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5G: The Catalyst to Digital Revolution in India

Content

Foreword by Deloitte

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India is at the cusp of a digital revolution powered by increasing broadband and internet penetration, exponential data uptake, the Government's focus on digitalisation and increasing trend of technology adoption across industries. This revolution is likely to generate new growth avenues, boost industrial productivity and has the potential to transform the socio-economic fabric of the country.

In addition to 5G providing significant network performance characteristic improvements over the previous generations, it is expected to also add various service dimensions beyond the traditional voice and data through enabling technologies like Internet of Things (IoT), Artificial Intelligence (AI), Robotic Process Automation (RPA), Augemented Reality / Virtual Reality (AR/ VR) etc. giving rise to use cases across industry verticals. New business models and intermediaries are emerging in the 5G value chain to cater to the need for connectivity and for providing differentiated services to niche market segments as well as customers.

This report presents a view on:

- India's current telecom ecosystem and preparedness to embrace 5G;

- Impact of 5G on various telecom industry stakeholders as well as potential and relevance of 5G across industry verticals;

- Potential business models and intermediaries that could evolve in lieu of 5G;

- Key considerations which would be key to ensuring 5G commercial launch in India in line with global launch.

5G could be the answer to the digital aspirations harbored by the industry and our society. However, considering the underlying infrastructural and business challenges faced by the telecom sector; a coordinated roadmap between the public and private sector can go a long way in cementing the right ecosystem required for the successful adoption of 5G in India.

We hope that you find this report insightful and enriching!

Message from CII

Umang Das
Summit Chairman &
Co- Chairman, CII National
Committee on Telecom & Broadband

Faster speeds, higher bandwidth, lower latency. The next era of wireless technology 5G will open the door to life-changing innovations.

5G - the fifth generation of wireless networks will allow new innovations to flourish and dramatically change our day-to-day lives; as telecom firms spend billions on current network and new technologies to prepare for the next era of wireless service – one that relies on dense networks of small cells.

Billions of new connected devices will come online in the next decade. These devices will need to transmit significantly more data and do so reliably. Today's

wireless networks need to be enhanced to enable this connectivity. As society becomes increasingly dependent on the transfer of mobile data, current technologies need to boost up to handle the demands of the progressively digital-savvy consumer.

To help make this possible, 5G technology will use new frequencies of spectrum, i.e. the radio waves that are used to carry cellular signals. With smarter devices and appliances hitting the market every year, we believe that the introduction of 5G systems in the coming years will offer a faster, and more efficient infrastructure to prepare us for the Internet of Things.
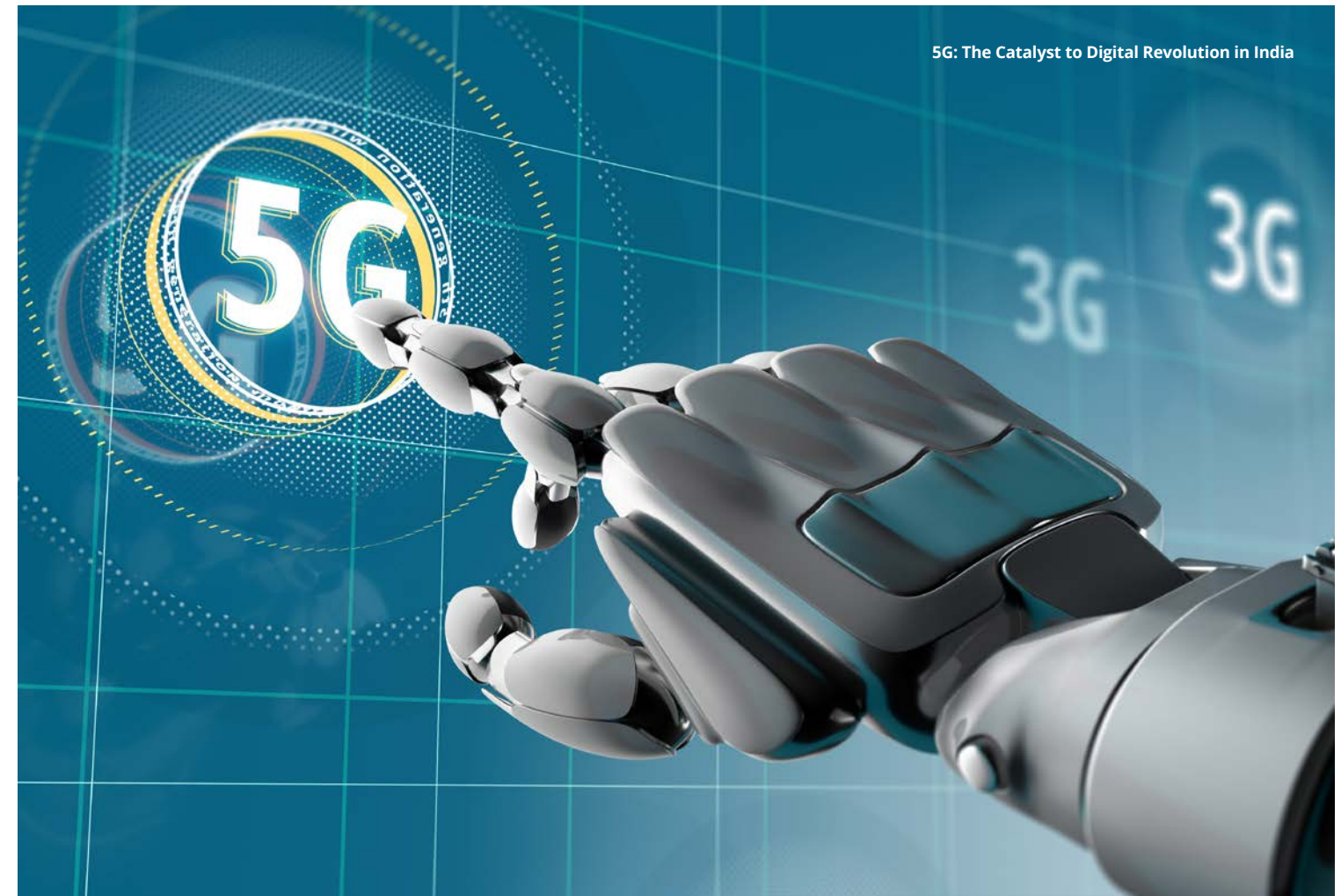
The 5G shift to unlock future potential

While the Industrial Revolution in the late 1700s and early 1800s had significant impact on the Gross Domestic Product (GDP) per capita of several economies in Europe and North America; for India it had an adverse impact with India left to be a mere supplier of raw material for the British industries. From then till now, there have been revolutionary periods of growth and industrialisation across the world however none can potentially have similar impact on the Indian industry and economy as the growth of mobile broadband and digitalisation. These digital technologies could be the drivers that are likely to transform industries and the Indian society itself, accelerating them on an unprecedented growth trajectory.

With the rise in mobile phone penetration and uptake of data services, the internet economy in India is expected to touch the USD 155 billion mark by 2018, contributing to around 5% to the GDP.[1] This is likely to grow by 1.5-1.75 times in next 2-3 years.[2]

It is believed that India's digital economy has the potential to reach USD 1 trillion by the year 2025 driven by increased proliferation of smart phones, increased internet penetration, growth of mobile broadband, growth of data and social media.[3]

5G is envisaged to be the key catalyst that would fuel this growth.

Why will 5G be the catalyst?

The Industrial Revolution in the 1800s saw the textile industry take its place as the dominant industry aided by rapid technological developments in the industry resulting in development of the 'factory system'. The 'factory system' soon got replicated across other industry verticals. In this Digital Revolution, Information Communication and Technology (ICT) is the dominant industry and it is the focus on broadband and impending technological shift to 5G in the sector that is expected to serve as the 'Catalyst'. It is envisaged that this technology shift is likely to give rise to opportunities through digitisation by the introduction of new services & products,

new intermediaries in the value chain and greater efficiencies in productivity across industry verticals.

The evolution to 5G is logical for Telcos
While 4G was a clear upgrade in technology from 3G, 5G is more focused on incremental enhancements on existing Long Term Evolution (LTE) technology thereby allowing operators to evolve their LTE networks. As telcos are deploying these enhancement on LTE; new service dimensions are opening up. This incremental approach makes the transition logical and telcos are already on the path to 5G.

Realising the importance and potential of 5G, the number of operators ideating and investing in the technology is growing substantially. Out of the 681 LTE commercial networks globally, more than one-fifth, i.e. 154 operators across 66 countries are already in the process of conducting field trials and testing 5G. Moreover, it is expected that 3% of the network-based mobile service providers are likely to launch 5G network commercially by the year 2020.[4]

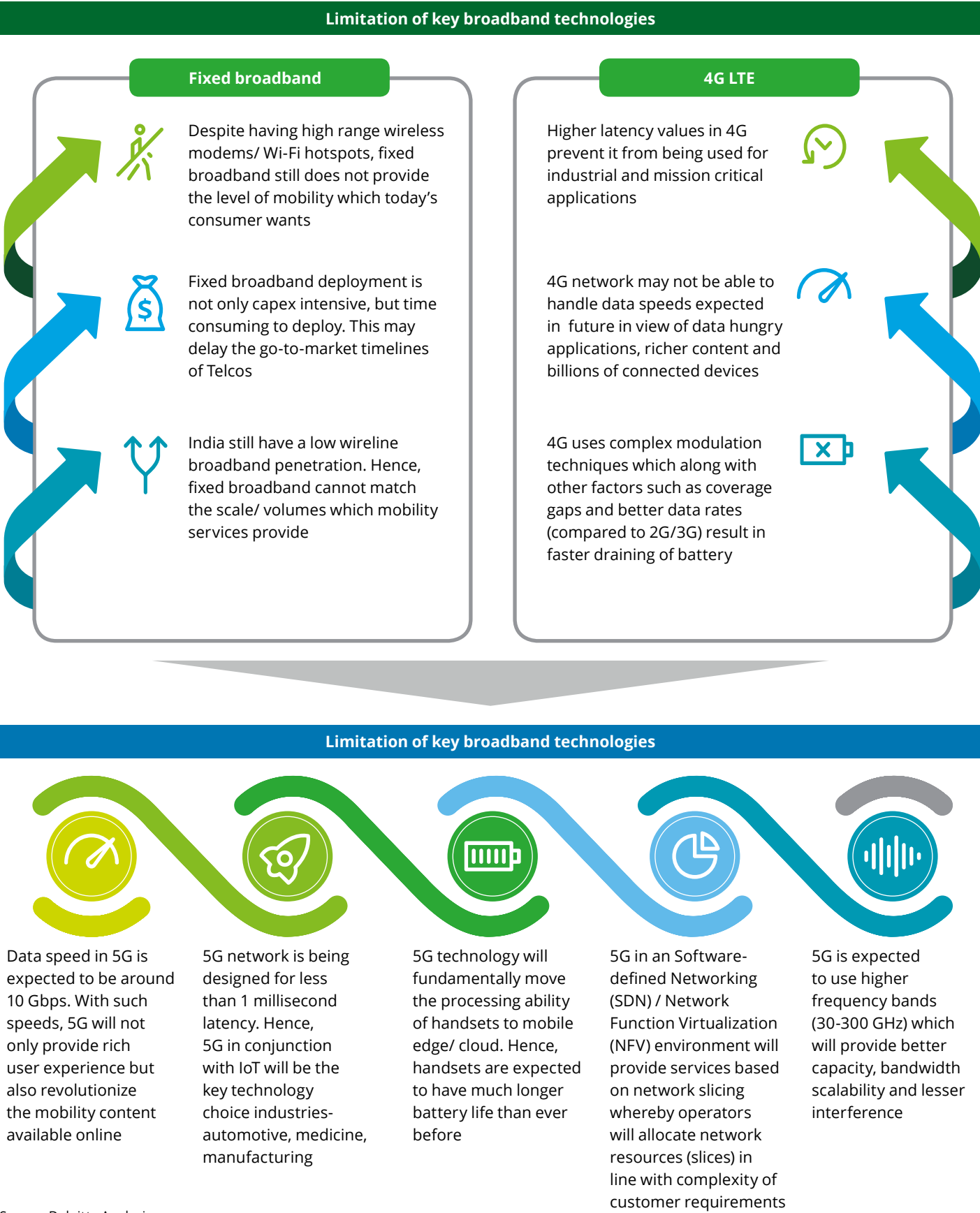## Table 1- Global early bird 5G timelines by Telcos

Country	Moving Towards 5G
United States	**AT&T** will introduce mobile 5G through portable hotspot to customers in few cities across the US at the end of year 2018
	Verizon is rolling out commercial service over 5G fixed wireless networks in several cities partnering with OEMs Samsung & Ericsson (year end 2018) on millimetre waves
	T-Mobile committed to a massive, multi-year investment in 5G networks partnering a deal of USD 3.5 billion with Nokia with complete suite of equipment and services to start deployments in 2019
	Sprint will launch mobile 5G services on its 2.5 GHz spectrum holdings on a nationwide basis in the first half of the year 2019
China	**China Mobile** is conducting trials for 5G in a string of cities and will start pre-commercial use of 5G by the year 2019 before its commercial launch by 2020 with an expected ~ 10,000 5G base stations across locations
	China Unicom will start 5G test this year, pre-commercialize 5G in 2019 and is expected to achieve large-scale commercialization by the year 2020
South Korea	**SK Telecom** has formed a 200-member task force to fasten commercial launch of 5G services and has acquired spectrum in the 3.5 GHz and 28 GHz frequencies for coverage and hotspot based capacity
	Korea Telecom is expected to launch its commercial 5G network by March 2019. It had earlier completed 5G trials during the Winter Olympics Games in the city of PyeongChang with 5G-driven visual technologies
Australia	**Telstra** has conducted 5G network data call trial with Ericsson and Intel as a part of Telstra 2022 strategy and is planning to deploy its 5G network with full commercial deployment expected in the year 2020 in high demand areas
United Kingdom	**Vodafone** shall be using frequencies in its 3.4 GHz band for 5G trial across seven cities in UK and is expected to commercially launch in the year 2020.

Source: Deloitte Analysis

On one hand, the new features and specifications being released as upgrades for LTE are enabling telcos to reduce the capex and opex expenditure on network deployments through improved spectrum utilisation, energy efficiency and network densification through small-cells, on the other, the features also focus on improving network performance. 5G is characterised by greater peak data rates, higher throughput, lower latency and high connection density as compared to 4G networks, thus is expected to result in improved user experience.

Figure 1: Comparative view of current broadband technologies vs. 5G

Limitation of key broadband technologies

Fixed broadband

Despite having high range wireless modems/ Wi-Fi hotspots, fixed broadband still does not provide the level of mobility which today's consumer wants

Fixed broadband deployment is not only capex intensive, but time consuming to deploy. This may delay the go-to-market timelines of Telcos

India still have a low wireline broadband penetration. Hence, fixed broadband cannot match the scale/ volumes which mobility services provide

4G LTE

Higher latency values in 4G prevent it from being used for industrial and mission critical applications

4G network may not be able to handle data speeds expected in future in view of data hungry applications, richer content and billions of connected devices

4G uses complex modulation techniques which along with other factors such as coverage gaps and better data rates (compared to 2G/3G) result in faster draining of battery

Limitation of key broadband technologies

Data speed in 5G is expected to be around 10 Gbps. With such speeds, 5G will not only provide rich user experience but also revolutionize the mobility content available online

5G network is being designed for less than 1 millisecond latency. Hence, 5G in conjunction with IoT will be the key technology choice industries-automotive, medicine, manufacturing

5G technology will fundamentally move the processing ability of handsets to mobile edge/ cloud. Hence, handsets are expected to have much longer battery life than ever before

5G in an Software-defined Networking (SDN) / Network Function Virtualization (NFV) environment will provide services based on network slicing whereby operators will allocate network resources (slices) in line with complexity of customer requirements

5G is expected to use higher frequency bands (30-300 GHz) which will provide better capacity, bandwidth scalability and lesser interference

Source: Deloitte Analysis

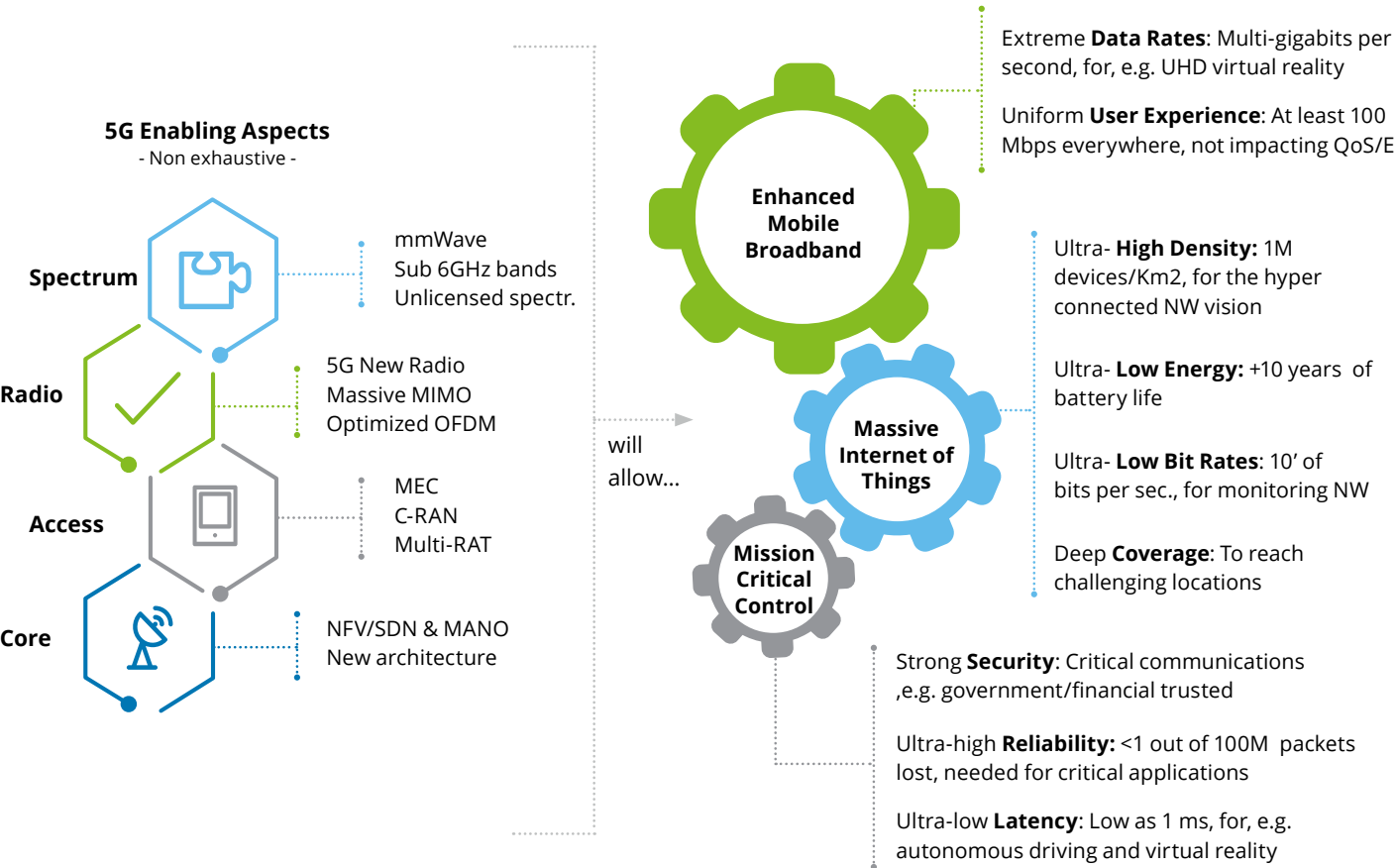## 5G will cater to diverse service requirements

While there have been technological advancements from second generation through to fourth generation in telecom, none of the previous developments expanded the service dimension beyond the traditional revenue streams in the sector. More so, cause a technology shift in the ways other industry verticals operate. 5G is expected to add to those service dimensions through improved network performance characteristics as well as enabling technologies such as IoT, AI, robotics etc.

5G has several potential use cases across industry verticals. Most of these can be grouped in three main categories:

Figure 2: Key 5G service characteristics[5]

5G main use cases

5G Enabling Aspects
- Non exhaustive -

Spectrum
mmWave
Sub 6GHz bands
Unlicensed spectr.

Radio
5G New Radio
Massive MIMO
Optimized OFDM

Access
MEC
C-RAN
Multi-RAT

Core
NFV/SDN & MANO
New architecture

will allow...

Enhanced Mobile Broadband

Massive Internet of Things

Mission Critical Control

Extreme **Data Rates**: Multi-gigabits per second, for, e.g. UHD virtual reality

Uniform **User Experience**: At least 100 Mbps everywhere, not impacting QoS/E

Ultra- **High Density:** 1M devices/Km2, for the hyper connected NW vision

Ultra- **Low Energy:** +10 years of battery life

Ultra- **Low Bit Rates**: 10' of bits per sec., for monitoring NW

Deep **Coverage**: To reach challenging locations

Strong **Security**: Critical communications ,e.g. government/financial trusted

Ultra-high **Reliability:** <1 out of 100M packets lost, needed for critical applications

Ultra-low **Latency**: Low as 1 ms, for, e.g. autonomous driving and virtual reality

- **Enhanced Mobile Broadband (eMBB)** – Improved and uniform high throughput experience, better in building/ indoor access, capability to cater to dense/ crowded areas, improved spectrum utilisation are expected to enable deployment of data intensive use cases like Augmented and Virtual Reality (AR/VR), Cloud, 3-D Video/ 4K screens. Telcos need to monetise this opportunity would drive the adoption of 5G. eMBB use cases are also contributing to expansion of the existing 4G network, network densification and fiber deployment for FTTx value proposition.

- **Ultra-Reliable and Low-Latency Communications (uRLLC)** - Commonly known as Mission Critical Services (MCS), this 5G feature provides a highly available and reliable network. The ultra-low latency based performance attributes reinforced with highly secured network infrastructure is expected to facilitate real time capabilities and performance to support services which requires greater monitoring and control.

Improved reliability and ultra-low latency applications have ramifications across industry verticals. Some key examples include autonomous vehicles, drones and robotic applications, real time industry applications, health monitoring system / tele-health, smart grid and intelligent transportation.

- **Massive Machine Type Communications (mMTC)** – Limited network connectivity and reliability in dense urban areas as well as device power requirements limited the wide scale application IoT with 4G/ LTE. 5G improves upon the low power operational capabilities for devices/ sensors utilizing both licensed and unlicensed spectrum bands through CAT–M1 and NB-IoT advancements. mMTC use cases have resulted in new industry verticals originating, such as smart cities and impacting several others such as agriculture, energy/ utility management, industrial automation, smart logistics, smart grids and smart consumer wearables to name a few.

Table 2: Envisage use case mapped with key 5G characteristics

Enhanced Mobile Broadband (eMBB)	Ultra-Reliable and Low-Latency Communications (uRLLC)	Massive Machine Type Communications (mMTC)
Fixed Wireless Access service	Autonomous vehicles	Asset tracking and predictive maintenance
Enhanced in-building broadband service	Drones and robotic applications	Smart cities, buildings, and agriculture
Real-time augmented reality service	Health monitoring system / tele-health	Internet of Energy/Utility management
Real-time virtual and mixed reality service	Smart grid and metering	Industrial automation
Crowded or dense area service	Intelligent transportation	Smart logistics – advance telematics
Enhance digital signage	Factory automation	Smart grid and metering
High definition cloud gaming	Remote operation	Smart consumer wearables
Public Protection and Disaster Response (PPDR) Service	Self-driving car	Environment management
Massive Content Streaming service	Mission critical services - security & safety	Intelligent surveillance and video analytics
Remote surgery and examination	High definition real time gaming	Smart retail

Source: Deloitte Analysis

Table 3: KPI coverage across 5G cases

Service Category	Peak Data Rate	User Experience Data Rate	Spectrum Efficiency	Mobility	Latency	Connection Density	Network Energy Efficiency	Area Traffic Capacity
eMBB	High	High	High	High	Medium	Medium	High	High
mMTC	Low	Low	Low	Low	Low	High	Medium	Low
uRLLC	Low	Low	Low	High	High	Low	Low	Low

Source: Deloitte Analysis

Limited by high costs of fiber deployment for broadband connectivity; 5G provides a lower cost wireless alternative for last mile connectivity with almost matching speeds and user experience. It is estimated that a 10% increase in broadband penetration could result in 1% increase in GDP[6]. With relatively low broadband penetration in the country, the opportunity is huge.

Meeting user demand and enhancing competitiveness

5G networks are expected to not only enable telcos to meet user demand for high speed data network, but also support rich content type such as 4K/ 8K videos, AR/ VR allowing telcos to counter the threat of OTT players who have impacted telco revenues negatively in the past decade. Telecom service providers are forging partnerships with players across the value chain to develop content and relevant offerings.

5G is also likely to strengthen the suite of enterprise services for telcos by providing a more agile and efficient network with the ability to meet varied demand/ on-demand requirements through network slicing, virtualization, software defined networking, mobile edge computing and cloud.

Transition towards 5G is gaining momentum globally

This transition is also fueled by early steps being taken by governments in many countries including initial investments in technology development as well as focus of regulatory bodies in planning for upcoming commercial roll outs.

Table 4: Other prominent forums with global partnerships to build momentum for 5G deployment

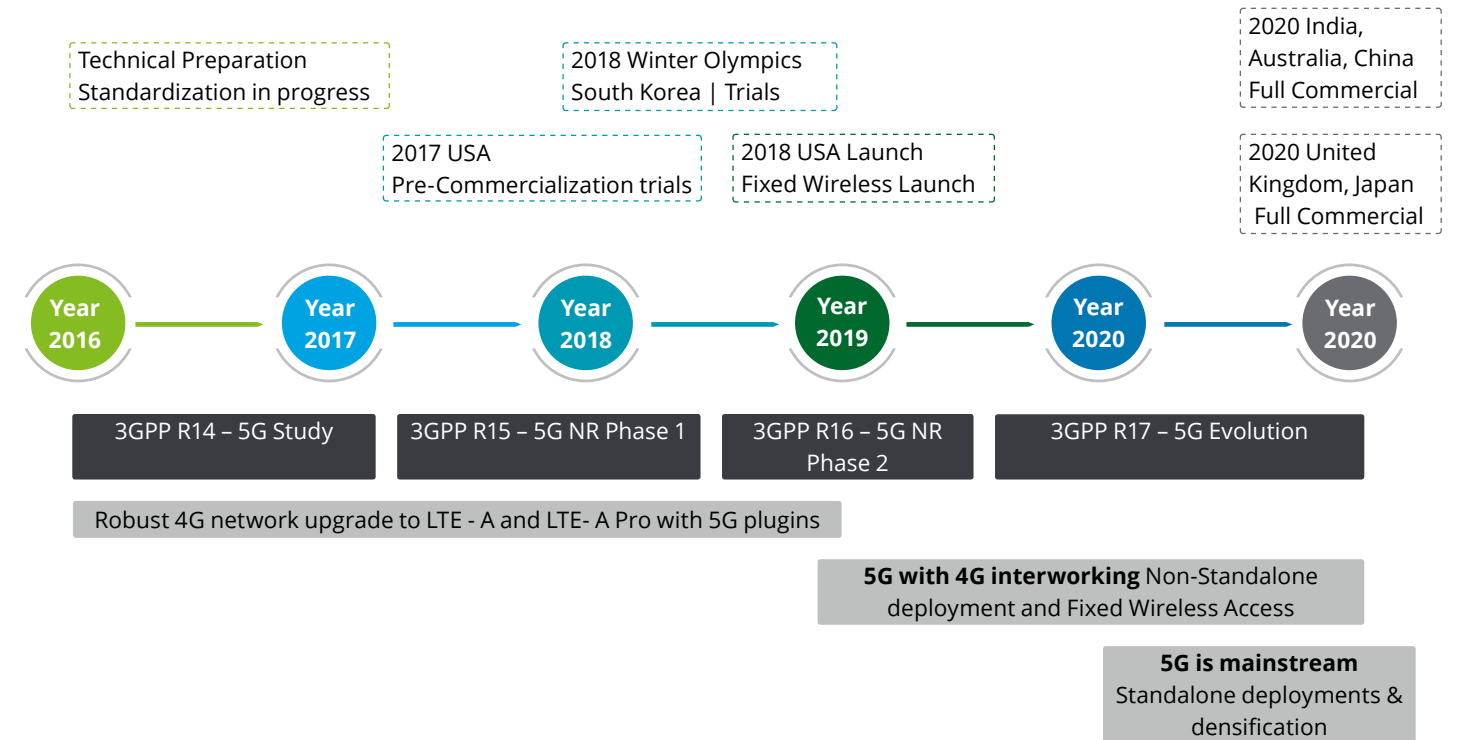| Country	Partnerships	Established	Vision
India	5G High Level Forum	2017	5G High Level Forum was set up to develop a vision for 5G in India and recommend policy changes/ action plan to achieve the vision
	Partnership with premier technical institutes in India	2018	Department of Telecom (DoT) is in process of setting up a development center for 5G at IIT Madras to create the right ecosystem for 5G development in India
China	**IMT 2020** 5G Promotion Group	2013	Jointly established by three ministries in China, it is one of the major platforms in the world to promote the research of 5G infrastructure
Japan	**5GMF** Fifth Generation Mobile Communications Promotion Forum	2014	Conduct research & development concerning 5G and further promote education and awareness
Republic of Korea	**5G Forum**	2013	Consisting of members from public and private sectors, its goal is to assist in the development of the 5G standard and contribute to its globalization
United Kingdom	**5G Innovation Network**	2018	It's a 'network of networks' to facilitate and encourage the engagement and coordination of organizations working on 5G activities across the UK.
United States	**5G Americas**	2016 *(renamed)	Advocates for advancement in LTE technologies and their evolution to 5G encompassing networks, services, applications, and connected devices
Australia	**5G Working Group**	2018	Fosters an ongoing 5G dialogue between industry, subject matter experts and Commonwealth Government representatives on how best to realize the benefits of 5G across a range of portfolios and sectors.
Europe	**5G – IA** 5GPPP - 5G Infrastructure Public Private Partnership	2014	Collaborative research program across 43 projects and a part of Horizon 2020 to create benefits out of 5G technology supporting digitization and integration of vertical industries in Europe

Source: Deloitte Analysis

In India, all industry stakeholders are actively involved in the endeavour to commercially launch 5G by 2020 through investments in R&D, formulation of test beds, technology trials for deployment and study of use cases.

The telecom regulatory authority is simultaneously working on the spectrum plan for 5G focused on global standardisation, aligning the spectrum plan with global spectrum allocations for 5G and spectrum harmonisation to facilitate this endeavour.

Figure 3: Roadmap of 5G deployment

Technical Preparation Standardization in progress		2018 Winter Olympics South Korea | Trials		2020 India, Australia, China Full Commercial
	2017 USA Pre-Commercialization trials	2018 USA Launch Fixed Wireless Launch		2020 United Kingdom, Japan Full Commercial

Year 2016	Year 2017	Year 2018	Year 2019	Year 2020	Year 2020
3GPP R14 – 5G Study	3GPP R15 – 5G NR Phase 1	3GPP R16 – 5G NR Phase 2		3GPP R17 – 5G Evolution	

Robust 4G network upgrade to LTE - A and LTE- A Pro with 5G plugins

5G with 4G interworking Non-Standalone deployment and Fixed Wireless Access

5G is mainstream Standalone deployments & densification

Preparedness: India's key to success

Taking view of the benefits 5G can bring to the entire value chain across consumer and business, Government of India (GoI), through Department of Telecom (DoT) has released the Draft National Digital Communication Policy (DNDCP), and emphasised on creating an actionable plan for the rollout of 5G application and services.

To address timely development of 5G infrastructure, DoT has also setup a high level forum '5G India 2020' to develop the roadmap for operationalising 5G services in India by the year 2020.

Through this forum, all key stakeholders in the industry have been working towards developing the right eco-system for 5G commercialization. One of the focus actions is to achieve a globally-competitive product development and manufacturing ecosystem targeting 50% of India's market and 10% of the global market over 5-7 years[7]. These efforts are aligned with roadmap for 5G implementation globally for commercial deployment by 2020.

Progressive steps taken towards the overall development of 5G ecosystem in India

- **Building ecosystem for Research & Development (R&D)**
  DoT is seen to be focused on development of Intellectual Property Rights, standards formulation and proof of concepts through research projects, global standardisation forums, PPP projects, testbeds and pilot roll-outs

- **Incremental upgrades and trials by Telco with Original Equipment Manufacturer (OEM)**
  Telcos and OEMs are jointly conducing trials and feasibility studies for 4.5G/5G based technologies to get better insights on economics, performance and technical challenges of deploying these new techniques.

- **Re-defining the spectrum management framework**
  DoT is presently working with Telecom Regulatory Authority of India (TRAI) and industry stakeholders to define the 'Spectrum Management Framework' specifically focused on spectrum allocation for 5G. Further, the option of freeing up more of the spectrum for digital communications and spectrum harmonisation is also being deliberated.

- **Streamlining Right of Way (RoW) and accelerating 'Fiberisation'**
  Fibre backhaul is critical for deployment of next generation technologies and high speed 5G network infrastructure. India aims to increase its fibre backbone to 2.5 million km by the year 2022, up from the current 1.5 million km.[8] To facilitate this deployment, the government streamlined the Right of Way (RoW) policy in 2016. This also included streamlining of application procedure, 'single-window' clearances, dispute resolution in a time bound manner, along with rationalizing administrative expenses across the entire approval process.

- **Enabling an inclusive business environment to promote partnerships and innovation**
  To develop a collaborative environment between the growing start-up eco-system and ICT infrastructure providers, DoT is in process to formalise various fiscal and non-fiscal benefits for start-ups, encouraging academic collaborations, conducting pilots and testing, along with concessions on imports – products and services.

- **Leveraging opportunities through Digital India initiatives**
  More than 300,000 km of fiber is planned to be deployed under the government's flagship 'BharatNet'

program providing fiber connectivity to rural India.[9] This network can accelerate 5G penetration across the country and expand the digital revolution to rural India through initiatives such as smart villages, IoT adoption, analytics and cloud solutions to improve productivity across sectors such as agriculture, MSMEs, banking etc. Moreover, 5G network could be deployed using Low Mobility Large Cell (LMLC) and Fixed Wireless Access (FWA) based last mile solutions to expand mobile coverage, enhance data throughput across villages, government offices, healthcare and educational institutions, etc.

Is it worth the effort or just a pipe dream?

The advancement from 2G to 3G, followed by 4G and LTE were also technological advancements; built upon an existing telecom backbone, supplemented by additional investments in technology and infrastructure. Undoubtedly, every such leap in technology opens up new opportunities for the telecom service providers.

Ironically, the "4G story" from the recent past demonstrates that, despite huge investment influx amidst plenitude of promised opportunities, business growth for telecom service providers seems to be tepid.

Given this conundrum, it is worthwhile to deliberate upon 5G, in terms of the prospects and business opportunities given the long payback periods for the large capex investments.

5G has full attention of all key telecom industry stakeholders making it pertinent to understand the potential.
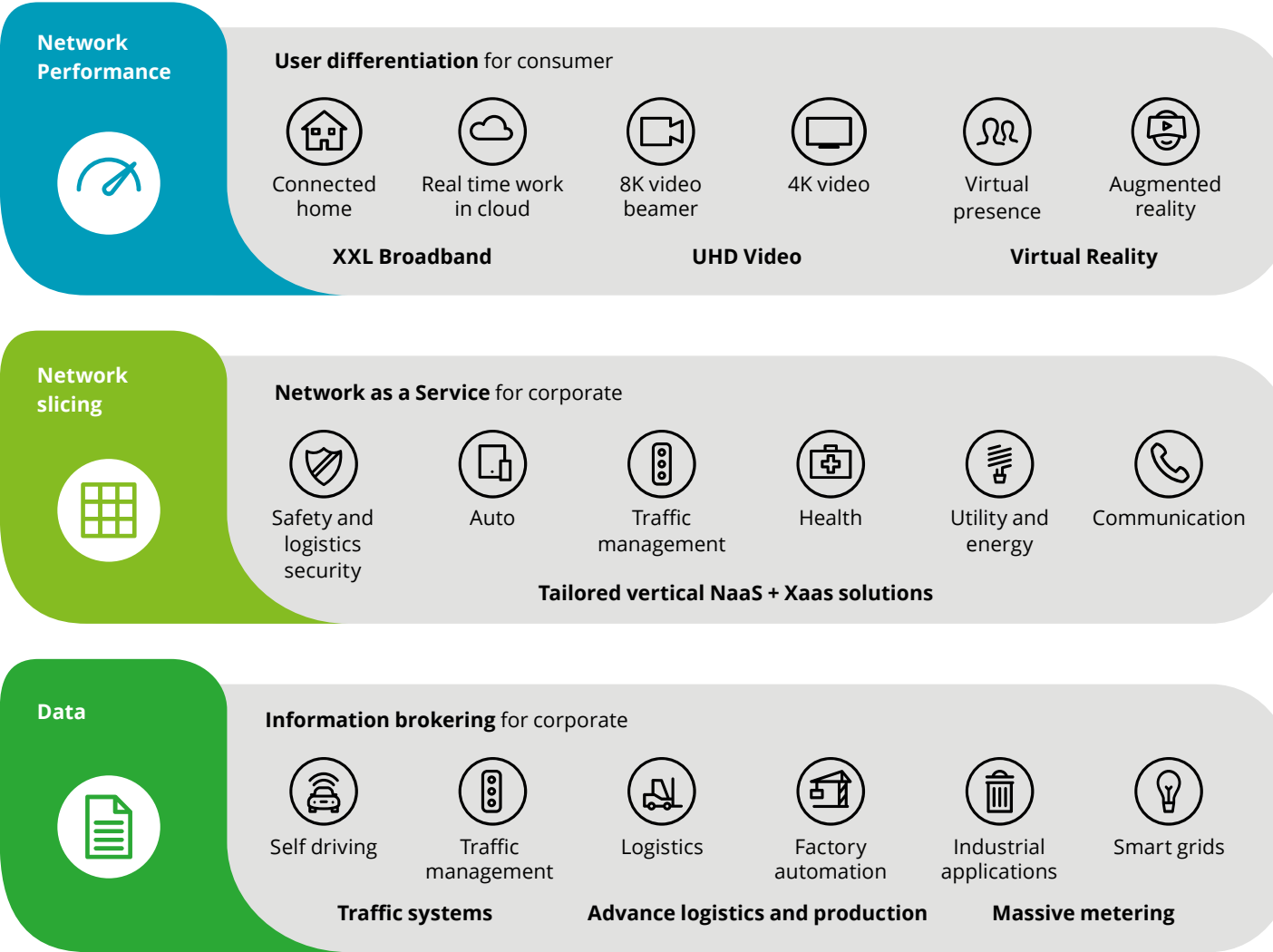
Voice of mobile operators

Introduction of 5G networks coupled with mature solutions across NFV/SDN, cloud automation and IoT networks, is likely to drive more agile and future oriented networks to support the unrealised business case of existing 4G networks and further giving rise to diverse service portfolios. New radio access capabilities through 5G, coupled with solutions such as Low-Power Wide-Area Network (LPWAN) for IoT connectivity, mobile edge computing, content caching service along with content delivery networks for augmented and virtual reality, are expected to generate new experiences and help garner new consumers and generate new revenue streams.

Figure 4: 5G business models for operators[10]

Operator's business models
Powered by:

Network Performance

User differentiation for consumer

- Connected home
- Real time work in cloud
- 8K video beamer
- 4K video
- Virtual presence
- Augmented reality

XXL Broadband　　**UHD Video**　　**Virtual Reality**

Network slicing

Network as a Service for corporate

- Safety and logistics security
- Auto
- Traffic management
- Health
- Utility and energy
- Communication

Tailored vertical NaaS + Xaas solutions

Data

Information brokering for corporate

- Self driving
- Traffic management
- Logistics
- Factory automation
- Industrial applications
- Smart grids

Traffic systems　　**Advance logistics and production**　　**Massive metering**

5G is also expected to provide opportunities for operators to charge a premium for their services, penetrate markets in shorter time, and drive better customer experience with increased uptake in service, eventually boosting the Average Revenue per User (ARPU).

In the telecom industry, this opportunity driven by network and IT convergence is seen giving rise to intermediaries across application development, analytics, security and other IT driven services.

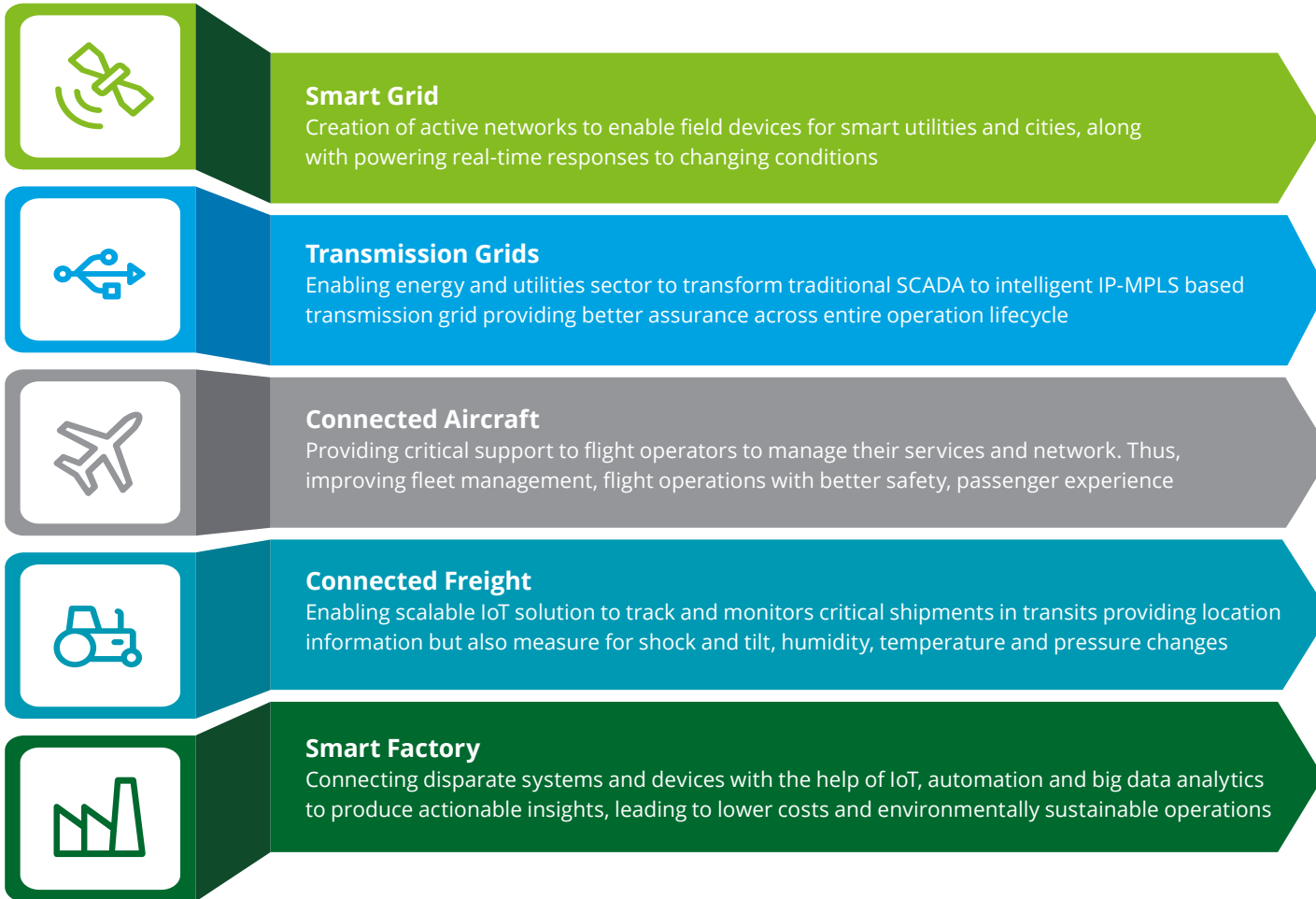## Voice of Original Equipment Manufacturers (OEMs)

Over the years, telecom OEMs have thrived on proprietary hardware and software. Software-defined networks have resulted in network programmability on open source platform implemented on Commercial-Off-The-Shelf (COTS) hardware. Complemented with network function virtualization, OEMs are seen orienting their products towards open source built-up, giving rise to revenues from diverse sources such as Everything–as-a-Service (XaaS).

Driving partnership projects - creating value across industry sectors

Unlike 4G and the previous generation technologies, 5G is expected to embrace and support specialised use cases across industries like manufacturing, energy, utilities, healthcare, pharmaceutical, transportation and logistics. OEMs are entering these verticals to design and build next generation features such as end-to-end network security, automation and analytics.[11]

5G network complemented with IoT has the potential to result in orchestration of solutions focused on maximising productivity and efficiency. With new growth avenues across vertical industries, equipment vendors are well positioned in building partnerships to create solutions and leading implementation for diverse requirement across sectors.

Figure 5: Inflight initiatives/ use cases between OEMs and industries

Smart Grid
Creation of active networks to enable field devices for smart utilities and cities, along with powering real-time responses to changing conditions

Transmission Grids
Enabling energy and utilities sector to transform traditional SCADA to intelligent IP-MPLS based transmission grid providing better assurance across entire operation lifecycle

Connected Aircraft
Providing critical support to flight operators to manage their services and network. Thus, improving fleet management, flight operations with better safety, passenger experience

Connected Freight
Enabling scalable IoT solution to track and monitors critical shipments in transits providing location information but also measure for shock and tilt, humidity, temperature and pressure changes

Smart Factory
Connecting disparate systems and devices with the help of IoT, automation and big data analytics to produce actionable insights, leading to lower costs and environmentally sustainable operations

Source: Deloitte Analysis

Voice of handset manufacturers

By year 2023, approx. 1 billion 5G devices are expected to be connected worldwide[12]. Pioneers in this space, such as Qualcomm, Mediatek, Huawei, Intel and Samsung have already unveiled a slew of pre-commercial 5G chipset versions. Moreover, test trials are being conducted across multiple 5G enabled devices such as smartphones, laptops, Customer-Premise-Equipment (CPE), and pocket routers. The advent of 5G networks with AR/ VR capabilities is expected to open up demand for new series of devices.

The handsets might be expensive at the beginning, attributed to the intensive capital outlay during the development of 5G chipsets and on ancillary technologies. Nevertheless, drawing parallels to the previous generation handsets and devices, the prices would eventually decline with growing volumes.

Voice of infra providers

Currently, the industry has ~471,000 towers across the country. Since, India is set to witness a multi-fold increase in data consumption, the industry is expecting to foresee at least 100,000 more towers with an approx. investment of USD 2.78 billion in the near future to stride towards 'Digital India' initiative and

sheltering possibilities for deployment of new technologies including 5G, and IoT.[13]

Since, high frequency spectrum bands will also be considered by telecom operators for the deployment of 5G networks, it is expected to result in low coverage deployments, thereby, restricting and localizing services. In order to promote ubiquitous network connectivity and quality through densification of network, telecom operators are seen investing in small cells, fibre networks, in-building solutions, street furniture, and Wi-Fi hotspots. This eventually is expected to have a bearing on infrastructure providers as well, since the infrastructure requirement will be paramount to implement any of the above mentioned scenarios.

Furthermore, 'Digital India' initiatives like 'BharatNet' and 'Smart Cities', along with high rate of fiberisation across various parts of India have brought telecom tower companies' implementation capabilities to the fore.

Figure 6: Key growth areas for tower companies[14]

New Business Areas
IBS, Small cells, Wifi offloading
Fiberized backhaul network
Managed services

Energy Management
Clean energy sources
Data analytics
Energy efficient equipment

Innovative Site Acquisition & Rollout Models
Site deployment
Acquisition for data roll-out
Street level coverage network
Managed services

New Team/Skill Development and O&M Process Automation
R&D and innovation skills
Site Analytics management skills
Automation of non-intelligent processes

Commercial Models and OpEx Reduction
Pass through vs Fixed fuel cost
Rental cost reduction
Field force utilization

Newer Concepts like RAN Sharing and Network Cooperation
RAN Sharing
Network Cooperation (NetCo)

Source: Industry Discussions, Deloitte Analysis

Voice of a digital customer

India is dominated by the millennial population with median age of 27 years[15], which represents a customer base that is not only young, but also increasingly digital. This demographic segment accounts for 61% of internet users and 78% of online shoppers[16]. The voice of this digital customer demands an enormous amount of high speed mobile data and ubiquitous connectivity to meet their specific needs such as media streaming (video, audio) with improved content and quality (e.g., 4K/8K UHD), over-the-top (OTT) mobile content (e.g., Netflix, Amazon Prime Video), and far richer user-created content (e.g., WhatsApp, Instagram, Facebook).

What are the new age millennials looking for?

Digital has become a lifestyle. It is not just about traditional voice and data services; the digital consumer lives in smart homes, drives connected cars, fashions smart wearables, immerses in video experience – eats, lives and breathes digital. This consumer is now exploring beyond reality into the realms of the virtual world.

5G promises to offer a better video viewing experience on any device, irrespective of the user being static, or mobile. Imagine a financial services firm that could transform an ATM into a full-service branch powered by videoconferencing over a 5G fixed wireless connection, or in the near future being serviced by VR bots in the branch. 5G is expected to offer the requisite bandwidth and low latency that is fundamental to mobile VR experiences. Further, VR would extend far beyond gaming where users could be able to attend sporting events and concerts via their VR headsets capturing live experiences.

The digital consumer's smart wearables include smartwatches, fitness trackers, VR headsets, smart wristbands, activity trackers, sports watches, and other medical wearables (e.g. diabetes monitor). These devices will automatically connect with stores utilising beacon based technology, allowing consumers to receive push advertisements and notifications with personalised deals, boosting sales and making store visits more tailored to their needs. The market size for wearable devices is estimated to exceed USD 12 billion by 2023, growing at a CAGR of over 24% from 2016 to 2023[17]. Additionally, through the development of indoor navigation apps that utilise computer vision technology to track users' movements, shoppers may also be able to use their wearables to navigate across large stores or malls.

Answering the question

Given the wide spread use cases for 5G and their far reaching implications coupled with the responsiveness of the telecom ecosystem participants, and fueled by the government's vision for Digital India, there is a definite market-calling for this technological upgrade. Having established the case for this upgrade, there is also, beyond any doubt, a need to assess the viability, approach and deployment plan to ensure readiness in terms of operating model, commercial model, and infrastructure necessary to get the ball rolling.
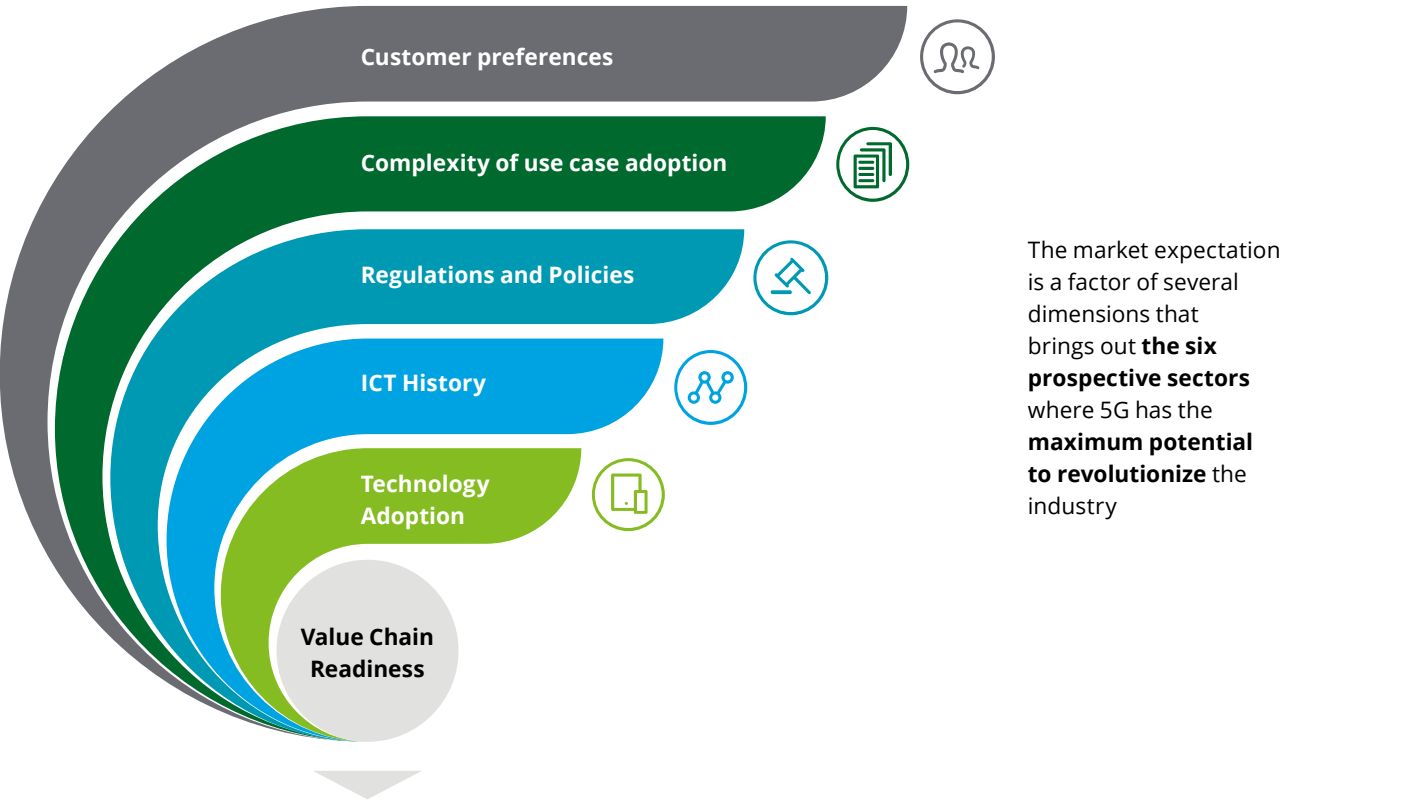

How will this digital revolution transform industry?

5G, with its superior features, channelised through enhanced Mobile Broadband (eMBB), Ultra-Reliable and Low-Latency Communications (URLLC) and Massive Machine Type Communications (mMTC) capabilities, is expected to revolutionise the industrial landscape and facilitate in unlocking global economic output of up to USD 12.3 trillion in 2035[18]. Manufacturing is expected to have the largest share of 5G enabled economic activity in 2035, up to USD 3.4 trillion.[19]

Figure 7: Market expectation from 5G use case categories

- Customer preferences
- Complexity of use case adoption
- Regulations and Policies
- ICT History
- Technology Adoption
- Value Chain Readiness

The market expectation is a factor of several dimensions that brings out **the six prospective sectors** where 5G has the **maximum potential to revolutionize** the industry

Impact of 5G

Industry	eMBB	mMTC	uRLLC
Agriculture	High	High	Medium
Automotive	High	High	High
Energy & utilities	Low	High	Medium
Healthcare	High	Medium	High
Manufacturing	High	High	Medium
Media & Entertainment	High	Medium	Medium

Source: Deloitte Analysis

01. Manufacturing

The marketplace is compelling manufacturers to become efficient and competitive through adoption of technology to tackle the challenges of shortened product life cycles, increasing labour costs and discrete manufacturing processes requiring process specialisation. It is anticipated that global manufacturers will spend USD 70 billion into IoT solutions and begin realising gains from 5G use cases by 2020[20]. Many countries, including China, US, Germany and the UK, have begun to realise the need for smart manufacturing and have started to implement policies to facilitate them.

The Indian government, with its 'Make in India' campaign, aims to establish India as a global manufacturing hub through various policy measures that have even contributed to the 9.3% growth of this sector in the year 2017[21]. 5G in India is expected to provide the network to keep these factories connected real time with suppliers/ customers etc., thereby making them smarter and much more efficient – the factories of the future!

Key use cases for the digital manufacturing ecosystem – connected, agile, and effective

- **Enhance efficiency through robotics [22]:** Remote assistance and robotic control would help perform labour intensive, precision as well as manufacturing activities in hazardous environments there by increasing process quality and reducing production time. In the future, 5G could enable a system of collaborative robots to share information through cloud, allowing smart factories across geographies to learn from one another through AI processes. Robots will no longer need to be the processors of the data, and could offload the processing function to the cloud thereby increasing dexterity and lowering energy consumption.

Figure 8: Digital future of manufacturing sector[20]

- Synchronized planning
- Connected customer
- Smart factory
- Intelligent supply
- Digital development
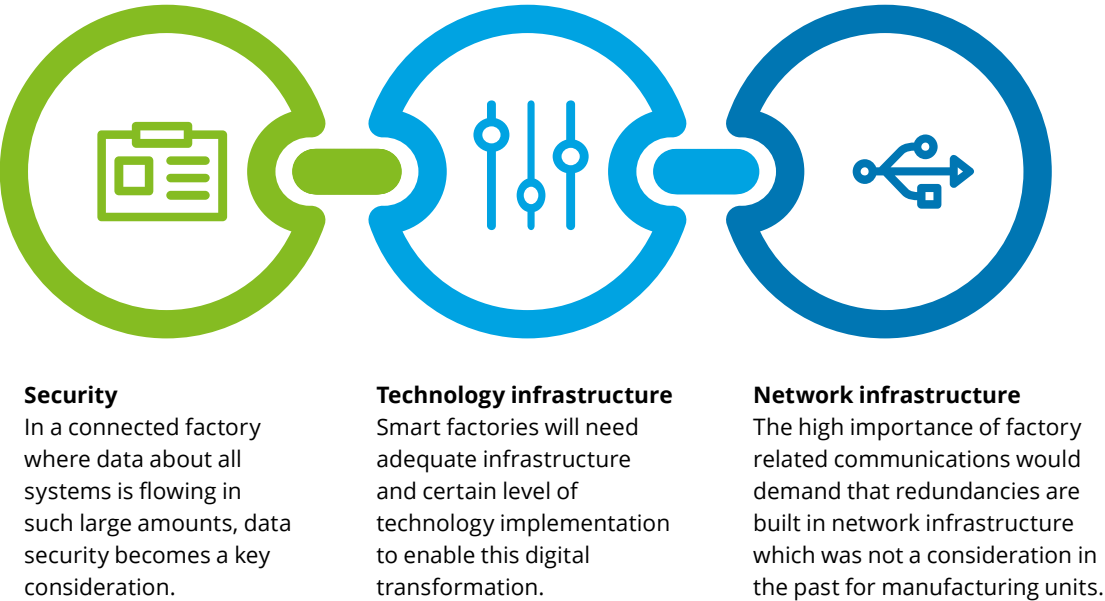- Dynamic fulfillment
- Digital core
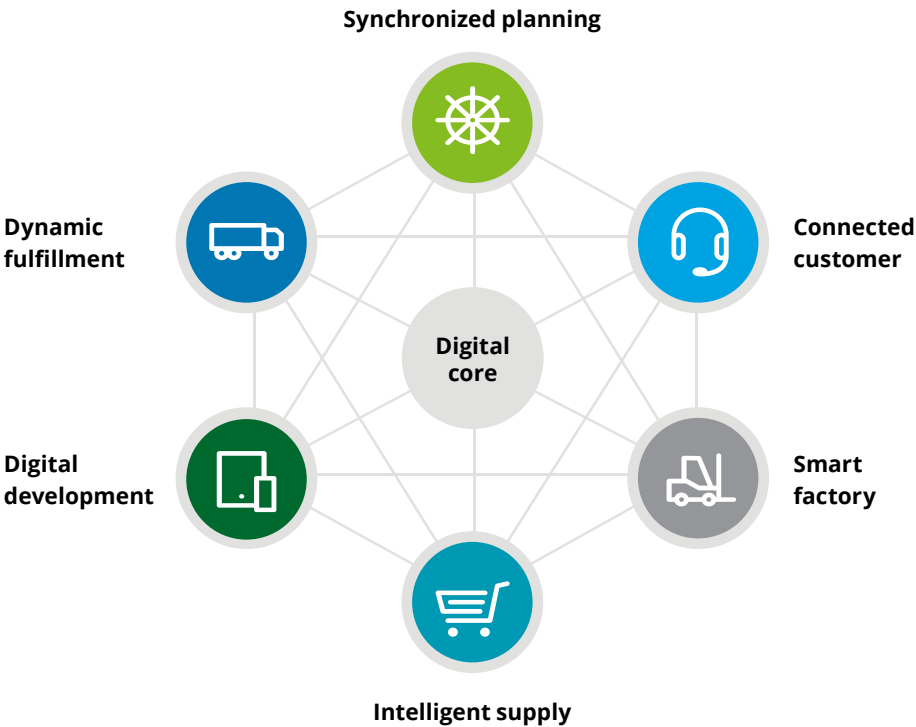
- **Automation through Internet of Things (IoT):** IoT is expected to enable cell automation and process automation with sensors being controlled through control units. Autonomous guided vehicles could help transformation between assembly lines. IoT application would have a far reaching impact on efficiency and safety, also allowing greater flexibility in operational processes.

The transfer of heavy data such as 3D models and historic data sets could empower manufacturers to make timely and informed decisions. Digitisation achieved through IoT is expected to reduce factory equipment maintenance costs by up to 40% and increase manufacturing productivity by 10-25%.[23]

- **Effective operations through Augmented Reality (AR):** With 5G enabled AR, companies could be able to create a virtual back office and remotely use the data obtained by the smart devices to provide training and instructions. Companies have also been experimenting with ART (Augmented Reality Troubleshooting), allowing remote trouble-shooting, thereby improving the response time. This is helping in optimising maintenance planning, reducing production down-times and increasing production efficiency.

Having acknowledged the widespread potential of digitisation in manufacturing, it is vital to discern the dependencies on which its success hinges upon.

Figure 9: Key considerations for implementing use cases in digital manufacturing

Security
In a connected factory where data about all systems is flowing in such large amounts, data security becomes a key consideration.

Technology infrastructure
Smart factories will need adequate infrastructure and certain level of technology implementation to enable this digital transformation.

Network infrastructure
The high importance of factory related communications would demand that redundancies are built in network infrastructure which was not a consideration in the past for manufacturing units.

Source: Deloitte Analysis

Indian manufacturing has also embarked on this journey in the quest for greater efficiency and flexibility. Manufacturers with no strategy to invest into a digital future might fall behind, while the early adopters are expected to gain a head start and establish their foothold on the future landscape of the sector.

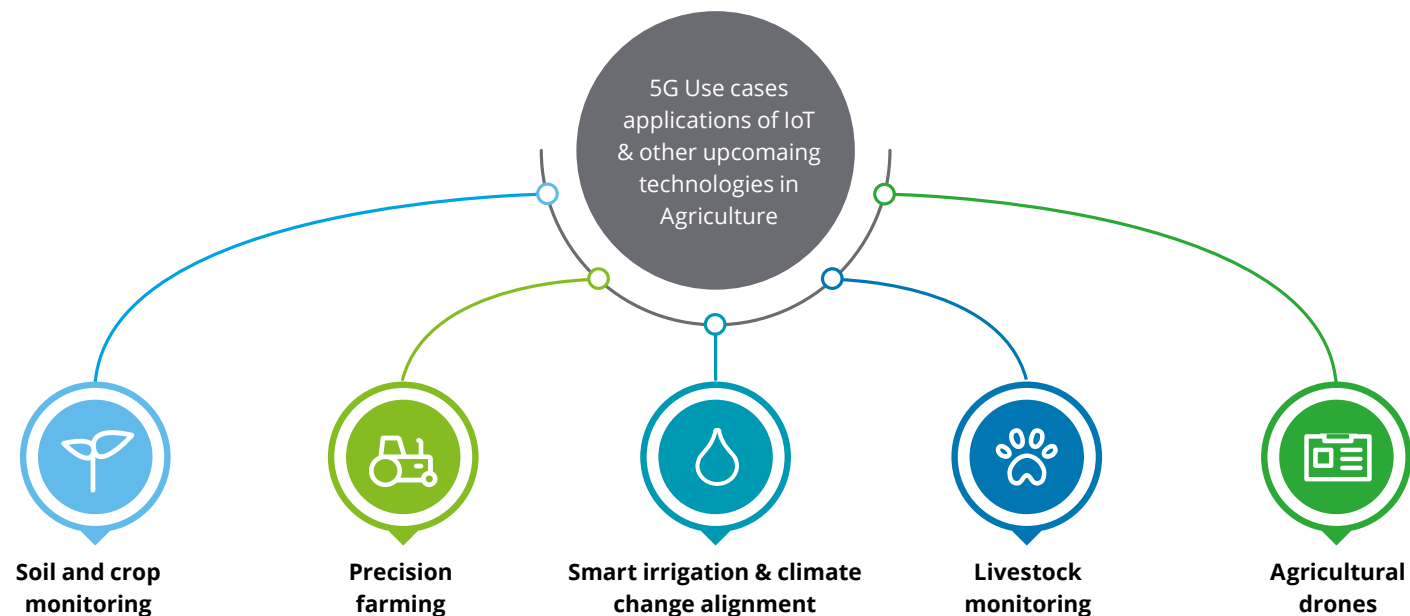## 02. Agriculture and allied industry

Though, India ranks third in agriculture and farm output globally, given the country's agro-climatic conditions, the sector fulfils only 50 to 60% of the potential yield for most of the crops.[24] This unrealised potential can be attributed to various challenges broken across its value chain.

Figure 10: Agricultural value chain and its challenges[25]

Production
- **Marginal land holdings**
- **Stagnant yields** in last 20 years for most of the crops
- **Water and land use** continue to be **mismanaged**
- **Lack of data capture and analysis** from field

Processing
Fluctuating commodity prices exacerbates problems for farmers and communities

Distribution
Various infrastructure constraints – unavailability of appropriate power, roads, storage (cold & dry) and other agri-logistics

Retailing
Poor farm returns. Individual in agriculture earns **3 times lesser** (on average) than what Individual from non-agriculture does

Consumption
Information asymmetry – Information on changing customer patterns does not reach farmers

Introduction of digitisation and adoption of technologies such as IoT, Big data analytics, Artificial Intelligence, drones etc. is expected to aid in overcoming mostof the current barriers and boost agriculture sector by improving productivity of yield, bringing transparency across value chain, ensuring smarter supporting infrastructure while increasing the farm returns.

5G Use cases applications of IoT & other upcomaing technologies in Agriculture

Soil and crop monitoring

Precision farming

Smart irrigation & climate change alignment

Livestock monitoring

Agricultural drones

Key considerations for Use Cases in India

Vast geographical coverage	Providing connectivity in vast rural geographic spread in India
Low income of farmers	Ability to invest in 5G use cases
Small agriculture land holdings	Given that, around 67% of the operational land holding is marginal (less than 1 hectare)[26], lack of economies of scale to deploy advanced technologies
Government policies	Current policy environment focusses mainly on connectivity, roll out of services in still being envisaged
Infrastructure unpreparedness	Other infrastructural gaps with roads, transportation etc.

03. Automotive industry

Significant investment in the research for V2X (Vehicle to everything) communication, where the vehicle communicates with varied elements such as other vehicles, infrastructure, devices, grids etc. could enable a plethora of use cases / features such as collision avoidance, real time traffic routing, pedestrian's safety alerts, emergency braking etc.

5G Use Cases for the automotive industry

Various new use cases are expected in the near future enabled through IoT, AI, cloud and automation[27]	
Less than 5 years	Connected cars platforms and basic features, Vehicle sensing, virtual assistants, Real time data analytics, over the air software upgradation / deployment, virtual assistants, HD maps, monitoring systems
5 – 10 years	Automotive Lidar, Vehicle to vehicle communication, Digital personalisation, In vehicle advanced UI, mobility as a service
More than 10 years	Autonomous vehicles

The lifeline of this connected vehicle ecosystem is ubiquitous connectivity with minimal latency. Although various features of connected vehicles have been tested and partially implemented in developed nations through LTE, the power of this connected vehicle ecosystem can truly be harnessed through introduction of 5G networks.

In Indian context, though, fully automated autonomous vehicles might not look like a possibility in near future more so because of the lack of compliance to traffic rules rather than lack of technology; with 5G, the wave of V2X based solutions is expected to be triggered and basic V2X features with partial automation may become prevalent across India. While V2X features may only be seen in high end luxury vehicles to begin with, these are expected to extend to other medium and small range vehicles in the medium term.
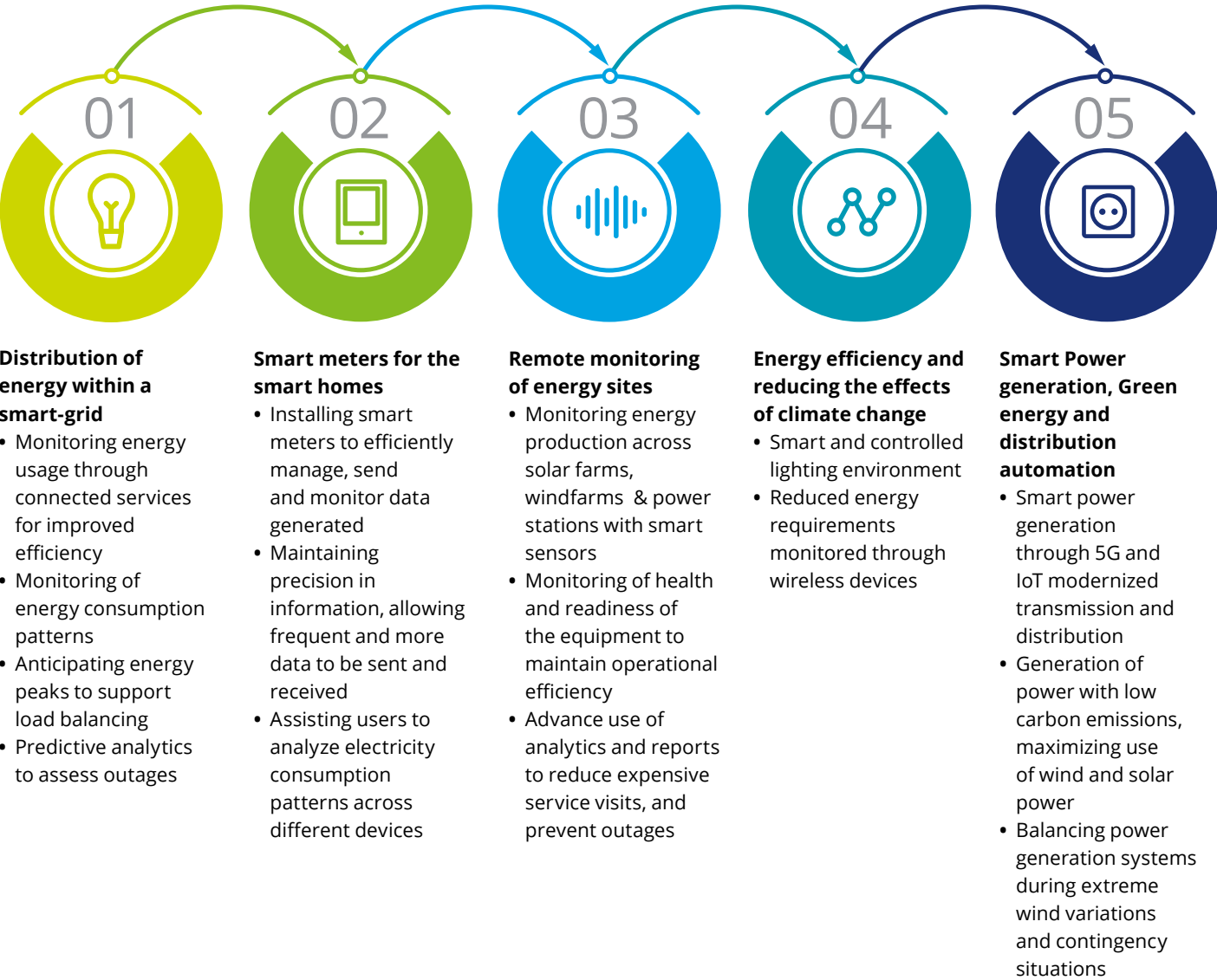
04. Energy and utilities

Digitisation of energy sector in India could enhance electricity access to the population as well as improve energy efficiency and utilisation thereby resulting in environmental sustainability. This can also help reduce unplanned outages by close monitoring of equipment, help spot human errors and quickly

localise damages due to external factors such as extreme weather. Low latency feature and high data rates offered by 5G networks have the potential to meet these requirements, which eventually could translate into effective utilisation of resource and reduced losses.

Figure 11: 5G enabled uses cases across energy and utility sector

Distribution of energy within a smart-grid
• Monitoring energy usage through connected services for improved efficiency
• Monitoring of energy consumption patterns
• Anticipating energy peaks to support load balancing
• Predictive analytics to assess outages

Smart meters for the smart homes
• Installing smart meters to efficiently manage, send and monitor data generated
• Maintaining precision in information, allowing frequent and more data to be sent and received
• Assisting users to analyze electricity consumption patterns across different devices

Remote monitoring of energy sites
• Monitoring energy production across solar farms, windfarms & power stations with smart sensors
• Monitoring of health and readiness of the equipment to maintain operational efficiency
• Advance use of analytics and reports to reduce expensive service visits, and prevent outages

Energy efficiency and reducing the effects of climate change
• Smart and controlled lighting environment
• Reduced energy requirements monitored through wireless devices

Smart Power generation, Green energy and distribution automation
• Smart power generation through 5G and IoT modernized transmission and distribution
• Generation of power with low carbon emissions, maximizing use of wind and solar power
• Balancing power generation systems during extreme wind variations and contingency situations

Source: Deloitte Analysis

05. Healthcare industry

5G enabled technologies such as IoT, big data analytics, artificial intelligence (AI) and machine learning (ML) have the capability to overhaul the healthcare system.

• **Mobility:** Connected healthcare is allowing remote diagnosis for complex cases, performing pre-planned surgeries in remote locations etc. All this will be feasible through 5G, which is expected to not only improve the reach of healthcare services across India but also the quality of diagnosis and subsequent treatment.

• **Monitor Health:** "The Internet of Medical Things (IoMT)" could make it possible for physicians to remotely monitor patient's ingestion and medicine intake in real time. Wearable sensors to wireless charging implants are widely being used to measure various physiological signs and physical activities. These sensors are likely to have enhanced capabilities to capture vital health related signs along with features to detect failing implants thereby minimising healthcare hazard. Point of Care (POC) testing and medical diagnostics could allow a patient being treated in a nearby clinic or the patient's home instead of a centralised laboratory/ hospital, thereby resulting in quicker diagnosis and results to patients.

• **Automation:** Remotely operated robotic surgeries, robot assisted therapies and surgeries enabled through mission-critical features of 5G networks requiring high reliability, high availability, and low latency could bring advanced medical treatment which is out of reach of the rural population.

• **Online consultations:** Online consultations and virtual doctor-patient interactions on account of high data speeds is expected to reduce the long waiting time for patients

• **Data Management:** Centralisation of patient records, making them more accessible and secure is expected to expedite diagnosis and treatment options for patients

This digitalisation is expected to bridge the gap across demographics for basic necessities, reducing disparities in the delivery of health care across the country and making it more affordable to citizens.

Figure 12: Key considerations for developing use cases in healthcare sector

Capital Investment
5G-enabled integrated, intelligent, and massive healthcare system in every city, town, and community of the world will require enormous capex, time and human capital

Security and Privacy
5G security threats are more serious to healthcare systems due to the possibility of cyber-attacks that can be detrimental on the society. Appropriate security framework should be considered to prevent such instances

Data Governance
Secure access to an online central repository of medical records

Technology Shift and Penetration
Spreading awareness among specialists, with new innovations and better utilization of 5G

06. Media and entertainment

Media and entertainment is a sector which is driven by consumer preferences and behaviour. With increasing usage of smartphones and adoption of digital initiatives by consumers in this space, there has been rapid development in the media and entertainment industry which is gradually moving towards enhancing customer experience.

5G enabled services:
With affordable smartphones and increasing uptake of digital products, Media and Entertainment industry is expected to be one of key sectors to be impacted by 5G. Future use cases in this sector are seen primarily requiring ubiquitous connectivity and high data rates with low latency as highlighted below:

• **Immersive experiences:** Online AR/ VR gaming of the future will require tactile internet experience (high data rates at low latency). This in combination with voice recognition technology is likely to evolve towards voice interaction with virtual characters through smart wearables.

• **Enriching gaming experience:** This will comprise of features such as replays, player views from different angles, real time language translation between players etc.

• **User/machine generated content from smart devices** could help users to share data real time which is likely to improve the user experience.

• **Cooperative media production** could allow content to be worked upon by different users in multiple locations simultaneously.

• **Distributed performance** is expected to have the capability of distributed content sourced from different locations in real time.

Figure 13: Trends across emerging segments in media and entertainment sector

	FY2016	FY2017	FY2018E	FY2020E
Online Gaming	397.2	447.2	620.6	1,055.10
Digital Media	824.9	968.8	1,194.70	1,691.20
Animation & VFX	855.5	998.70	1,241.30	1,768.80
Live Events	1405.4	1,773.70	2,342.90	3,475.60
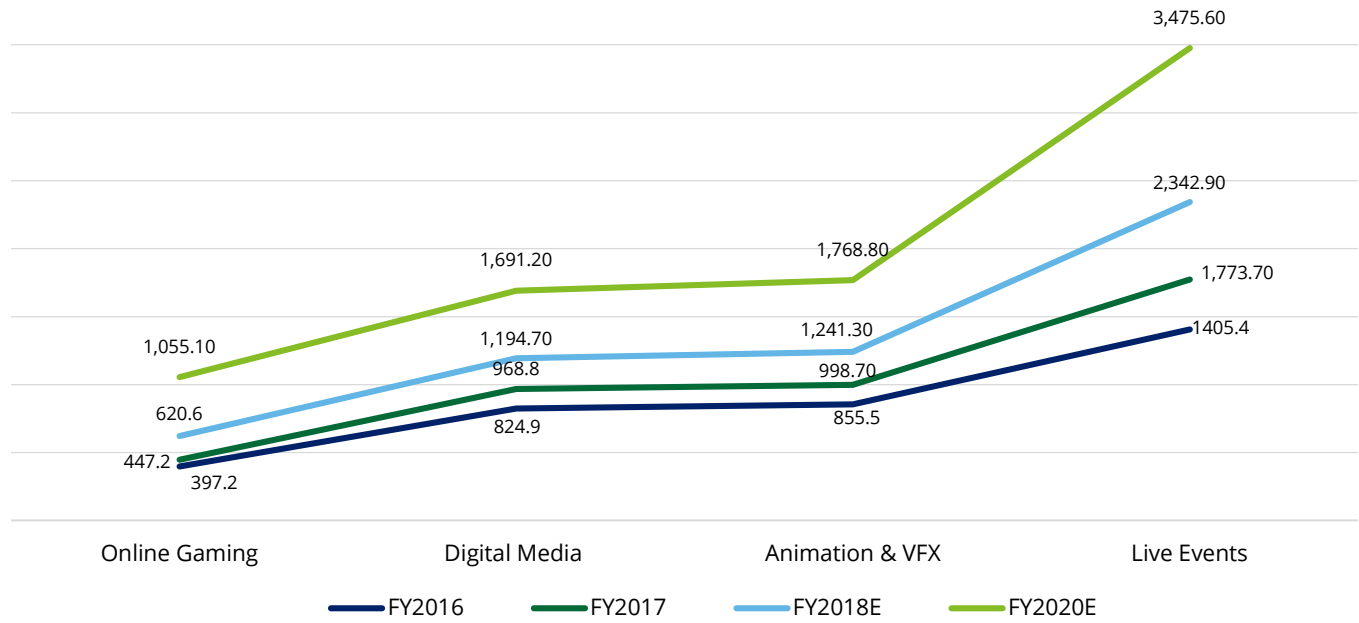
Figure 14: Improving income pattern in India (2005 – 2025)[28]

Indian residents shifting from low to high income groups (%) Million Household, 100%

| | Elite(>30800) | Affluent(15400-30800) | Aspires(7700-15400) | Next billion(2300-7700) | Strugglers(<2300) |
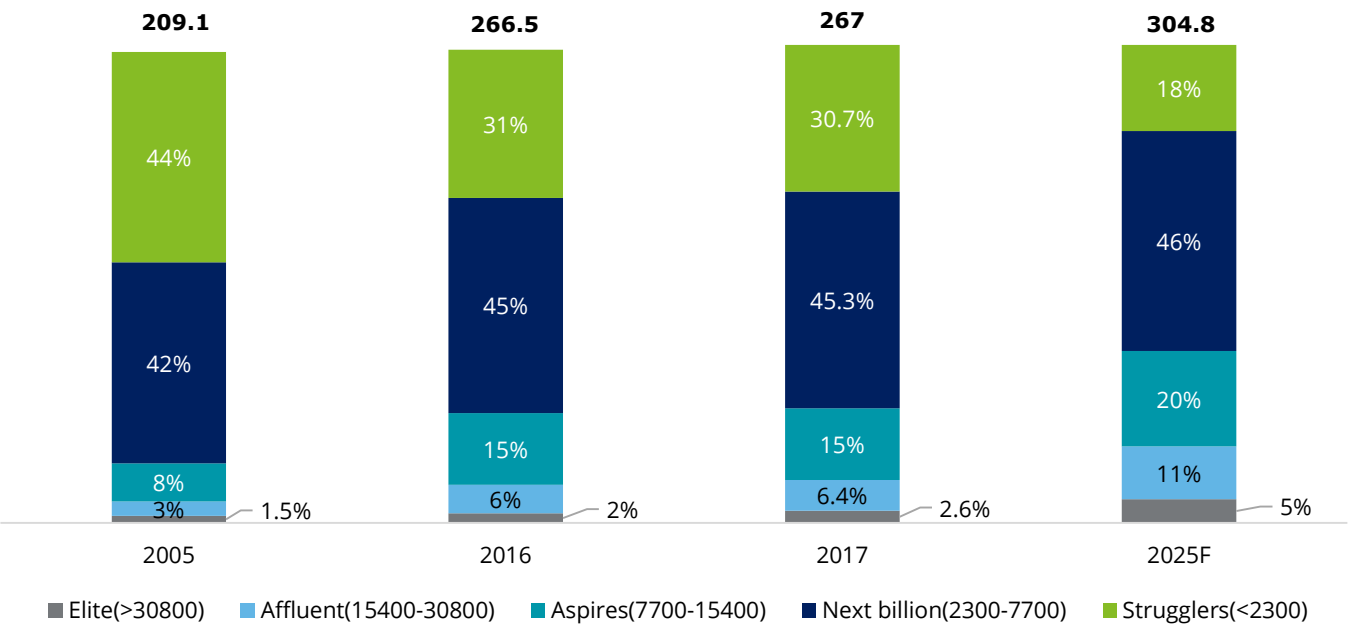
In India, with the increasing use of internet and other digital resources, consumption of services across digital media, online gaming, animation & VFX as well as live event viewing is expected to grow at a rapid pace.

5G networks are expected to bring a new era of professional live-streaming of sports and other live events. User-generated live streams are also expected to proliferate and these dramatic improvements in media consumption could lead to innovations across premium content services such as dedicated virtual reality sports channels and multi-player mobile games. Distribution of high-resolution digital content and media will require seamless coverage and high bandwidth which 5G in the near future can provide.

07. Retail

Today's retail industry is largely driven by customers expecting a unique and personalised shopping experience, with customised products. With the e-commerce boom, users are seen getting this experience online. This trend coupled with increasing cost in the retail space is changing the store stocking patterns with shift from in-store stock to storing stock at central warehouses. With a growing inclination towards omni channel retail; retailers are required to offer complete flexibility in sales channels along with better consumer experience.

About 43% smart phone users are already making weekly purchases on their phones[29]. Majority of smartphone shoppers expect to have a personal shopping advisor, digital shopping assistants to help them with purchasing decisions. Further, AR-VR technology integrations are likely to give smartphones all the benefits of a typical physical stores within next 3 years.[30]

Through 5G enabled emerging technologies, retailers can adopt various use cases:

- **In-store analytics:** In-store analytics is proving to be very useful for determining retail trends, demand/ consumption patterns, optimise pricing and providing retailer insights that are quintessential for decision making.

- **Interactive fitting rooms** Interactive "magic mirrors" have the ability to recognise a particular product (through RF-ID tags) the moment someone tries it in a store. Accordingly, this data can be used to send customised alerts on a near real time basis (matching shoes, trousers etc.) to enhance customer experience and boost sales.

- **Interactive storefront windows:** Interactive and exciting messaging on touch-screens linked to motion-sensors which could attract customers and invite them into the stores, increasing store footfall.

- **Handheld devices:** The magic-tabs could turn store managers and executives into customer service "genies" by providing customers with information and insights to help improve the shopping experience.

- **Heat mapping technology:** Analysing security footage in real-time using AI-driven algorithms can help retailers understand how consumers move through the store and what could be done to better engage with them.

- **Beacons:** Beacon technology could help retailer to send push notifications to consumer's smart phones/ wearables while in the store. This feature could also help in improving in-store navigation for customers.

- **Out-of-stock instances:** Using RFID tags, retailers could aim at achieving 99% inventory accuracy, a 50% reduction in out-of-stocks, a 70% reduction in shrinkage, and sales lifts in the 2% to 7% range[31].

Owing to the robust investment in retail and rapidly increasing number of internet users, online retail in India is expected to be at par with the physical stores in the coming few years.

To compete effectively, retailers need to consider reacting to the needs of the tech-savvy digital consumers. With 5G, retail companies could use innovative technologies with more data speed and reliability, gather more data, and ultimately create more business opportunities, augment revenues and building long-lasting relationship with satisfied customers.

08. Smart cities

Increasing urbanisation through development of infrastructure coupled with digitalisation is paving the way for smarter living.

Enhancing safety, increasing energy efficiency, improving air quality, efficient transportation and boosting overall quality of life are the need of the hour. The stimulus for making cities smarter is not just driven by the need to modernize, but also to provide citizens with better quality of life.

While existing 4G, HetNet and wireline networks are already being utilised in smart cities around the world, they are limited by the number of connections they can support, the data they can transmit, and most importantly the speed they can offer, all of which are seen creating hurdles in deployment of smart cities use cases. Enabled by LPWAN and fiberisation along with support of mMTC capabilities, 5G networks are expected to overcome these hurdles, and enable large number of connections, providing super-high bandwidth, and ultra-low latency based communications, to build a connected city – a smarter city.

The market expects over 50 billion devices to be connected to mobile networks worldwide by 2020[32], causing a large volume of communication occurring between machines, rather than humans. In the smart city context this connected city could enable use cases such as:

- **Video surveillance and analytics –** Providing surveillance and security services enabling assurance and mitigating concerns over safety

- **Intelligent transport and traffic management –** Managing traffic could be easier through controlled traffic signals and sensors regulating the flow of traffic throughout the city in response to demand

- **Smart grids and metering systems with smart street light –** Enabling better management and conservation of energy, thereby, keeping a check over pollution and further reducing outages

- **Solid waste management –** Improving operational costs by optimising routes for garbage trucks through elimination of unnecessary pick-ups, providing dynamic collection routes and schedules for a complete optimisation of the collection operations

Figure 15: Potential distribution of 5G use cases across humans and machines[33]

In the not-too-distant future, our cities are expected to be smarter, cleaner, and safer places to live. At the heart of each of these smart cities will be a 5G network.

09. Government

This revolution also provides an opportunity for the government to improve it's connect with the citizens. Digitalisation could help improve delivery of government services to citizens and also lower transaction costs for citizens. Before the digitalisation journey, digitisation of citizen records and govt. data/ information across departments is critical. In the Indian context, with Aadhar, a unique, uniform citizen ID has been created.

As steps are being taken for digitisation of government data, creating an end to end digital experience from a citizen's view point for accessing government services anytime and from anywhere could greatly enhance the viability and reach of government programs.

An example where digitalisation could greatly improve govt. reach and improve the success of the programs is the education sector. The future learning model could be a virtual, immediate, and interactive, enabling personalisation and on-demand availability of skill programmers. Through capabilities such as 'Tactile Internet' along with VR and AR, adopting methods such as tele-teaching, tele-mentoring, virtual university, virtual classroom, and virtual team-working, etc. could become easier.

10. Public protection and disaster relief

National authorities or relevant operators use Public Protection and Disaster Relief (PPDR) radio communications for managing services with regards to public safety, security, defense and emergency. To further modernise and enable reliability over critical communications, the use of 5G network is expected to be supportive in addressing the requirements. Capabilities such as mMTC, reinforced with Mobile-Edge Computing (MEC) and eMBB solutions are expected to allow flexible use of radio resources, thus, improving communications.

Moreover, capabilities through network slicing at core infrastructure could also

be helpful in enabling traffic prioritisation models during critical communications. This includes the ability to dynamically pre-empt some users in order to provide immediate services for first responders in an emergency or perilous situations.

Sensors, cameras and other automated devices are significant sources of information to ensure public safety. Through building synergies across such source feeds, 5G networks could also support integrating information from diverse source feeds or devices into Public Safety operations, enabling it to become less reactive and more proactive.

Figure 16: Potential distribution of 5G use cases across humans and machines

Operational efficiency
Public Safety operations and mission critical field services are expected to leapfrog to the next levels of efficiency through mobility and digitalization

Cost reduction
High reliability networks involve high cost. Cost would be a key consideration to have a unified pan India PPDR network

Public safety
Public security and safety is a critical government agenda. The question of safety is relevant, not only for citizens but also for first responders. Mission critical applications surveillance, video analytics, facial recognition system can help improve efficiency and effectiveness of first responders

Evolving business models and new intermediaries

Intermediaries for connectivity: Prerequisite for 5G is network densification of existing 4G/ LTE networks. Further, through use of various technologies such as small cells, IBS, DAS, Wi-Fi telcos are seen building heterogeneous networks, which can provide the required network coverage. This need has given rise to opportunity for OEMs to offer 'small-cell-as-a-service', 'hetnet-as-a-service', which are networks deployed and managed by OEMs utilised by telecom service providers to densify their network there by enabling 4G expansion and prepare for impending launch of 5G.

Intermediaries for network infrastructure: Cloud companies and tech start-ups have emerged providing network infrastructure resources for computing, storage and processing as well as network functions such as security, firewall, load balancing, software-defined WAN, big data analytics etc. to customers. 'Network-as-a-service' offered by these set of intermediaries is finding takers in small and medium scale enterprises with no or minimal investments in their IT network.

Intermediaries based on differentiated services: With the range of 5G use cases across industry verticals requiring different characteristics for example, low latency and high reliability application for robotics in manufacturing and automotive sectors; high data throughput requirements for augmented reality use cases; the traditional offerings based on connection speed and volume of usage could see a shift. Basis the service provider's ability to make this shift to have offerings for relevant niche industry verticals as well as tariffs customised to offering type, there is an opportunity for intermediaries. Downstream to telecom service providers, these intermediaries could acquire bandwidth from the telecom service providers based on defined SLAs for throughput, latency, reliability etc. and create differentiated services/ applications based on niche industry vertical they want to cater to with suitable tariffs to meet the customer needs.

In the previous section we understood the far reaching application of 5G use cases across industry verticals though eMBB, uRLLC and mMTC capabilities. While it is difficult to predict which of those use cases would drive the 5G demand, collectively the large number of use cases could possible support the investment case for 5G.

The network capabilities added through network slicing in the 5G environment is expected to allow telcos to offer 'made to order' solutions for their customers. Complemented by Software Defined Networking (SDN) and Network Functional Virtualization (NFV), telcos could be able to deliver the network customised to customer needs and deploy such networks in quick time with reduced capex and opex requirements. This is expected to enable telcos to try various service offerings at low cost with faster time to market, fostering innovation. Telcos are seen forging partnerships across the value chain to explore opportunities for new services leading to new business models and intermediaries.

Challenges in Implementation

India is no longer seen to be adopting the wait and watch approach and has stepped up its efforts towards 5G commercial deployment in sync with the global timelines. Through building partnerships, R&D investments and network trials, industry specific service requirements are being currently understood while keeping in mind the considerations required for a viable business case. There exist inherent challenges in the Indian market which could hamper meeting these timelines.

- **Right of Way(RoW) and lack of uniform policy framework**
  The current regulatory framework for deploying network infrastructure has always been one of the most contentious issues in the industry. Delays due to complex procedures

across states, non-uniformity of levies along with administrative approvals have impacted telecom service providers in rolling-out Optical Fibre Cables (OFC) and telecom towers.

Although, new RoW rules and standardized processes with applicable charges were introduced in the year 2016, however, roadblocks have hampered implementation.

Going ahead, densification of network as promulgated by 5G use cases, is expected to require deployment of extensive infrastructure; however, any inconsistencies and delays while securing RoW may further result in complex deployment and longer build time.

- **Limited giga-backhauling to meet future requirements**
  To meet high throughput and low latency expectations from 5G technology, a strong backhaul network is a key requirement. India has about 1.5 million Kms of fiber deployed with less than 25% of the telecom sites connected through fiber.[34]

Being listed far below several countries in the ICT Development and Global Connectivity Index, India needs to accelerate across digital transformations through technology enablers such as broadband networks in tandem with data centers, cloud, big data and Internet of Things. However, enabling broadband networks through fibre implementation could be a long capital intensive project and will require an estimated investment of USD 8 billion to increase fibre footprint and reach 77-80% of tower assets in key urban areas.[35]

Moreover, while BharatNet had its own set of challenges during implementation, government is still striving for rural broadband connectivity. It is imperative that these efforts are expedited to build the requisite backhaul infrastructure required for 5G.

Furthermore, cost effective solutions such as E-band and V-band based microwave backhauling – permitted worldwide for ultra-high capacity gigabit backhauling, is yet to be introduced in India. Being relatively quicker and economical in terms of deployment, these could enable the industry to steer in the right direction required towards creation of 5G networks.

- **Industry crippling under margin pressure**
  While the investment for 5G would grow incrementally as advancements on existing 4G/ LTE technology, with 5G spectrum and network densification needs, it is anticipated that industry might require an additional investment of USD 60 to 70 billion to seamlessly implement 5G networks.[36] In midst of such rising debt levels and market consolidation activity, the telcos are seen to be constrained on capital expenditure.

- **Network modernisation and densification will be complex**
  Given the relatively shorter and fragile nature of the mid frequency band (sub 6 GHz band), delivering better throughput and performance through 5G networks would require a closely packed - denser small cell network architecture. In this regard, the small radio cells will need to be more scattered and deployed high in numbers onto the street furniture such as bus shelters, lamp-posts, traffic lights, etc. along with boosting 'in-building' solutions though fixed wireless solutions. Small cell based network densification is yet to be realized at a significant scale using 4G network backhaul. With current 4G network coverage, building commercial 5G use cases over 4G networks may pose a challenge in the near term.

- **Strengthening the security apparatus with evolving technologies**
  The rise of new business architecture evolving through 5G networks are likely to present new challenges to security and privacy protection. As industries are expected to thrive on 5G and cloud based ecosystem, it is expected to lead to promoting huge number of interconnected devices. Building a new

trust model secured with business continuity will be one of the key essential drivers for enabling connected industries.

Across the globe, cyber attacks are increasing in frequency and sophistication with rising internet penetration and digital connectivity. It has been estimated that such attacks cost the global economy one-per cent of annual GDP, up to US 575 billion per year.[37]

Moreover, according to The Global Cyber Security Index released by the UN telecommunications agency International Telecommunication Union (ITU) in the year 2017, only about half of all the countries had a cybersecurity strategy or are in the process of developing one. The index, which was topped by Singapore at 0.925 saw India at 23rd position.

Figure 17: Global Cyber Security Index by International Telecommunication Union (ITU), 2017[38]

Global Cybersecurity Index

#Represents Global Rank
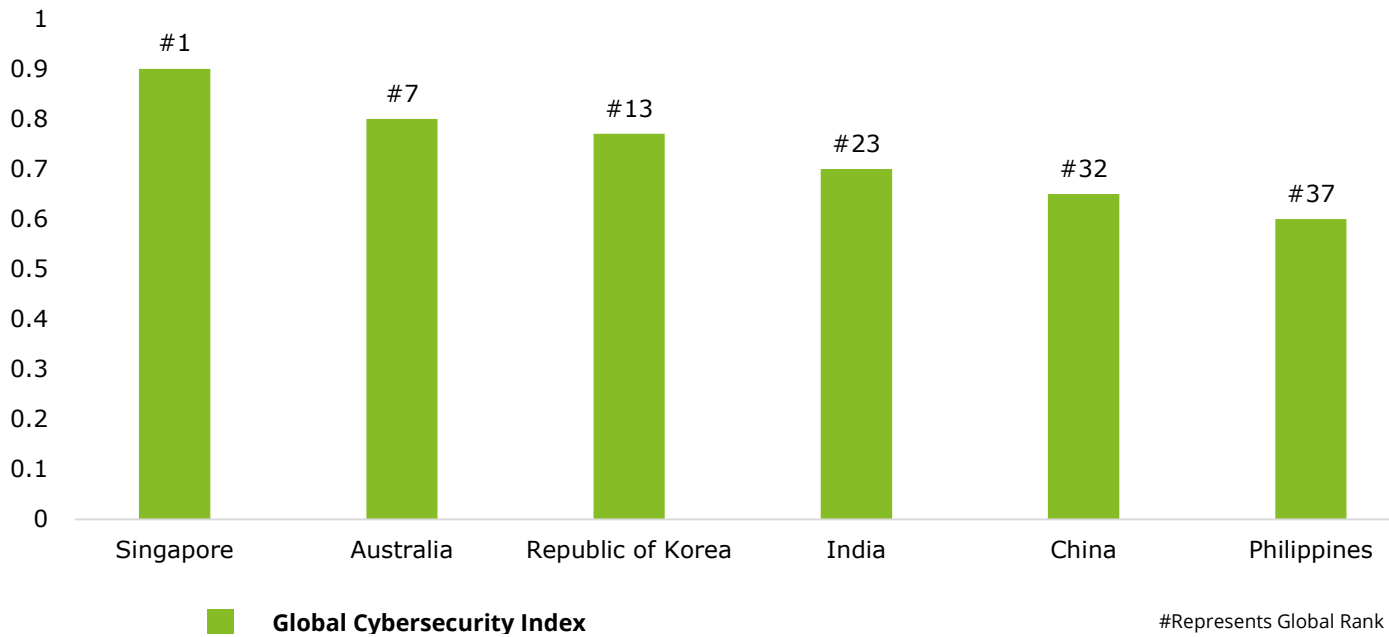
National Cyber Security Policy 2013 was introduced in India to provide an umbrella framework for defining and guiding actions related to cyber security, with proposed strategies to include developing an assurance framework, strengthening regulation and promoting research and education. While the policy was well received, a robust implementation framework would drive adoption by the industry.

Presently, as India is at the cusp of digital transformation and trying to realise commercial viability across 5G based networks, policy framework need to be implemented well in advance to secure the connected ecosystem evolving in lieu of 5G.

Conclusive Remarks

Deloitte believes that there is a sense of eagerness and urgency with respect to the arrival of 5G in India. The industry is likely to witness a timely arrival of 5G in line with global launches unlike 2G, 3G and 4G technologies.

Deloitte believes that in order to understand the economics and performance, operatos are taking intermediate steps to evolve from LTE to LTE-A and LTE-A Pro in preparation for 5G. Some of the network suppliers have already commenced 5G trials with Indian operators in the second half of 2017.

5G is expected to extend beyond the traditional voice and data sevices. 5G network characteristics of increased reliability, lower latency, higher throughput, increased connection density would enable massive commercial deployments of technologies such as IoT, AI, RPA, AR/ VR facilitating use cases across industries like automotive, media and entertainment, healthcare, retail, manufacturing and agriculture amongst others. Further, from a societal standpoint, 5G use cases for intiatives like smart cities have the potential to improve the life of citizens through significant improvement in services like public safety, utilities, transport to name a few.

Deloitte is of the view that 5G is likely to pave the way for more wide spread IoT application by introducing new devices and services across industries. As there is specific direction and focus on IoT both by the Government and industry bodies, 5G is expected to become critical in the expectation of provisioning of billions of connected devices. 5G is likely to give rise to innovative business models with many new intermediaries focused on connectivity, service differentiation, content and application entering the telco value chain. Telecom service provider collaboraton in the industry vertical and across would be critical to enable digital transformation across the value chain.

Regulatory support from the government providing the right ecosystem for research and development, regulatory framework for spectrum, data and information security, IoT, digital as well as inclusive business environment to encourage domestic and international players to invest in the technology would be key to technology implementation.

Glossary of Terms

Term	Description
3-D	Three-Dimensional
3G	Third Generation
3GPP	Third Generation Partnership Project
4G	Fourth Generation
4K	4,000 pixels
5G	Fifth Generation
5GMF	Fifth Generation Mobile communications promotion Forum
5GPPP	Fifth Generation Infrastructure Public Private Partnership
AI	Artificial Intelligence
AR	Augmented Reality
ARPU	Average Revenue per User
ART	Augmented Reality Troubleshooting
ATM	Automated Teller Machine
BSNL	Bharat Sanchar Nigam Limited
BTS	Base Transceiver Station
CAT-M1	Category-M1; technology used for LPWAN
CII	Confederation of Indian Industry
cm	Centimetre
CoE	Centre of Excellence
COTS	Commercially-Off-The-Shelf
CPE	Customer-Premise-Equipment
C-RAN	Centralized-Radio Access Network
CSTF	Cyber Security Task Force
DL	Download Limit
DNDCP	Draft National Digital Communication Policy
DoT	Department of Telecom
DTH	Direct To Home
eMBB	Enhanced Mobile Broadband
EMF	Electromagnetic Field
EMR	Electronic Medical Record
F-OFDM	Filtered Orthogonal Frequency Division Multiplexing
FTTx	Fiber To The x
FWA	Fixed Wireless Access
FY	Fiscal Year
GDP	Gross Domestic Product
GHz	Gigahertz
GMV	Gross Merchandise Value
GoI	Government of India
HD	High Definition
IaaS	Infrastructure as a Service
ICT	Information & Communications Technology
IIT	Indian Institute of Technology
IMT	International Mobile Telecommunications
IoMT	Internet of Medical Things
IPL	Indian Premier League
ITU	International Telecommunication Union
km/hr	Kilometre per Hour
KPI	Key Performance Indicator
LMLC	Low Mobility Large Cell
LTE	Long Term Evolution

Term	Description
LPWAN	Low Power Wide Area Network
LTE-A	Long Term Evolution- Advanced
MANO	Master Node
MCS	Mission Critical Services
MEC	Multi-access Edge Computing
MHz	Megahertz
MIMO	Multiple-Input and Multiple-Output
ML	Machine Learning
mm	Millimetre
mMTC	Massive Machine Type Communication
ms	Millisecond
MSME	Micro, Small and Medium Enterprises
NB-IoT	Narrowband-Internet of Things
NetCo	Network Cooperation
NFV	Network Functions Virtualization
NSA	Non-Standalone
NW	Network
OEM	Original Equipment Manufacturer
OFC	Optical Fibre Cables
OFDM	Orthogonal Frequency-Division Multiplexing
OTT	Over-the-top
POC	Point of Care
PPDR	Public Protection and Disaster Relief
PPP	Public Private Partnership
QoE	Quality of Experience
QoS	Quality of Service
R&D	Research & Development
R14	Release 14
R15	Release 15
R16	Release 16
R17	Release 17
RAN	Radio Access Network
RFID	Radio Frequency Identification
RoW	Right of Way
SCMA	Sparse Code Multiple Access
SDN	Software-Defined Networking
sq.km	Square Kilometre
TRAI	Telecom Regulatory Authority of India
UHD	Ultra-High-Definition
UHF	Ultra High Frequency
UI	User Interface
UK	United Kingdom
UL	Upload Limit
UN	United Nation
uRLLC	Ultra-Reliable-Low-Latency Communication
US	United States
USD	United States Dollar
V2X	Vehicle to Everything
VFX	Visual Effects
VoLTE	Voice over Long Term Evolution
VR	Virtual Reality
XaaS	Everything–as–a–Service

About Confederation of Indian Industry

The Confederation of Indian Industry (CII) works to create and sustain an environment conducive to the development of India, partnering industry, Government, and civil society, through advisory and consultative processes.

CII is a non-government, not-for-profit, industry-led and industry-managed organisation, playing a proactive role in India's development process. Founded in 1895, India's premier business association has around 9000 members, from the private as well as public sectors, including SMEs and MNCs, and an indirect membership of over 300,000 enterprises from around 265 national and regional sectoral industry bodies.

CII charts change by working closely with Government on policy issues, interfacing with thought leaders, and enhancing efficiency, competitiveness and business opportunities for industry through a range of specialized services and strategic global linkages. It also provides a platform for consensus-building and networking on key issues.

Extending its agenda beyond business, CII assists industry to identify and execute corporate citizenship programmes. Partnerships with civil society organisations carry forward corporate initiatives for integrated and inclusive development across diverse domains including affirmative action, healthcare, education, livelihood, diversity management, skill development, empowerment of women, and water, to name a few.

As a developmental institution working towards India's overall growth with a special focus on India@75 in 2022, the CII theme for 2018-19, India RISE : Responsible. Inclusive. Sustainable. Entrepreneurial emphasizes Industry's role in partnering Government to accelerate India's growth and development. The focus will be on key enablers such as job creation; skill development; financing growth; promoting next gen manufacturing; sustainability; corporate social responsibility and governance and transparency.

With 65 offices, including 9 Centres of Excellence, in India, and 10 overseas offices in Australia, China, Egypt, France, Germany, Singapore, South Africa, UAE, UK, and USA, as well as institutional partnerships with 355 counterpart organisations in 126 countries, CII serves as a reference point for Indian industry and the international business community.

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