weather information collection and global positional system. Mobile edge computing should be built into all 6G networks.
Remote Management & Diagnostics	Yes
Encryption	Yes (Flexible and Anti-Virus)
Memory Capacity	Large
Clarity/Quality (Audio & Video)	Yes

So far, the evolution of wireless network evolution has been primarily driven by an incessant need for higher data rates. While this demand for higher data capacity will continue to grow, the emergence of the Internet of Everything (IoE) system, connecting billions of machines to machines communication, is attaining a

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transformative paradigm shift from the rate-concentric enhanced mobile broadband (eMBB) services of yesteryear's towards ultra-reliable, low latency communications (URLLC).

6G driving applications, as shown in figure 1.

6G wireless network should be planned for global coverage with space roaming. In a satellite network system, the satellite will be for voice and multimedia communication; navigational satellite for the global positional system (GPS) and earth image satellite for additional information such as weather update. The 6G will be the most advanced generation in wireless communication but there will be some challenging issues specifically during the roaming usage of mobile phone from country to country since satellite moves constantly in a specific orbit.

Artificial intelligence (AI) and machine learning (ML) will play a vital role both in system and link-level solutions of 6G wireless networks. New access methods will be required for vast machine to machine type communications. Modulation and duplexing schemes beyond Quadrature Amplitude Modulation (QAM) and Orthogonal Frequency Division Multiplexing (OFDM) ought to be developed and it is high time to embark upon analogue types of modulation at THz frequencies.

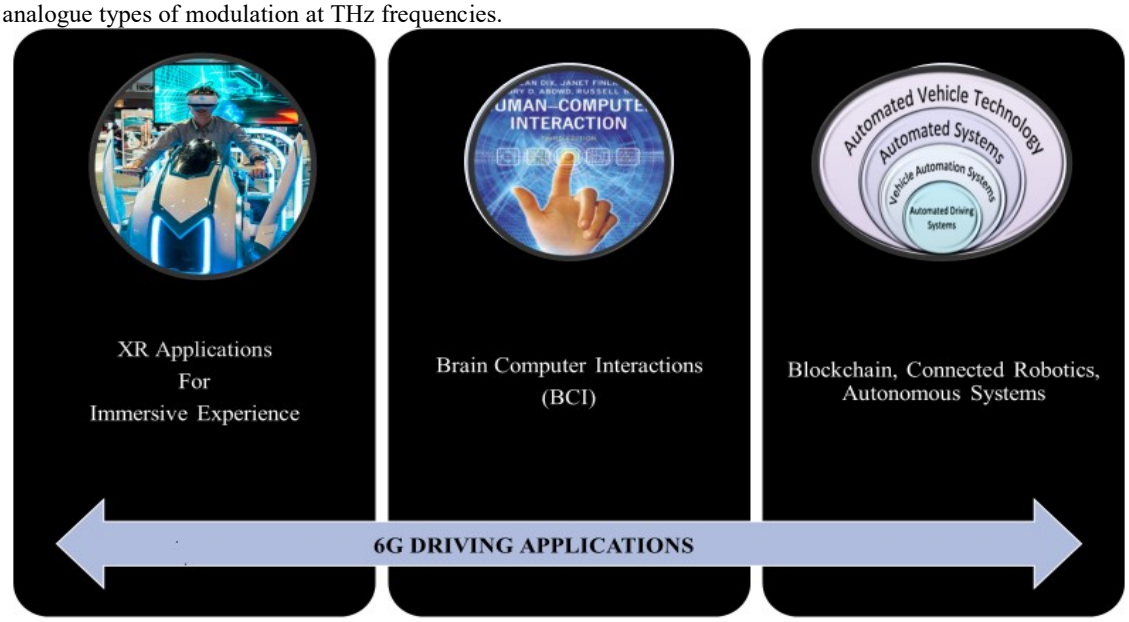

Fig.1 6G Driving Applications

Most of the 6G applications require higher bit rates than 5G catering to IoE applications such as eXtended Reality (XR) encompassing virtual reality (VR), augmented reality (AR) and mixed reality (MR) and wireless brain – computer interactions (WBCI). 6G should deliver around one (1) Terabit/second and will motivate exploration of frequencies beyond sub6 GHz requiring higher reliability providing pervasiveness across most 6G applications.While live multimedia streaming applications will remain central to 6G, the key determinants of the system performance will be four new application domains:

1) Multisensory XR Applications: XR will yield many killer applications for 6G across the AR/MR/VR spectrum. Upcoming5Gsystemsstillfallshortofprovidingafullimmersive XR experience capturing all sensory inputs due to their inability to deliver very low latencies for data-rate intensive XR applications. A truly immersive AR/MR/VR experience requires a joint design integrating not only engineering (wireless, computing, storage) requirements but also

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perceptual requirements stemming from human senses, cognition, and physiology. Minimal and maximal perceptual requirements
2) Connected Robotics and Autonomous Systems (CRAS)
3) Wireless Brain-Computer Interactions (BCI)
4) Blockchain and Distributed Ledger Technologies (DLT).

The following are five mobile industry goals in the 6G era:

- Boundless secured (encrypted) connectivity for IoE.
- Innovation networks with optimal economics including satellite networks.
- The digital transformation of industry verticals.
- Transform the mobile broadband experience.
- Integration of satellite networks.

The author predicts that some carriers are going to innovate in the Iterative Network Naming Technology (INNT) field and decide to take that challenge head-on.To integrate the three kinds of satellite networks (navigation satellite networks for global position, the telecommunication satellite networks, earth imaging satellite networks) to provide position identifier, multimedia and internet connectivity, as well as weather information services for mobile users.

6G EnablingTechnologies

Smattering technologies will mature along the same time of 6G and will play arole towards the end of the 6G standardization and research process. One prominent and eye-catching technology is quantum computing that can provide quantum computing communication enabling security and long-distance networking. To enable the applications (mentioned above) and guarantee their performance, a cohort of new, disruptive technologies must be integrated into 6G, as shown in figure 2:

1) Above 6GigaHz for 6G–from small cellsto tiny cells - exploiting frequencies beyond mmWave, at the terahertz (THz) band with extreme low latency.
2) Transceivers with Integrated Frequency Bands - an integrated system that can leverage multiple frequencies across the microwave/mmWave/THz spectra.
3) Communication with Large Intelligent Surfaces: Massive MIMO will be integral to both 5G and 6G due to the need for higher data rates. Artificial Intelligence (AI) will also enable 6G to automatically provide MPS to its users and to send and create 3D radio environment maps.
4) The AI-enabled 6G functions will be complemented by “collective network intelligence” where network intelligence is pushed at the edge, running AI algorithms and machine learning on edge devices to provide distributed autonomy. This edge AI leap will create a 6G system that can integrate the services of

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communications, computing, control, localization, and sensing (3CLS).

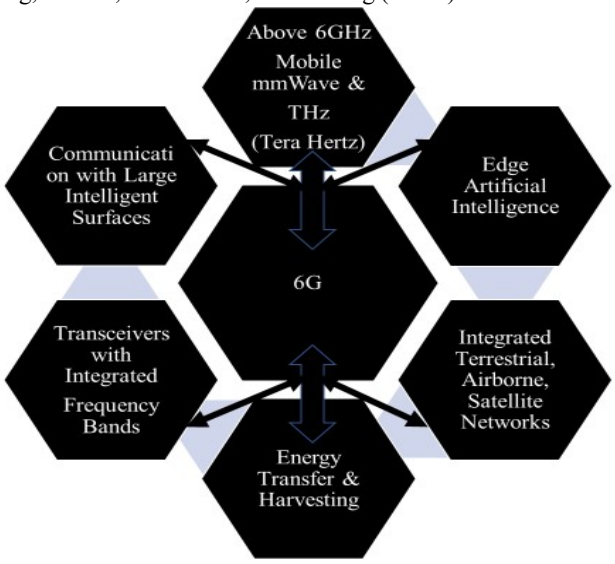

Fig. 2 6G Enabling Technologies

5. Integrating Terrestrial, Airborne, and Satellite Networks into single wireless system will be essential for 6G to provide connectivity to hotspots and to areas in which infrastructure is scarce.
6. 6G can provide energy, along with 3CLS and it is plausible to foresee 6G base stations providing basic power transfer for devices, particularly implants and sensors.https://mobileidworld.com/ntt-docomo-looks-ahead-2030-new-6g-white-paper-012407/

6G Spectrum and Key Performance Indicators (KPI)Targets

The KPIs ought to be critically reviewed and the author proposes following KPIs to be considered:

(i) Peak data rates: 100 Gbps to 1Tbps
(ii) 0.1 radio latency
(iii) Ultra-reliability – Max. one out of million outage
(iv) 10000 times traffic increase
(v) 20 years battery life
(vi) 10cm indoor and 1meter outdoor positioning

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6G Driving trends, as shown in figure 3:

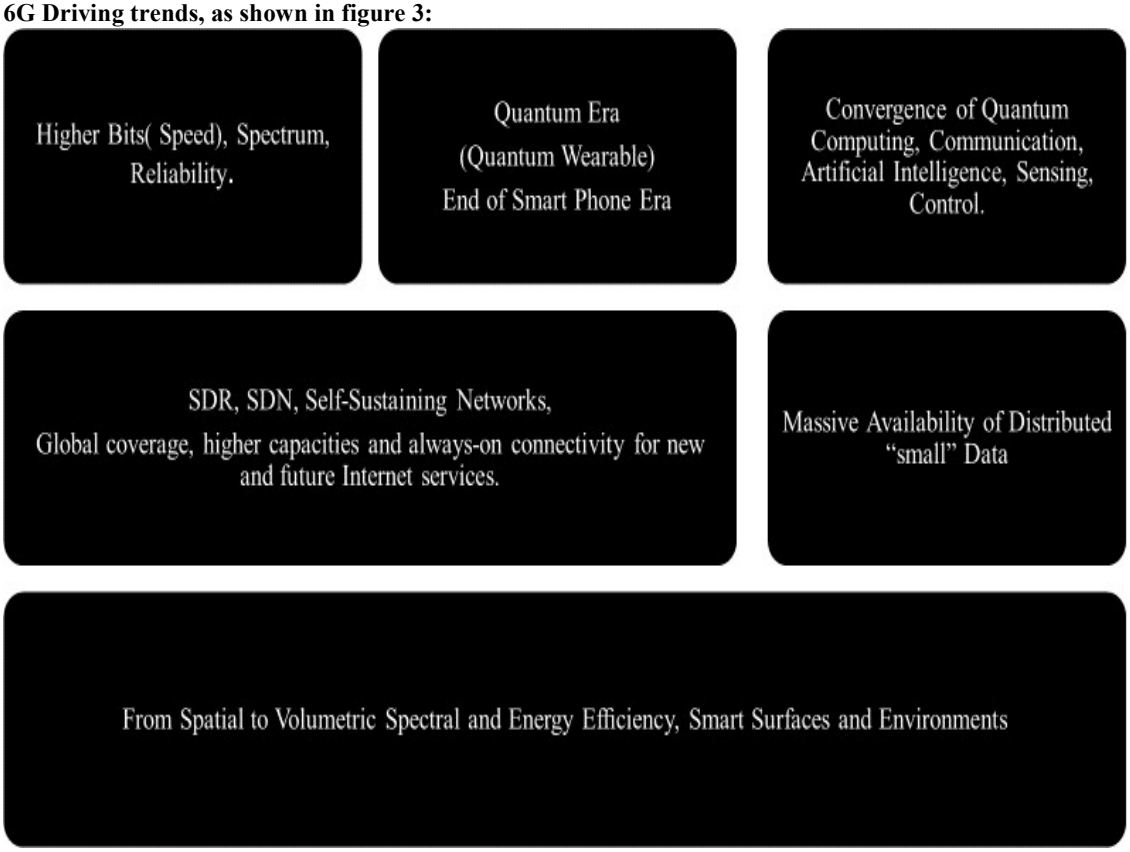

Fig. 3 6G Driving Trends

Trend 1 – Most of the driving applications of 6G require higher bit rates than 5G. The need for higher reliability will be pervasive across most 6G applications and will be more challenging to meet at high frequencies.
Trend 2 – 6G must deal with ground and aerial users, encompassing smartphones and XR/BCI devices along with flying vehicles. This 3D nature of 6G requires an evolution towards a volumetric rather than spatial bandwidth definition [2].
Trend 3 –The use of such smart large intelligent surfaces and environments for wireless communications will drive the 6G architectural evolution.
Trend 4 –The data revolution will continue soon and shift from centralized, big data, towards massive, distributed "small" data. 6G systems must harness both big and small datasets across their infrastructure to enhance network functions and provide new services. This trend motivates new machine learning and data analytics techniques that go beyond classical big data.
Trend 5 – Self-Organizing Networks (SON) has only been scarcely integrated into 4G/5G networks due to a lack of real-world need. 6G will require a paradigm shift from classical SON, into a self-sustaining network (SSN) that can maintain its key performance indicators (KPIs), in perpetuity, under highly dynamic and complex environments stemming from the rich 6G application domains.
Trend 6 – The convergence of various technologies requires 6G to disrupt this premise by providing multiple functions that include communications, computing, control, localization, and sensing(3CLS).
Trend 7 – Smartphones were central to 4G and 5G. Wearable devices whose functionalities are gradually replacing those of smartphones.

6G Recommendations

- 6G ought to deal with ground and aerial users, encompassing smart surface wearables and XR devices.

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- 6G systems should motivate new machine learning and data analytics techniques harnessing both big and small datasets across their infrastructure to enhance network functions and provide new services.
- Blockchain (distributed ledger technologies) motivate an urgent need for intelligent Self-Organizing Networks (SON) to manage network operations, resources, and optimization. Therefore, 6G requires a paradigm shift from classical SON into a self-sustaining network (SSN) that can maintain its key performance indicators in perpetuity and rich 6G application domains.
- 6G must deliver multiple services for applications such as XR, BCI, CRAS, and DLT where tracking, control, localization, and computing are an inherent feature.

6G technology, aiming to actualize technological advances including the following: (i)the simultaneous achievement of several requirements such as ultra-high-speed, high-capacity, and low-latency connectivity,(ii) The pioneering of new frequency bands including terahertz frequencies, (iii)the expansion of communication coverage in the sky, at sea, and in space, (iv)the provisioning of extremely low energy and low-cost communications, (v)the ensuring of extremely reliable communications, and (vi)the developing of capabilities for extremely massive connectivity and sensing.

Wireless communication system for dynamic operating Giga & Tera communications concept - 6th generation and 7th generation (with space roaming) is focused on the specifications of future generations technologies. The four countries that have developed the satellite systems are: the GPS by USA, the COMPASS system developed by China. The Galileo system by EU, and the GLONASS system developed by Russia. In 6G roaming and handoff will be the challenging issue because all the satellite systems are based on different networks and 6G has four different standards, therefore how it will occur is still a big question?

The last decade has seen several science and technology breakthroughs. A handful of technologies will mature along the same time of 6G and play a key role in the 6G standardization and research process. One such disruptive, prominent, eye-catching technology is quantum computing (QC) that can provide long-distance secured networking. The quantum era is emerging through an approach that will deliver the most stable and scalable quantum computer accessing quantum-inspired cloud services and quantum networking to provide end-to-end quantum programming and transform risk management solutions. While quantum computing is still years away from becoming a conventional technology, it is a tight arms race.

7G/7.5G mobile network system should be supported by the global navigation satellite system, the earth image satellite system, the telecommunication satellite system, and the 6G cellular system. 7G Wireless would leapfrog the technical capabilities of 5G and 6G and will characterize satellite and space roaming functionalities in remote portable correspondence providing numerous elements to deal with every one of the downsides of past era frameworks.

The next generation wireless networks (NGWN) has the following fundamental characteristics:

- Packet-based transfer with a variety of identification schemes for the purposes of routing in Internet Packet networks.
- Support for a wide range of services, applications and mechanisms enabling multiple last mile technologies.
- Compliant with all regulatory requirements.
- Convergence of services between fixed and mobile networks
- Separation of control functions among bearer capabilities, call/session, and application/service
- Decoupling of service provision from transport, provision of open interfaces, and broadband capabilities providing transparency inter-working with legacy networks through open interfaces.

MAKING SENSE OF GLOBAL SPECTRUM POLICY PRESPECTIVES

The author contends that the regulators should consider setting spectrum aside for local use should adopt the following three-step approach: (i) market failure to justify a departure from a conventional market-based award procedure, (ii) the costs and benefits of setting aside spectrum for localized use , and (iii) the alternative policy options to set-aside. Spectrum leasing is a good example of a pioneering, alternative policy approach, to be set out.

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Policymakers and regulators seek to ensure the efficient use of spectrum (scarce resource) and maximize the benefits of spectrum use for society. By adopting to global standards and regulatory best practices, regulators should create an environment for the mobile sector that fosters innovation, and fair competition that serves the interests of consumers. Reforms with respect to liberalization of the mobile sector policy shifts started in the 1980s and the industry benefited from light-touch regulation and a competitive market-based regime. This environment led to nearly ubiquitous mobile service and affordable access. Thus, wireless technology has become the biggest consumer technology of all time. Without government's spectrum road map and regulatory rules for spectrum license, taxation and coverage obligations MNOs may be left with no choice but to delay investment, which in turn can delay the provision of mobile services to consumers. The primary goal of governments globally should be to get the most out of its wireless spectrum resources.

https://www.commerce.senate.gov/2015/7/wireless-broadband-and-the-future-of-spectrum-policy

Why do high spectrum costs impact investment and consumer pricing?

1. Hold-up problem:
(i) Spectrum awards are not one-off,
(ii) If firms believe their expected returns will be extracted in successive auctions, they will change their investment strategy
2. Internal financing constraints:
(i) High spectrum expenditure may exhaust existing funds and require financing,
(ii) Investment by multinational parents or external sources may be redirected towards more profitable markets or ventures
3.Observed pricing decisions:
(i) In sectors with naturally constrained competition, firms with high sunk costs may engage less in price competition,
(ii) High spectrum expenditure may act as a signal for firms not to lower prices.

Frequency extension and improved spectrum utilization

5G NR can support frequency bands up to 52.6 GHz. The author proposes extension to approximately 100 GHz for the future generation wireless technology such as 6G. U.S. FCC (USA) has already recommended frequencies such as 95 GHz to 3 THz to be considered for 6G. The upper part of the mmWave band to the "terahertz wave" band is under investigation to achieve extreme high data rates exceeding 100 Gbps. One can assume that radio waves up to approximately 300 GHz is in the examination range for 6G. However, "terahertz waves" do not propagate far. Technological examination such as advance in Radio Frequency (RF) device technology and utilization based on the above-mentioned new network topology is necessary. The development of such high-frequency bands and the coverage extension can the sky, sea, and space. It should be noted that power efficiency become more important than the spectrum efficiency. Research is underway to optimize the selected application of multiple bands as per the application.

The need for globally harmonized "5G & Beyond" spectrum

Spectrum harmonization continues to be vital for the global wireless industry in the "5G & Beyond" era to enable economies of scale, roaming for end users, and facilitates cross-border coordination. Industry and regulators ought to take action towards the following goals: (i) spectrum to be allocated for wireless services globally on a primary/co-primary basis, (ii) consistent frequency arrangements should be adopted across all markets, (iii) consistent regulatory frameworks ought to strive for same technical standards governing the use of specific frequency bands. ITU-R Working Party 5D is leading the IMT-2020 standards and the 3GPP 5G NR as the harmonized standard for 5G spectrum networks. Good spectrum policy and well-designed spectrum auctions are essential to the continued development of "5G & Beyond" services.This challenge for MNOs is magnified by the exponential increase of IoT/ IoMT/IoE, bringing machines to humans and machines to machines into everyday lives. www-file.huawei.com/-/media/CORPORATE/PDF/public-policy/public_policy_position_5g_spectrum.pdf

GSMA& key 5G spectrum policy positions

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Groupe Speciale Mobile (GSM) defines the GSM standard as the internationally accepted digital cellular telephony standard. The *GSM*Association (GSMA) is a trade body that represents the interests of 800 mobile network operators worldwide creating a broader mobile ecosystem. GSMA develops policy positions for the mobile industry connected over five billion subscribers (8.5 Billion mobile connections) reflecting trillions of US dollars that mobile operators have invested in networks, services, and the spectrum policy position that make this possible. "5G & Beyond" offers an opportunity to empower citizens and businesses using widespread ultra-fast connectivity and plays a vital role in realizing the socioeconomic benefits of the Internet of Things. To attain the fair spectrum policies, governments must adopt supportive the following regulatory frameworks to enable all the benefits of using mobile connectivity:https://www.gsma.com/aboutus/history

1. 5G needs a substantial amount of new harmonized mobile spectrum clearing prime bands to be prioritized. Regulators objective should make available 80-100 MHz of contiguous spectrum per operator in prime 5G mid-bands (i.e. 3.5 GHz) and 1 GHz per operator in mmWave bands (i.e. 26/28 GHz).
2. 5G requires spectrum within three key frequency ranges: Sub-1 GHz, 1-6 GHz and above 6 GHz.
(i) Sub-1 GHz supports coverage across suburban, urban, and rural areas to support Internet of Things (IoT) services.
(ii) 1-6 GHz offers spectrum within the 3.3-3.8 GHz range for the basis of many initial 5G services.
(iii) Above 6 GHz requires to meet the ultra-high broadband (26 GHz and/or 28 GHz bands) speeds envisioned for 5G.
3.WRC-19 realized the ultra-high-speed vision for 5G so government backing is essential. The GSMA recommends supporting the 26 GHz, 40 GHz, 50 GHz and 66 GHz bands for mobile.
4. 5G spectrum management approach should be exclusive licensed spectrum.
5. Sharing approaches are better options where verticals require access to spectrum.
6. Regulators and Governments should avoid inflating 5G spectrum prices and need to adopt national spectrum policy measures to encourage long-term heavy investments in 5G networks
7. Regulators must consult 5G stakeholders to make sure spectrum awards and licensing approaches consider commercial and technical deployment plans.
Multi-national mobile operators (MNOs) globally began to roll out 5G during 2020 and the following segments will benefit:

Spectrum owners
Spectrum (airwaves that carry communications signals) owners (governments and private companies) own licenses to transmit signals across them. Spectrum remains the lifeblood of the 5G networks, and rising demand for 5G services benefit licensed spectrum owners. Good spectrum policy and well-designed spectrum auctions are essential to the continued development of 5G service. USA, Canada, European countries, China, India, and other countries around the world generally rely on auctions to allocate spectrum. The conditions of the auctions and the objectives of spectrum policy differ among countries.

In 1959, the use of auctions to allocate the radio spectrum was first suggested. In the US, the auction was introduced in 1993-94, to allocate the Personal Communications System (PCS) frequency spectrum. In Europe (some countries), 2G spectrum auction was introduced in1990s. By the end of the 2000s, almost all European countries introduced spectrum auctions. The spectrum auctions have three advantages over beauty contests. First, a well-designed auction efficiently allocates the spectrum. Second, spectrum auctions are neither time-consuming nor opaque. Third, auctions can raise substantial funds to support public finances. Findings show that spectrum auctions to raise public revenues, not only transfer profits to government but also sacrifice consumer surplus. Research suggests that the spectrum allocation mechanism affects market outcomes. But no empirical study findings show major affects of spectrum auction on the market outcomes. Hence, it is key to evaluate spectrum allocation methods by focusing on market outcomes.

Equipment manufacturers:
5G network equipment owners likely to benefit as mobile operators invest in equipment's before launching 5G services. Vendors get the opportunities with strong control over intellectual property.

Cell (base stations) tower owners:

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Owners of cellular towers benefit, as existing towers may be used to deploy new equipment capable of delivering 5G signals. Within urban areas, where data demands to be dense, an effective 5G network require strong signals to be carried over short distances and is accomplished by deploying 5G networking equipment across a greater number of tower locations.

Spectrum – making the most of a scarce and valuable resource
The GSMA's mission is to ensure spectrum is managed in a fair, transparent way without delay to maximize the benefits for all**.** Effective spectrum management is critical to further expand mobile access to meet the rapid increase in demand particularly for data services and enhance the quality. Awarding spectrum through an auction or another method of implementation is important. In all spectrum awards the primary objective should be to encourage efficient spectrum use and the significant investment necessary to provide high quality mobile services. Research shows that when prices are too high, MNOs are discouraged to invest in their networks that impacts the quality and reach of services. When spectrum management is done over the long term, mobile operators can feel safe to make investments to improve coverage and speeds, it leads to massive benefits for the whole of society.https://www.gsma.com/

USA Spectrum Policy: Provisions in the 2012 spectrum act in USA
USA started to launch 5G commercial services in 2019. The national mobile operators – AT&T, Sprint, T-Mobile US and Verizon – have moved with 5G and have introduced of their rollout plans. 5G and 4G networks co-exist and will remain complementary for years to come and targeting a phased approach to 5G network deployments.Streamlining regulation and policy developments in the spectrum availability, infrastructure deployment, and economics is going to influence 5G development and delivery over the next decade. It is projected 5G will reach 100 million mobile connections by 2023 and will become the leading mobile network technology by 2025, with 200 million 5G connections.https://fas.org/sgp/crs/misc/R43256.pdf

Pioneering the lowest latencies and ultra-high speeds are dependent on access to spectrum in the range of 26 GHz and 28 GHz have emerged for the 5G spectrum bands. To increase flexibility, 40 GHz (37-43.5 GHz) is also important. At WRC-19, countries supported 26 GHz, 40 GHz, and 66 GHz for ultra-low latency and ultra-high-speed and ultra-low latency business, consumer, and government services. This means national governments globally can consider 5G spectrum assignments across the identified mmWave spectrum to deliver long-lasting socio-economic benefits. At WRC-19 the global ecosystem adopted around the mmWave spectrum giving a big boost to the 5G. The GSMA urges governments and regulators to prioritize mobile broadband services – above revenue maximization – when awarding new frequencies.

The provisions in the Public Safety and Spectrum Act (Title VI) cover reallocation of spectrum, assignments of spectrum rights, spectrum change procedures used by the US federal government, provisions to apply future spectrum license auction revenues toward deficit reduction; to establish a governance and planning structure to deploy public safety, and to assign additional spectrum resources for public safety communications. The spectrum needs of emerging technologies of future economic growth are not specifically addressed in the Spectrum Act. and policy makers have given scant attention so far.

The Spectrum Act employs three key policy tools: (i) allocating additional spectrum; (ii) reassigning spectrum to new users; and (iii) opening spectrum for unlicensed use. Other policy options that may be employed to increase spectrum capacity include requiring that wireless network infrastructure be shared; changing the cost structure of spectrum access; moving to more spectrum-efficient technologies; and sharing spectrum. The adoption of new generation wireless technologies that enable spectrum sharing is emerging as a major policy consideration for spectrum management.

European Union (EU)spectrum Policy
The European 5G Observatory objectives to monitor market developments, including trials and other actions by industry stakeholders and 5G rollout in Europe and beyond focusing primarily on developments in Europe, along with developments in USA, Japan, China, South Korea that could impact the European market.In the global race for economic prosperity and sustainable development and economic prosperity, "5G & Beyond" technology innovation is becoming a new engine of economic growth. Policymakers acknowledge and

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recognize that Giga and Tera bit connectivity propels the digital transformation for industries and society at large. Hence, a successful deployment of 5G across Europe is an essential condition for the European digital transformation.https://5gobservatory.eu/about/what-is-the-european-5g-observatory/

In 2019, Vodafone has invested approximately €5 billion in 5G spectrum across the EU to roll out 5G services in 100 European cities. To embark the digital transformation journey and given the profound impact of 5G on the industrial and business sectors, Vodafone is working closely with business customers across a range of industries as per the conditions set by governments and regulators. There is an ongoing regulatory discussion on the issue of whether internationally harmonized cellular spectrum should be 'set aside' for private localized use to create the largest value to society. 'An industrial 5G Spectrum Policy for Europe', demonstrates that set-aside policies will lead to a significant consumer welfare loss. For example, Germany alone the decision to set aside 100MHz from the recent spectrum auction could cause a consumer welfare loss of between €6.2 - €15.6 billion for a license ending in 2040. It is key that European regulators should consider the evidence and evaluate the policy alternatives if Europe is to achieve its Giga/ Tera bit per second society vision.

United Kingdom spectrum policy

Ofcom is the competition authority and regulator for the United Kingdom (UK) communications industries. The UK telecoms regulator (Ofcom) have released spectrum in both shared spectrum bands and in licensed spectrumfollowing a general move towards spectrum liberalization in the US and Germany, targeted towards industrial transformation.OFCOM'S objective is to achieve early global harmonization and facilitate spectrum in the most appropriate and timely way to enable innovation, investments, and competition in the 5G services development to benefit businesses and consumers. In addition, at least one 5G band, is provided on a priority basis to the development of a global 5G ecosystem. Ofcom has worked closely with other European spectrum regulators to identify bands that have the potential to be globally harmonized via the European Conference of Postal and Telecommunications Administrations (CEPT).Radio Spectrum Policy Group (RSPG) in the identification of three bands to enable 5G in Europe: (i) 700 MHz; (ii) 3.4-3.8 GHz; and (iii) 24.25-27.5 GHz (the 26 GHz band).Ofcom uses a format known as 'simultaneous multiple round ascending' to work in the following staged manner: (i) principal stage - Companies first bid for airwaves in separate 'lots' to determine how much spectrum each company wins; (ii) assignment stage - is a round of bidding to determine the specific frequencies that winning bidders will be allocated.https://www.ofcom.org.uk/__data/assets/pdf_file/0021/97023/5G-update-08022017.pdf

Switzerland spectrum policy

Europe has most of the global 5G deployments and, it's obvious that Switzerland hands-down ahead of the pack. The author contends that Switzerland is "impressively in the lead." Swisscom, Sunrise and Salt are offering commercial 5G services. Switzerland's Federal Communications Commission (ComCom) has raised US$379 million through 5G auctions dated Jan. 29 to Feb. 7, 2019. Licenses were awarded and the frequencies were awarded in a simple auction format known as a clock auction. The implementation of spectrum cap allowed the regulator (ComCom) to ensure that all mobile operators were able to acquire a wide range of 5G frequencies at reasonable prices. Sunrise purchased 10 megahertz in the 700 MHz band, 100 megahertz in the 3.5 GHz range and 15 megahertz in the 1.4 GHz band. Salt secured 20 megahertz in the 700 MHz band, 80 megahertz in the 3.5 GHz band and 10 megahertz in the 1.4 GHz band. Swisscom secured 30 megahertz in the 700 MHz band, 120 megahertz in the 3.5 GHz band and 50 megahertz in the 1.4 GHz band. The frequencies are assigned for 15 years, and the awarding of frequencies are of key importance for the digitalization of Switzerland, and in line with the Federal Council's 'Digital Switzerland' strategy. https://www.rcrwireless.com/20190820/5g/5g-in-switzerland

China Spectrum Policy

China's government allocated**5Gspectrum** in the mid-band frequency range to the three state-owned mobile operators, preparing the way for large-scale network testing in 2019 and the launch of commercial **5G**services in 2020. Both China Unicom and China Telecom received 3.5 MHz and 100MHz band (also known as the C-band). China Mobile obtained 260MHz of spectrum in the 2.6GHz and 4.8GHz bands. China remains the largest projected market for 5G with roughly 430 million connections by 2025. China is playing an important role in bridging ICT and automotive industries. The government's ambition to make automotive is one of the targeted key sectors in the 'Made in China 2025' strategic plan. Shanghai and Beijing have already issued

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regulations on road testing of self-driving cars. The use of 5G technology in vertical sectors carries several implications for a supportive public policy environment. China's national spectrum planning, requests for spectrum allocation from different verticals that may cause spectrum fragmentation, and innovation slowdown. Regulators ought to avoid further spectrum fragmentation and, under a technology and service neutrality scheme to provide 5G services to verticals assigning internationally 5G harmonized spectrum to help drive economies of scale. There will be about 1 million new 5G base stations in China in 2020.

Japanspectrum policy

5G creates new markets for the IoTs such as cars, industrial devices, and smart meters to make new partnerships to deal with the changes in profit structures. Japan promotes three activities to support 5G realization for 2020 and beyond: (i) support activities by Fifth Generation Mobile Forum (5GMF), (ii) R&Ds on 5G technologies cooperation through Industry-Academic-Government, (iii) standardization activities at the ITU and 3GPP. Spectrum designated for local 5G released in Japan at the end of 2019. Companies, local governments and universities are expected to apply to use the new spectrum. This will enable enterprises, regional authorities and other organizations in Japan to deploy the next-generation wireless connectivity based on LTE and 5G technologies to create local private networks. Japanese firms NEC, Fujitsu, Toshiba has unveiled a plan to provide local 5G services. Nokia announced in 2020 strategic partnership ecosystem to bring local 5G/private wireless LTE to industrial and government customers in Japan. Applications submitted by NTT DoCoMo, KDDI, SoftBank and e-commerce giant Rakuten had been approved by the communications ministry after determining that the companies' applications met the conditions of the allocation of 5G spectrum.

Japan has decided to create a law aimed at fostering new industries using next-generation ultrafast communications networks known as 5G. Specifically, the law under consideration is designed to help companies in Japan's telecom industry forge business ties with their U.S. and European peers free of national security concerns and expand 5G services in the country at a faster pace. Under the plan, if the government approves that companies are not using electronic parts with security risks when they build base stations and factories involving 5G technologies, they will be eligible for tax benefits or subsidies. The scheme will also be in step with the 5G policy of the United States, which has blacklisted Chinese telecom giant Huawei Technologies Co., citing security concerns. As Japan is lagging far behind other countries in the development of 5G technologies, the government has recognized the need to prepare an environment in which domestic companies find it easier to form business tie-ups with major players in the industry such as Sweden's Ericsson and Finland's Nokia. Japan's industry and information ministries have sought a tax-brake system aimed at increasing 5G-related investment to be included in the government's tax reform package for starting April. 2020.Japan plans to launch 6G by 2030 with 100-times faster than the current 5G. https://www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/Documents/Events/2017/Sep-SECB/Presentations/D1-2-Kan%20Runtian-Radio%20Spectrum%20Management%20Strategies%20in%20China.pdf

South Korea spectrum policy

South Korea completed a spectrum tender process in June 2019 and awarded spectrum in both the 3.5 GHz and 28 GHz bands with the availability of 280 megahertz in the 3.5 GHz spectrum band and 2,400 megahertz in the 28 GHz band. The spectrum was divided into 28 blocks and 24 blocks and the operators SK Telecom, KT, and LG U+ had a 10block cap per spectrum band. The operators paid a total of 3.6183 trillion won (US$3.3 billion) for the spectrum.

India spectrum policy

On December 30, 2019, the government of India has decided to give spectrum to all telecom companies for trails on the 5G network including operators who want to work with China's well-known network equipment company Huawei. The government of India is planning to auction 5G spectrum soon on par with the world's high-speed broadband.

Africa spectrum policy

The 48 countries population of Africa is 1 billion (Approx.). 40% of the population in Sub-Sahara Africa (SSA) are under the age of 16. This demographic segment that has significantly lower levels of mobile ownership. As per GSMA, the mobile industry made a total contribution of 110 billion USD to the SSA economy. Broadband

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subscription penetration in SSA (41%) is low compared to the global average- 74%. 5G provides an opportunity for an increase in broadband penetration in the SSA continent. 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. 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, therefore 5G spectrum availability critical for countries in SSA. Particularly, licensed spectrum in low-band, mid-band and high-band as well as license-exempt spectrum should be made available to enable 5G. Based on progress made on 5G standardization, regulations, trials, deployments, now is the right time for regulators and policy makers in the region to prepare for 5G spectrum auction and deployments. Therefore the author recommends for SSA countries to consider the following: (i) develop a 5G spectrum roadmap, (ii) call for studies on 5G applications for SSA, (iii) review and update SSA ICT policy for new technological development i.e. "5G & Beyond , (iv) development of a SSA broadband (including 5G) infrastructure strategy/action plan. A 5G spectrum roadmap should consists of: (a) 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), (ii) license-exempt spectrum: unlicensed spectrum in the 6 GHz band (within 5925 – 7125 MHz); (iii) unlicensed spectrum accessed in the 60 GHz range (e.g. 57 – 66 GHz and 66 – 71 GHz). https://spectrum-series.com/\

Middle East spectrum policy

There will be more than 50 million 5G connections across the Middle East and North Africa (MENA) region by 2025, with 5G networks covering approximately 30 per cent of the region's population by that point. Middle East Mobile Operators are 5G early adopters and it is going to spark an unprecedented wave of innovation in the Middle East merging ICT with cyber-physical systems, endowed by advanced wireless communication and industrial IoT services. This wireless transformation will be powered by "5G & Beyond" networks to drive economic growth in the region like no previous generation of mobile technology. The secured high speeds, low latency and massive number of connections in 5G networks will support smart city and agriculture transformation in many countries in the Middle East enabling new revenue streams from IoT applications.The Middle East region is also the world's largest center for oil and gas operations. The domain choice of IoT connectivity for these energy industries will be 5G. The application of 5G-enabled automation reduces costs by 1% with 5G being the key enabler. In 2019, Ericsson started the commercial roll out of 5G with operators in advanced markets such as the UAE, Saudi Arabia, Qatar, and Bahrain.The Gulf Cooperation Council (GCC) states will be amongst the first in the world to launch commercial 5G networks.https://www.gsma.com/mena/resources/5g-spectrum-public-policy-position

Latin America spectrum policy

The median prices for capacity spectrum in Latin America are twice compared in Europe. Hence, there is reason to be concerned about spectrum policy. Spectrum costs are considered as sunk costs. Thus, spectrum auctions are sometimes viewed as a risk-free means of maximizing state revenue. High spectrum spent in Latin America links with: (i) lower quality, and (ii) higher consumer prices for mobile broadband data. High prices linked to decisions by policymakers. In Latin America, the following three types of policy challenge are widespread: (a). high annual license fees creating disincentives for investment in networks and price competition; (b) delays in making spectrum available and uncertainty over future supply; and (c) direct awards at high prices (compared to global benchmarks), often coupled with inappropriate award rules and license conditions. Many Latin America countries have a mixed track record of making spectrum available in a timely manner and making credible commitments regarding future releases.

The Latin America most common policy challenges mentioned below differ from those that are observed more globally:

Inappropriate license fee regimes	Artificial Spectrum Scarcity	Inappropriate Award Rules

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Annual fees high: (i)The market is distorted by discouraging interest in licenses (ii)Incentives are reduced to invest. (iii)Price competition made riskier.	Holding back spectrum from the market: (i)Artificially inflates demand for spectrum and raises spectrum prices (ii)Reflecting a failure to license enough spectrum for mobile services. or (iii) Use of spectrum caps to create artificial scarcity for a subset of operators. (iv)Failing to provide a roadmap for future spectrum releases: (v)Artificially inflates demand for spectrum because bidders do not know when future opportunities to acquire spectrum will arise. (vi)Lack of transparency in award processes and award formats that do not allow for price discovery.	Onerous license terms, such as: (i)Inappropriate coverage obligations that reduce value of licenses. (ii) Discourage license acquisition leading to disputes over fulfilment of obligations. (iii)Short license terms to discourage investment in network infrastructure. (iv)Inclusion of asset reversion in license terms to discourage innovation and investment. (v)Lack of transparency in award processes and award formats that do not allow for price discovery. (vi)Use of first-price sealed bid auctions that frustrate price discovery, leading to uneven price outcomes and potential inefficient allocation. (vii)Use of direct awards or beauty contests with unduly high reserve prices.

Radio spectrum is used to carry information wirelessly for many vital services. This is especially relevant in Latin America, where many users do not have access to (or cannot afford) fixed broadband and rely on mobile networks to access the Internet. Demand for this precious national resource is so great that regulators take great care to ensure it is used as efficiently as possible. Efficient use helps to ensure that the socioeconomic benefits that spectrum enables can be maximized.

https://www.weforum.org/agenda/2019/04/5g-drive-industry-middle-east-africa-mena/,
https://www.gsma.com/newsroom/press-release/middle-east-mobile

Research shows that the U.S. led the pack, with users experiencing peak 5G download speeds of 1.8 Gbps andin second place - Switzerland, with 5G peak speeds of 1.14 Gbps; the third fastest 5G peak speeds in South Korea, at about 1 Gbps.

Future spectrum for better connectivity

Mobile broadband connections data traffic continues to rise. This challenge for MNOs is magnified by the emerging 'Internet of Things', bringing machines to machines and machines to humans into everyday lives. Hence, the increase of mobile spectrum is a major concern for the mobile industry regulators and need to be addressed. MNOs investing in new technologies that are more spectrally efficient, reframing spectrum allocations and adding more base stations of all sizes. But future spectrum bands are essential to increase capacity and the MNOs are focused on securing the future of mobile building blocks, and spectrum is key. Mobile networks with greater capacity aren't possible without governments laying the groundwork, including working with organizations like World Radiocommunication Conferences (WRCs) and need to work together towards ensuring harmonization globally for future spectrum creating the economy of scale and minimizing cross-border interference.

"5G & BEYOND" INNOVATIONS AND THE FABRIC FOR SOCIETY

The wireless sector is defined by ingenuity, and innovation.The next generation of wireless network (NGWN) – is not only over 100 times faster than 4G, but also will reduce latency in connections, making the network appear even faster. The 5G smartphone App is the tip of the iceberg. The following characteristics are the "5G& Beyond" innovation drivers for various industrial applications and societal benefits, as shown in figure 4:https://mbamci.com/innovations-with-5g-technology/

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(a) Self-driving cars

Self-driving vehicle technology moves up the autonomy levels to fully autonomous with more computing power moved to the cloud. "5G& Beyond"technology brings 3D maps of cities along with self-driving cars. This innovation involves collecting vast amounts of data that's constantly being collected by vehicles, and 5G makes it happen due to the high speed and low latency. "5G& Beyond" is not only breakthrough for self-driving vehicles but also, it'll be a key technology enabler for the transportation industry.

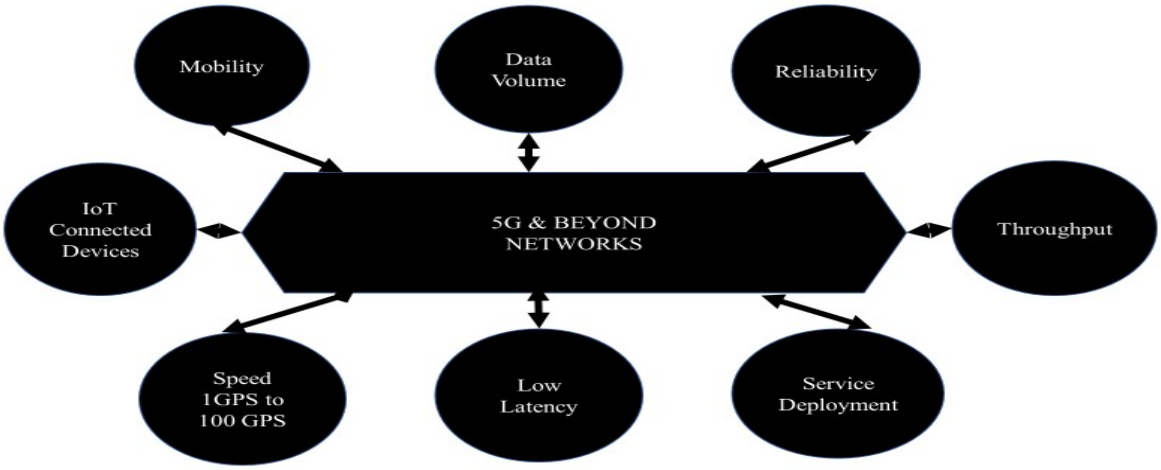

Fig.4 "5G & Beyond" Network Characteristics

(b) Wireless XR ecosystem

At present virtual reality's (VR) limitations involve the cords along with buying a headset and the space modern graphics chips take up, and the heat they generate. If VR headsets can be visual devices and offload computing power to the cloud, then they will be wireless and more powerful. Hence, "5G& Beyond" will make that possible. The next generation of devices will connect directly from the headset to the "5G& Beyond" network, empowering a new wave of headset innovation. "5G & Beyond" networks and technologies are going to be the prime driver for the entire XR (a term for augmented, mixed, virtual and other reality devices) ecosystem.

(c) Wireless smart cities, smart buildings, and smart homes

Broadband's next challenge will come from "5G& Beyond" wireless. When MNOs around the world begin pushing "5G& Beyond" networks for the home cities and buildings, it will make sense to add these connections, and will bring additional revenue. "5G & Beyond" will change everything: Self-driving cars, wireless XR with immersive experience, and smart homes, smart cities, smart buildings, machine to machine connects creating billions of IoT connections inspiring innovations for the society at large. The above applications are just the tip of the iceberg, and no one knows yet what innovators will develop once "5G & Beyond" technologies and networks are launched.

(d) The "5G& Beyond" impact on the healthcare sector

It is projected more than $1 trillion dollars in products and services will be enabled by "5G & Beyond" for the global healthcare sector. 5G& Beyond" will enable 24×7-on, secure device connectivity for the stakeholders (patients, care providers and caretakers) of the health care industry. Patients could wear a remote medical sensor and go home which will essentially transmit the vital signs via 5G to their healthcare providers. This data can be monitored by the doctors and provide proper medical advice/prescriptions.

With "5G & Beyond" networks, patients and doctors can be connected worldwide, hence expensive in-patient care can be minimized by connecting more medical devices to IoT, that will empower doctors to monitor patients remotely. Senior citizens and physically challenged people will benefit by the "5G & Beyond" in healthcare. CT scan, X-Ray, Radiography, digital imaging reports can be transmitted anywhere across the globe for expert analysis minimizing costs. Many wearable devices/sensors like fitness trackers and smartwatches, can transmit key information to doctors.

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Tailored treatments for specific medical cases can be attained as IoMT will equip researchers with more data focusing on the diseases influencing people.

Pharmaceutical companies seeking quantum innovation to focus on developing precision medicine, and personalized medicine. Drug discovery is a complex, and lengthy daunting process. The symbiotic integration of quantum computing, genomics, "5G & Beyond", artificial intelligence has emerged to constitute *quantum genomics communication intelligence (QGCI)* to disrupt drug discovery process cutting down efficacy failure boosting a success rate significantly while minimizing investment. QGCI through its unique strength of quantum systems thinking will empower drug discovery exaltation.

(e) Integrant Branding for products and services

A comprehensive analysis and perspective of integrant technological developmental endeavors in the field of "5G & Beyond" mobile communication, intelligent cloud, and blockchain can ensure collective thinking related to a marketing strategy called "Integrant Branding". The collaborative culture of integrant technology development and integrant branding speed up the entire value chain process of a company enriching brand value acceleration**. Example: Nike, Inc,**worlds the most valuable brand in the footwear/apparel industry,focuses on the perspective of "Integrant Technology" design applications and "Integrant Branding" for brand value creation (BVC).

(f)The quantum revolution

Fifth Industrial Revolution‖- is poised to emerge with prominent and eye-catching disruptive quantum technologies to fundamentally transform the economy from digital to quantum. The protuberant and conspicuous technology concepts are emanating to form the ―Quantum Internet‖ (QI) in the future to enable transmission more than quantum bits (qubits) between any two points on earth in order to solve problems that are intractable classically. The concept binding symbiotic integration of quantum computing (QC) and 6G wireless will facilitate QI with secured quantum communications disrupting every industry globally to create quantum opportunities to attain quantum value co-creation (QVCC).

(g) Fueling precision agriculture/farming

5G has the potential to disrupt a huge number of industries, including one of the world's oldest: Farming. "5G & Beyond" networks can be 100 times faster than 4G, making communication between devices and servers much quicker and can carry much more data than other networks. This makes the technology ideal for transmitting information from remote sensors and drones - key tools that are being tested by farmers and helping to automate farming processes. Drones use 5G helping to improve potato production in the Netherlands. In Japan, 5G sensors are used to monitor the water temperature and salt concentration of oyster farms. In UK 5G smartphone App helps farmers track a "connected" cow and receive daily updates on the animal's health and behavior.

(h)Driving the next industrial revolution with flexible manufacturing

In an era of intense volatility because of shorter product lifecycles, globally manufacturing companies are under extreme pressure. Margins are being squeezed. Components increasingly become more varied and complex to produce. Workforces are aging and becoming costlier to maintain. "5G& Beyond" technologies provide the network characteristics essential for manufacturing that allow higher flexibility, lower cost, and shorter lead times for factory floor production reconfiguration, layout changes, and alterations. Competitiveness is everything to manufacturers. Profitability is achieved through new process innovations. This includes the continued automation of robots, streamlining logistics, and warehouse transportation to become truly flexible. 5G and IoT are the key drivers to enabling and enhancing these advances in manufacturing. "5G& Beyond" networks offer manufacturers to build smart factories to take advantage of technologies such as artificial intelligence, automation, augmented reality for troubleshooting, and the Internet of Things (IoT).With 5G& Beyond networks, MNOs can create new revenue streams. Manufacturing represents one of the most significant sectors for new revenue potential for MNOs addressing industry digitalization with "5G& Beyond" technologies.

(i)Real-time asset tracking and efficient delivery

One can use IBM code pattern to track environmental conditions for a food safety supply chain, refrigerated medical supplies, garden plant shipments, or any perishable shipment that are sensitive to the temperature,

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humidity, vibration, or time. If a cargo needs to be delivered within safe environmental parameters and a safe amount of time, it is extremely valuable to use an IoT Asset Tracking device that combines environmental sensors, calculates its location via GPS, triangulation, or beacons, and then reports its location via "5G & Beyond" networks. When multiple participants, such as farms, manufacturers, processing plants, trucks, ports, ships, distribution centers, consumer retail outlets, are involved in the safe shipment and payment of the cargo, a Hyperledger blockchain can be used to record immutable transactions as the shipment progresses through its delivery journey.

(j) Powering the future economy – 12.3Trillion of US Dollarsin goods and services by 2035
Half of the world's population lives in citiesand projected to increase to 68% by 2050. As the world gets smarter more connected, "5G & Beyond" and geospatial will together be powering smart cities of the future. As the urban ecosystems grow ever larger, digitization through technology has the potential to improve the lives of the people. Challenges of population pressure, traffic congestion, deforestation, infrastructure deterioration, and resource crunch impact cities globally, smart city innovations are an ideal solution saving the world 12.3 Trillion of US dollars by 2035. Reliable and credible geospatial information helps governments design better cities and enhance public services. Urbanization of the future is going to be driven by geospatial data. As cities get smarter, much of this data must be in real time. This is where geospatial and "5G& Beyond" converge powering cities of the future and bringing the next level of connectivity to industries and society that helps in shaping digital cities.5G & Beyond's higher frequencies carry huge amounts of data and have a very short range. The signal is so sensitive. "5G & Beyond" will also require denser telecom network therefore, authoritative and accurate geospatial data is key to plan network towers. Because of the sensitivity of radio waves, buildings with pipes, roof features, spires, air conditioners, and sloping roofs, can affect signal propagation. "5G & Beyond" wireless promises higher capacity, low latency, more reliability, and enhanced coverage, thus providing greater accuracy in positioning services. With location becoming fundamental to all business processes, and governance, the value of position (location) -based services such as advertising, marketing, transportation, retail, will increase. "5G & Beyond" rollout and its subsequent expansion will empower more mobile interaction opportunities.https://www.shroutresearch.com/blog/2017/1/16/the-5g-economy-will-add-123-trillion-of-revenue-by-2035

(k) A unifying connectivity fabric - like electricity, one will just expect it everywhere
5G & Beyond inventions are fueling the 5G ecosystem expansion. 5G as a unifying connectivity fabric not only supports today's services, but also establishes an innovative platform that endows unforeseen services tomorrow to bring significant economic value. User cases for the next few years from precision agriculture and flexible manufacturing, to collaborative workspace and autonomous transportation, 5G will be essential beyond the immersive entertainment experiences**.**

Based on the above innovations and applications, the next generation wireless platform, "5G & Beyond", has the potential to drastically transform societies through its impact on socio-economic structures ultimately sparking a new era of enhanced digitization of society at large. At present, however, the business models and corresponding business cases related to 5G are still emerging and significant investment will be required before any expected benefits can materialize. In this paper the author describes key areas where private and public sectors should collaborate to gain from and contribute to the opportunities offered by 5G & Beyond. To fully capitalize the benefits of "5G & Beyond" technologies the focus should be on the following: (i) open systems thinking and cross-sectorial innovations, (ii) flexible and timely spectrum policy for licensing, (iii) effective and efficient infrastructure regulation and policy, and (iv) custom use of network resources.

(l)With "5G & Beyond" networks small businesses can go Toe – to-Toe with the big players
With the ability to carry vast loads of data at speeds up to 100 times faster than those available today via 4G, Ultra-Wideband "5G & Beyond" network promises to usher in a massive improvement in value and efficiency for businesses that leverage its capabilities and also benefits the society at large. The capacity to collect near real-time data and process it at lightning-fast speeds benefits small and midsize businesses (SMBs) leverage the knowledge networks that, until now, were only available to the biggest, most deep-pocketed companies. Hence, this really opens the opportunity for a lot of the more traditional, small retailers, trade-like businesses, carpenters, electricians, plumbing, the local doctor, and self-employed entrepreneurs.

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The fundamental to "5G & Beyond" Ultra-Wideband is a powerful signal beamed from new low-frequency antennae with enough bandwidth and carry nearly as much information as an optical fiber without being tethered to a physical cable. With "5G & Beyond" Ultra-Wideband, sensors placed on objects from spinning jet turbines to implanted medical devices could send large amounts of vital data instantaneously, warning engineers or doctors of the tell-tale signs that a part is nearing replacement or an insulin pump is running out of medication. Earthquake warning systems could work in near real time, sending data to scientists and public safety officials and helping to give residents precious time to evacuate before their homes are lost in a tsunami.

A feature movie that takes seven minutes to download over a standard mobile connection. With "5G & Beyond" network the same movie can be downloaded in seconds. Assisted reality goggles could work remotely in near real time. Furthermore, a plumber can use IoT sensors to remotely monitor the flow of water or steam through a customer's pipes, and valves without having to shut down entire lines. In smart cities, 5G & Beyond networks could improve autonomous vehicle safety, and ease traffic jams. IoT sensors can track shipments by knowing exactly where their goods are at almost any given moment.

Manufacturers could use 5G Ultra-Wideband and IoT sensors to get rid of the wires that hobble the flexibility of their manufacturing systems. If a small or midsize size business can get rid of all the wires, but get wire-like speed ubiquitously, that could really transform the way one think about how one wants to set up a business.

(m) 5G& Beyond"will transform the way onework from anywhere in the following manner:(i) increased accessibility - ultra-fast wireless, 5G network, fully utilization capabilities built into various devices means one can connect from virtually anywhere ubiquitously, (ii) increased functionality - example, inspecting a manufacturing factory in a different location (even a different country) in real time, without having to leave home office, is a viable scenario when one won't constrained by the speed or reliability of the ultra-high speed connection, and (iii) increased productivity- the ability to work from anywhere will lead to increased productivity as workers are able to create an environment that works for them. 5G, in addition to ultra-faster data speeds, also means lower latency. 5G networks feature almost no latency, meaning that not only can one send more data with a command or interaction, but also do it instantly.

(n) "5G & Beyond" and edge computing fit into the future of chip-focused lineup: The Edge Computing enables mobile application developers, open stack, and cloud operators to deliver substantially reduced edge to edge (E2E) computational latencies, highly optimized network traffic utilization,better network resiliency, and multisite live migration. "5G & Beyond" will transform the landscape for cloud computing and quantum computing- the next generation computing processors. Devices communicating to devices without human interaction creates a completely different landscape where the amount of data growth going to be generated exponentially, and the infrastructure required to deal with that is going to have to completely transform. Therefore, the movement of people thinking about the mobile internet towards the internet of everything (IoE) going to have seismic transformations. The edge computing is going to be vitally important because the amount of data that will be generated just can't be consumed by traditional backhaul architectures. "5G & Beyond" is going to be more profound on the networking side than on the device side, and a transition that's as significant in the network as the transition was from analog to digital. The vision of network-based computing offered by MNOs is now thought out by companies like Intel and other chip makerscatalyzing and accelerating a new trendto market in the future.So, the author contends at the end of the day, the economics and the ability to deliver network evolution swiftly and rapidly is going to mean that the movement towards software-defined networking (SDN) is going to be inevitable. https://www.forbes.com/sites/forbestechcouncil/2018/09/07/how-the-5g-revolution-will-drive-future-innovations-of-iot/#12a2a015637e

"5G & BEYOND": GOVERNANCE AND GEO-POLITICS

Governments can play unique role in building infrastructure to facilitate strategic direction via planning, regulation and can be a substantial owner as well as provider. New infrastructure development requires maintaining economic competitiveness. Efficient and effective infrastructure is pivotal for ensuring economic prosperity. Well-developed infrastructure reduces the effect of distance between regions connecting at low cost to markets. Cyber infrastructure is important for growing and sustaining national economies. "5G & Beyond" networks are at risk if they are deployed with hardware and software from Chinese foreign companies subject to unfriendly government pressure or that are not engineered to high security standards. "5G & Beyond" network infrastructure becoming a foundation for the

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next phase of the digital revolution; therefore, it is at the center of an escalating trade and technology war between China and the US. Both countries view the control of the next wave of wireless technologies and related applications as acritical matter of economic and national security.https://www.eurasiagroup.net/live-post/the-geopolitics-of-5g

Is China dominating 5G standards? In short, no. China likely to be the lion's share of 5G subscribers over the next five years. Hence, it's obvious for the Chinese firms to want a larger seat at the ITU table.

Federal Communication Commission (FCC), USA has opposed any proposal for the government to build and operate a nationwide "5G & Beyond" network. Simply because the market, not government, is well positioned to drive investment and innovation. US government should push spectrum into the marketplace to encourage the private sector to develop and deploy next generation "5G & Beyond" infrastructure. Nationalized "5G & Beyond" network would be a counterproductive and costly issue from the policies governing the United States to win the "5G & Beyond" future.

China is gaining first-mover advantage in "5G & Beyond" as it has started the commercial-scale deployment of its domestic 5G network in 2020. This 5G deployment strategy in China marks the culmination to establish the country at the forefront of the next generation of mobile networks "5G & Beyond" and related applications via state-led initiatives such as China's 13th Five Year Plan (2016). At present, US and like-minded allies to exclude Chinese 5G networking equipment suppliers, such as Huawei, from deploying 5G networks. The US-China trade and technology confrontation has created policy debates and showing little sign of easing due to potential national security risks.

China and non-China camps split could lead to interoperability issues and would result in lower economies of scale and higher transaction costs. A bifurcated "5G & Beyond" ecosystem will increase the risk giving way to politically divided and potentially non-interoperable technology spheres of influence—one led by the US; another led by China. In a bifurcated world, third countries can gain access to this virtuous cycle will face difficult choices about whose 5G network technologies and related application ecosystems to adopt. Governments around the worldhas come under pressure from the US and allies to avoid dependence on China for 5G. The political fight over the "5G & Beyond" network and technologies is not in the best interests of both (China and USA) countries. US has an advantage in terms of innovation capacity. China will benefit from its head start in applications and use cases as it builds out its domestic 5G ecosystem.https://5g.security/5g-geopolitics/geopolitics-of-5g-massive-critical-iot/

LITERATURE REVIEW

The literature review [3] thoroughly explores the keywords and its explanation in the following sections:
Segment 1 – Introduction (mentioned above).

Segment 2 - Research background (mentioned above) includes (i) historical perspective of Gs, (ii) towards global definition of 5G and safety limits, (iii) towards a 6G global standard, 6G driving trends, 6Gapplications and 6Genabling technologies, (iv) frequency extension and improved spectrum utilization, (v) 6G recommendations, (vi) brief comments on emerging 7G/7.5G, and (vi) next generation wireless characteristics.

Segment 3 - Making sense of global spectrum policy perspectives (mentioned above) includes (i) the need for globally harmonized 5G spectrum, (ii) GSMA and key 5G spectrum policy positions, (iii) spectrum policy of USA, EU, Japan, India, China, Middle East, Africa and Latin America.

Segment 4 – Innovations & Societal Benefits (mentioned above) includes applications for (a) self-driving vehicles, (b)XR immersive experiences, (c)Integrate Branding for products and services, (d) IoT/IoMT/IoE for health care, pharma and other industries, (e) integrant branding for products and services, (f) quantum Internet (QI) for the emerging quantum revolution, (g) fueling precision agriculture/farming, (h) driving the next industrial revolution with flexible manufacturing, (i) real-time asset tracking and efficient delivery, (j) powering the future economy - $12 .3 Trillion In goods and services by 2035, (k) a unifying connectivity fabric - like electricity, one will just expect it everywhere, and (l) small businesses can go Toe – to-Toe with the Big Players, (m) 5G & Beyond" will transform the way one work from anywhere in the following manner, (n) "5G & Beyond" and edge computing fit into the future of chip-focused lineup.https://www.shroutresearch.com/blog/2017/1/16/the-5g-economy-will-add-123-trillion-of-revenue-by-2035

Segment 5 - Governance and Geo-politics (mentioned above): Governments can play unique role in building infrastructure to facilitate strategic direction via planning and regulation also can be a substantial owner as well as provider. Cyber infrastructure is important to growing and sustaining national economies. Both countries (China and

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US) view the control of the "5G & Beyond" networks and technologies as well as related applications as a critical matter of economic and national security.

Segment 6 – "5G & Beyond" technology aspects: 5G is not necessarily a single technology but a collection of technology types that incorporate all previous generations of cellular mobile systems. A key concept of "5G & Beyond" is the principle of 'Anything as a Service', where everything, from spectrum to infrastructure to high-performance computing, will be available as a service. Network densification is the dominant theme of wireless evolution towards "5G & Beyond". Another key technical aspect of "5G & Beyond" networks will be the use of high-frequency spectrum, above 6 GHz, and particularly the use of millimeter wave (mmWave) spectrum.

Segment 7– "5G & Beyond" networks costs: Cost modelling is an approach that allows one to compare the difference between data traffic demand and network costs for different deployment scenarios. The costs of "5G & Beyond" infrastructure densification depend heavily on the required throughput density, periodic interest rate, and base station price. "5G & Beyond" network may not just include the integration of mmWave. Although challenging, there may be improved spectral efficiency of the air interface. Hence, cost efficient capacity expansion strategies for MNOs are explored by specifically relating the production cost of transferred data to revenues. Consequently, the largest sensitivity can be found on the individual unit price of the base station required to deliver a "5G & Beyond" network of a specific coverage or capacity. Network infrastructure has very high fixed costs of delivery, therefore, is greatly affected by scale economies and population

Segment 8 - Spatial network rollout: There is a significant lack of literature that considers the spatial rollout of telecommunications technologies over time. Often re- searchers focus on just one key aspect, such as modelling spatial viability, as evident in the fixed broadband literature. In wireless, there has also been limited explicitly spatial modelling of the potential rollout of "5G & Beyond" network and technologies.

METHODOLOGY

The author uses sequential methodological approach, as shown in the figure 5a & 5b, for the "5G & Beyond" network delivery. The choice of research methodology is dependent on the nature of the problem. Morgan and Smircich (1980) argue [4], a sequential methodology, informally known as the waterfall, approach is taken step by step: (i) the analysis phase, (ii) the design phase, (iii) implementation phase, and (iv) finally the testing phase. A sequential methodology [5] process forces the analysis team to precisely define the requirements, then planning for design before implementation. In this study, focus on network densification and spectrum is considered. Furthermore, each part of the methodology is explained below to deal with the sources of uncertainty:

(i)Exploratory scenario: A set of exploratory scenarios should be utilized to demonstrate the temporal dynamics of the rollout and potential costs of deployment. The exploratory scenario captures the uncertainty associated with key economic and regulatory changes that focus on three areas such as capital intensity, infrastructure sharing, and end-user speed.

(ii)Strategies: Two primary strategies need to be considered for network dimensioning and end user speed required in the exploratory scenario. First option to integrate spectrum into existing microcells for achieving total geographic coverage in "5G & Beyond" to provide more bandwidth in areas of high demand. Second option network densification consisting of "5G & Beyond" small cell rollout to be deployed using specific MHz spectrum.

(iii)Geotype segmentation: Depending on the geographical region, geotypes to be created to represent the key supply-side variables that affect rollout costs. Geotypes are categorized based on a minimum population density as per the region. The projected population coverage for "5G & Beyond" is derived from assumptions to interpolate the population coverage for a specific annual capital intensity.

(iv)Infrastructure Sharing: An overview of the cost model should be considered for a non-virtualized "5G & Beyond" infrastructure. The capital expenditure is considered based on annual capital intensity in relation to the pace of "5G & Beyond" roll out. When "5G & Beyond" equipment costs are unknown, therefore future

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generations of network equipment with enhanced performance tend to be similar estimate in price to those of 4LTE Advanced systems.

(v)Dimensioning of networks for each exploratory scenario to be done using a model to calculate the minimum number of base stations required.

Fig.5a Sequential methodology step by step approach

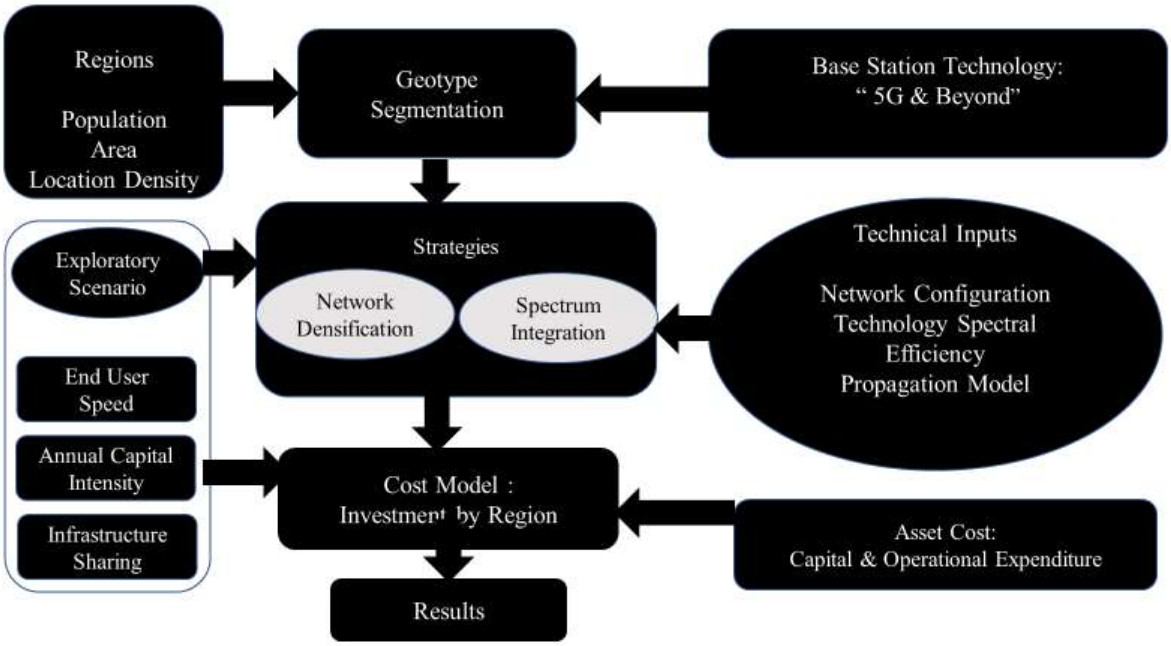

Fig.5bSequentialmethodology Process

To attain the results, the rollout of a national "5G & Beyond" network under business-as-usual conditions need to be illustrated. Then exploration of the temporal dynamics under exploratory variables including annual capital intensity, degree of infrastructure sharing in deployments, and required end-user speed executed by using the cumulative population covered to represent the spatial dimension for a period.

CONCLUSION &RECOMMENDATIONS

This research paper laid out a bold new vision for "5G & Beyond" that outlines the trends, innovations, governance, the global spectrum perspective, societal benefits and suggests that spectrum auctions have serious impact on market outcomes. The following two trends for "5G & Beyond are on the horizon: (i) cell cite densification, and (ii) software centric network.

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The author contends that “technological disruptive innovations are an unchartered territory”. This is particularly true in wireless technologies where progress continuous to amaze. “5G & Beyond” technologies promise transformative capabilities and the market will see additional competition in providing Giga/Tera bits per second access, as the performance of wired and wireless network converge. “5G & Beyond” networks will endow 100 billion IoT/IoMT/IoE connections within the next decade influencing the economic growth.

It is paramount that the entire future networks and massive connectivity industry participate in the “5G and Beyond”technology roadmap for the ecosystem stakeholders to benefit from a common perspective to address the future needs and challenges.

Network densification and additional spectrum allocation will play a key role in delivering “5G & Beyond” networking, but this will have a significant impact on the economics of delivery. Base station unit costs are critical and will have a significant impact in network densification strategies. While the literature on “5G & Beyond” networks provides insight into the technical specifications of various technologies, so far, little emphasis has been placed on the rollout implications for different national infrastructure strategies.

Public policy and regulation have profound impact on the wireless communications markets globally. An important policy issue in all regions around the world is investment in next-generation wireless technologies. Future investment in “5G & Beyond” technologies is heavily impacted by inconsistency at times, and complex regulations to promote competition while lowering prices for customers. Regulators occasionally rely on overly narrow definitions of a market that are not consistent with customer expectations or the economic drivers of competition in the value chain.

The term "next-generation wireless network"(NGWN) refers to key developments in mobile core and access networks to be deployed over the next decades to come during the 21st century. The author defines NGWN as a packet-based network with independent service-related functions and endows unfettered access for users supporting generalized mobility that allows consistent and ubiquitous services to users. The deployment of NGWN as global IP infrastructure has various implications for regulation such as universal service, consumer protection, interconnection, competition policy, network reliability and safety.

Based on author’s 35 years’ experience in the information communication technology (ICT) industry, the change to the wireless policy framework ought to be evolutionary in conjunction with technology evolution. The relevant questions reflecting commercial, technical, economic, and sociopolitical perspectives are: (i) how the overall framework should be changed? (ii) how dramatic the change should be? and (iii) what trajectory the evolution should follow?

The technology innovations, associated policy and regulatory regimes are often intertwined. From 2nd half of the 20th century this interplay has been apparent based on spectrum policy emergence in response to the growth of radio communications. The current and emerging technological advances suggest that the need for a careful reassessment of the spectrum policy globally is essential.

To conclude, the following recommendations are in order:

1. Establish a “5G & Beyond” Security Council as the primary mechanism for global coordination of “5G & Beyond” security and policies to Continuously sharing of threat and risk assessments among the council members.
2. Implement a two-prong review mechanism to review “5G & Beyond” network procurement from suppliers to ensure that MNOs buy equipment (i) not at high risk of compromising through pressure on the supplier by an unfriendly government and (ii) built with enough security features to minimize the risk for opportunistic hackers to compromise the equipment’s (hardware and software).
3.Policy makers and regulators are recommended to harmonize the spectrum allocation for “5G & Beyond”.
4.Priority for policy makers to set the stage for allocation of mmWave for “5G & Beyond”.
5. Use of low frequencies (e.g. 700, 800, 900, 1800 and 2100 MHz) in combination with C-band (LTE/NR uplink spectrum sharing) should be permitted.
6. New spectrum assignments should be technology and service neutral.
7. Trends of industry convergence should be considered when defining long term spectrum planning.

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8. Governments around the world ought to view next generation wireless infrastructure building as a cooperative goal benefiting society at large.
9. Execute a process for fast government decisions and imposition of penalties by seasoned officials, converting the burden of proof from the victim to the supplier and customize penalties for specific firms to the scale of economic damage.
10. Promote the development of an open, robust "5G & Beyond" sector in the democracies with free market capable of building alternative "5G & Beyond" solutions.

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BIOGRAPHY

Prafulla Kumar Padhi, a serial entrepreneur, techno-market futurist, techno-policy & governance advisor, has over 43 years of global business experience and held the Founder, CEO and Chairman of the Board positions for more than 25years and managed up to US$1.2 Billion revenue operations. His education qualification includes a Master of Science degree from the prestigious Massachusetts Institute of Technology (MIT), Cambridge, USA and a graduate of the Ivy League Wharton School of Business, University of Pennsylvania (USA) and holds seven diploma certificates from the Ivy League Columbia University (USA), the Ivy League Dartmouth College (USA), and Kellogg School of Management (USA). For more than 40 years, as a pioneer, Mr. Padhi has been involved in entrepreneurial venture endeavors in disruptive technologies and smart fashion wearable ventures globally. So far, he has done business in 46 countries and travelled to 142 countries. He is an author, freelance writer, independent researcher, teacher, innovator, pioneer, product marketing architect (patent/copyright holder) in the creation, design, marketing disruptive technologies and products.