Making India 5G Ready

Report of the 5G High Level Forum
Prepared by
The Steering Committee

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मनोज सिन्हा
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संचार राज्य मंत्री (स्वतंत्र प्रभार)
एवं
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MESSAGE

The Government of India, under the inspirational leadership of our visionary Prime Minister, Shri Narendra Modi has launched several path-breaking initiatives such as Digital India, Make in India and Skill India for leapfrogging the country into a Digital Economy. A robust, competitive landscape, which ensures availability of new communications technologies, services and applications, is central to the growth of GDP, increased in productivity and creation of new jobs in the economy. This requires an affordable, robust and secure digital communications network.

Providing an enabling environment for technology adoption and deployment is critical for inclusive development. The draft National Digital Communications Policy, 2018 (NDCP 2018) seeks to unlock the transformative power of digital communications networks – to achieve the goal of enhancing the well-being of the people of India through digital empowerment. Towards this end, NDCP 2018 attempts to outline a set of goals, initiatives, strategies and intended policy outcomes.

The emerging 5G technology has the potential for major societal transformation in India by enabling massive expansion of digital products and services across industrial, commercial, education, healthcare, agricultural, financial and social sectors. 5G will be the connectivity fabric of the emerging new era of ICT that has the ability to positively transform every sector of the economy and society.

The vision for 5G is driven by inclusivity, wherein our rural and under-privileged population can also benefit from 5G services. The Government is strongly committed to early, efficient and pervasive deployment of 5G mobile networks in India. India also aspires to manufacture for the world, and be a global manufacturing hub in this area.

I would like to congratulate the High Level Forum (5G HLF) for 5G India 2020 led by three Secretaries to the Government of India (Electronics & IT, Science & Technology and Telecommunications) for their collaborative leadership, and Professor A.J. Paulraj, Professor Emeritus, Stanford University USA, the Chair of the 5G Steering Committee, for his leadership role. I would also like to thank eminent members from industry, academia and my officers in the department for creating a framework and roadmap for 5G India 2020 to achieve India's digital communications vision. I seek the cooperation of all concerned in driving meaningful and disciplined implementation of the recommendations outlined in the report, which will help us reach our desired goal.

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  Mr. Ajay Prakash Sawhney, Secretary MeitY,
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Acronyms and Nomenclature

3GPP	3rd Generation Partnership Project
5G-NR	5G – New Radio
APAC	Asia Pacific
BIF	Broadband India Forum
BIS	Bureau of Indian Standards
CCSA	China Communications Standards Association
CEWIT	Centre for Excellence in Wireless Technology
CII	Confederation of Indian Industry
COAI	Cellular Operators Association of India
CTI	Common Telecom Infrastructure
DoT	Department of Telecommunications
DST	Department of Science and Technology
eMBB	Enhanced Mobile Broadband
eNBs	Evolved NodeB
ETSI	European Telecommunications Standards Institute
Gbps	Giga Bytes per second
ICT	Information and Communication Technology
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IISc	Indian Institute of Science
IIT	Indian Institute of Technology
IoT	Internet of Things
IP1	Infrastructure Provider (Tower Company)
IPR	Intellectual Property Rights

ITU	International Telecommunications Union
LMLC	Large Cell Low Mobility
MDU	Multi-Dwelling Unit
Meity	Ministry of Electronics and Information Technology
MIMO	Multiple-Input and Multiple-Output
mMTC	Massive Machine-Type Communications
MNC	Multinational Company
NB-IoT	Narrowband-Internet of Things
OEM	Original Equipment Manufacturer
OSD	Officer on Special Duty
SDO	Standards Development Organization
TEC	Telecom Engineering Centre
TIA	Telecommunications Industry Association
TSDSI	Telecom Standards Development Society of India
TSP	Telecom Service Provider
uRLLC	Ultra-Reliable and Low Latency Communications
USD	US Dollar
USO	Universal Service Obligation
WISP	Wireless Internet Service Provider

Participants

High Level Forum Members

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Regulatory Policy	Mr. R S Mathews, DG, COAI
Education and Awareness Promotion Program	Ms. Pamela Kumar, DG, TSDSI
Application and Use Case Labs	Ms. Pamela Kumar, DG, TSDSI
Major Trials and Technology Demonstration	Ms. Aruna Sundararajan, Secretary, DoT
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Participation in Intl. Standards	Prof. B Ramamurthi, Dir., IIT Madras

Executive Summary

5G is the next generation of cellular communications technology with evolutionary and revolutionary services that can have a deep impact on India. 5G can unleash new economic opportunities and societal benefits giving it the potential for being a transformational force for Indian society. It can help the country leapfrog the traditional barriers to development as well as advance the 'Digital India' vision. The cumulative economic impact of 5G on India can reach one trillion USD by 2035.

A 5G High Level Forum was set up by the Government in September 2017 to articulate the Vision for 5G in India and to recommend policy initiatives and action plans to realize this vision.

The three priorities for India in 5G are

a. Deployment – rolling out early, efficient and pervasive 5G networks to maximize the value offered by this new technology
b. Technology – building India's industrial and R&D capacity in the design and IP dimensions of 5G
c. Manufacturing - expanding the manufacturing base in 5G for both semiconductor fabrication as well as assembly & test plants.

A Steering Committee was constituted with Prof. A J Paulraj, Professor, Stanford University as the Chair. During the HLF meetings, the High Level Forum focused on Deployment as the initial thrust area. Seven task forces were set up under the Steering Committee to study - Spectrum Policy, Regulatory Policy, Education and Awareness Promotion Program, Application & Use Case Labs, Development of Application Layer Standards, Major Trials and Technology Demonstration and Participation in International Standards.

This report was prepared by the Steering Committee on behalf of the High Level Forum.

Key Recommendations

The recommendations of the Steering Committee are summarized below and detailed recommendations are presented in the respective taskforce reports.

- **Spectrum Policy**

  India's spectrum allocation for public wireless services should be enhanced significantly on various frontiers to realize digital infrastructure as a core utility under Digital India. Also, the cost of spectrum relative to per capita GDP is high. It is important that India builds a more favourable spectrum policy in the 5G era. The Committee recommends fresh 5G spectrum be allocated as follows

  a. For wireless access, licensed spectrum with an aggregate of 405 MHz + 137 MHz below 4 GHz and 5.25 GHz + 8.3 GHz below 45 GHz.
  b. For backhaul, 14 GHz of unlicensed and 10 GHz of lightly licensed spectrum in the 57 to 86 GHz band.
  c. For WiFi, opening additional bands of unlicensed spectrum in the 5 GHz band for outdoor use.

  The committee further supports three tiers in timing of spectrum release based on readiness of the various bands.

- **Regulatory Policy**

  Regulatory policy support for deployment of mobile networks is critical for its success due to its close linkages with the physical, financial and security infrastructure of the country.

  With advent of 5G, the base station density may go up heavily, increasing the need for a favourable regulatory regime. The Committee recommends that three expert committees on business, security and safety segments be created to develop clear guidelines on regulatory policy that can be promulgated by the Government.

- **Education and Awareness Promotion Program**

  There is an opportunity and need for India to connect to the evolving global eco-system around 5G. Given the imperative for various economic verticals to use 5G technologies, it is important to promote awareness of 5G and advance the related skills development within the country. The Committee recommends three initiatives - Attract global 5G conference

events to India, set up national 5G events and create a comprehensive skills development program.

- **Applications and Use Case Labs**

  Since 5G will support many applications, deeper and faster deployment in India can greatly benefit from the setting up of Applications and Use Case Labs. These labs will provide multiple functions – interoperability testing for new applications, fostering innovation in 5G use cases, and promote entrepreneurship to develop locally tailored solutions. The Committee recommends that the Applications and Use Case Labs be set up within different economic verticals in a phased manner.

- **Development of Application Layer Standards**

  The Applications Layer sits at the highest level in a technology standards protocol stack. While a vast number of Application Layer Standards have been developed over the years, with the advent of 5G and its rich applications potential, many fresh requirements will arise to address smart cities and smart homes to smart grids. Some of these applications can have an India specific characteristics.

  India is in its initial years of engagement in the global standards eco-system. 5G offers a new opportunity to engage in the standards process The Committee recommends both short term and longer term initiatives to develop a ten year strategy for Information Technology Standards.

- **Participation in International Standards**

  Telecommunication systems depend on many complex standards and there is a vast global standards development eco-system building such standards. Getting active in this eco-system will open up a new realm of opportunities for India. The Committee recommends short term initiatives like setting up 'Standards Project Teams' with funding enabling consistent participation to participate in standards activities. For the longer term, the Committee recommends that an expert committee be constituted to recommend a ten year strategy for Information Technology Standards in India.

- **Technology Demonstration and Major Trials**

  Over 150 5G trials have been conducted around the world. 5G trials will be an important learning opportunity for our Telecom Service Providers (TSP), academia and industry. The Committee recommends that the major global Original Equipment Manufacturers be invited to conduct major 5G trials in India in collaboration with local partners.

Implementation and Oversight

The implementation of the Committee's recommendations will be a significant task spread across multiple years and over several branches of the government, and public and private sector institutions. The Committee recommends creating a 5G Program Office within DoT and an Oversight Committee.

Core Technology and Manufacturing

This report focuses on promoting 5G Deployment. Building India's capacity in core technology development (Design and IP) and manufacturing for 5G and more broadly for all Information Technologies needs a deep and long term effort. However, the enabling measures of the report related to deployment are envisaged to trigger R&D and manufacturing aspects of 5G ecosystem as well considering India's market and innovation potential.

Terms of Reference

5G is the next generation of mobile communications technology. It will supplement the 2G, 3G and 4G mobile networks currently deployed in India and will add evolutionary and revolutionary services.

5G's services go well beyond those of prior generation mobile networks, all of which only delivered services on personal phone platforms. 5G will additionally also connect myriad of new devices including machines, sensors, actuators, vehicles, robots and drones, to support a much larger range of applications and services. Put together, this can unleash new economic opportunities, giving 5G the potential for being a transformational force for Indian society. India, in particular, can benefit greatly from 5G as it will enable the country to leapfrog the traditional barriers to development. 5G will also advance the reach and utility of the 'Digital India' and allied missions.

5G technologies will enter services gradually, beginning in 2019 and advance to a full range of services by 2024. By acting early to embrace the 5G opportunity, India can accelerate the 5G dividend and potentially also become an innovator in 5G applications.

A 5G High Level Forum was set up by the Government in September 2017 to articulate the Vision for 5G in India and to recommend policy initiatives and action plans to realize this vision. The 5G High Level Forum is chaired by the Secretary, DoT. See Appendix 1 for the High Level Forum Memorandum.

The first meeting of the High Level Forum was held on December 13, 2017, when it approved the following 5G Vision for India.

5G Vision for India

5G technology has the potential for ushering a major societal transformation in India by enabling a rapid expansion of the role of information technology across manufacturing, educational, healthcare, agricultural, financial and social sectors. India must embrace this opportunity by deploying 5G networks early, efficiently, and pervasively, as well as emerge as a significant innovator and technology supplier at the global level. Emphasis should be placed on 5G touching the lives of rural and weaker economic segments so as to make it a truly inclusive technology.

Supporting Initiatives

To realize this vision, the High Level Forum recommended policy initiatives at the Central, State and Local government levels, and programmatic initiatives by government and public / private sector agencies.

The High Level Forum appointed a Steering committee chaired by Prof. A J Paulraj of Stanford University, USA, to advance these initiatives. The Committee, with Prof. A J Paulraj as Chair, was charged to submit its report by August 22, 2018 on matters related to 5G deployment.

The Steering Committee created seven Task Forces, each with a Chair

- Spectrum Policy
- Regulatory Policy
- Education and Awareness Promotion Program
- Application and Use Case Labs
- Development of Application Layer Standards
- Major Trials and Technology Demonstration
- Participation in International Standards

High Level Forum and Task Force Process

The Task Force Chairs then recruited members from various Indian organizations and held periodic meetings. The progress made by the Task Forces was then presented in the meetings of the High Level Forum held in Sanchar Bhavan, New Delhi on Feb 7th, April 19th and June 14th 2018 with Secretary, DoT, in the Chair. At these meetings the High Level Forum reviewed the work done by the Task Forces.

The last meeting of the High Level Forum was held on Aug 23, 2018 at which time the Report prepared by the Steering Committee was approved.

Structure of Report

The report begins with a brief historical perspective on wireless services in India, and then discusses an overview of 5G services, global status and deployment timelines, Network and enabling technologies and the potential benefits of 5G to India. The report then summarizes the recommendations developed by the Task Forces to facilitate early, efficient and pervasive deployment of 5G. The report outlines action plans and monitoring mechanisms, and ends with a concluding section.

Introduction and Background

Wireless Networks in India

India's history with wireless services began early. The first experimental wireless telegraphy links were demonstrated as early as 1902. A Department of Wireless Telegraph was created soon thereafter, and wireless telegraphy came into routine use in Calcutta at Diamond Harbour in 1908. However, widespread use of wireless technology had to wait 90 more years. The first mobile phone service was launched in 1985 on a non-commercial basis, but it was only in 1995 that commercial service was started. The initial subscriber growth was modest, however new policy initiatives, beginning 2007, spurred rapid growth with the subscriber base reaching 560 million in 2009 and well over a billion by 2017. Early deployment of mobile networks was based on 2G technology, with 3G technology entering service in 2010 and 4G in 2016. All mobile services from 2G to 4G offered services based on increasingly advanced phones, with smart phones arriving about a decade ago.

2G and the early 3G networks primarily offered voice services, but beginning with later 3G and now 4G technologies, the networks provide internet based services like video, email, and social media. 4G technology has been a major inflexion in mobile technology with packet-switched data transmission and high speed connectivity.

4G networks now serve 240 million subscribers in urban areas across the country. LTE coverage in rural areas remains a challenge. 4G link speeds in India are picking up, averaging 6-7 Mbps as compared to 25 Mbps in advanced countries.

5G – The Next Generation Network

The macro level requirements for 5G have been defined by the International Telecommunications Union (ITU) in its 'IMT 2020' specification. The ITU significantly broadened the concept of mobile networks taking service delivery to new class of endpoints. The 3GPP (3rd Generation Partnership Project), an industry driven standardization body, that has undertaken the standardization of mobile technologies for the past 25 years and is currently developing standards for 5G networks based on the ITU requirements.

The 5G standards envisage various types of wireless services - high speed links with peak rates of 2 to 20 Gbps, low speed links but with high connection density

(one million per Sq. Km.) for sensing and actuating devices (IoT), and a completely new class of links that achieve both low latency (less than 1 millisecond round trip time) and high connection reliability (link outage of 0.99999). These services put together have the potential of creating revolutionary class of applications. 5G will extend the use of wireless technologies, for the first time, across completely new sectors of the economy. 5G will enable both existing and new wireless service providers to develop novel business models to offer innovative applications to individuals and to different economic verticals from industrial, commercial, educational, healthcare, agricultural, financial and social sectors. These verticals can be serviced through public and private sector enterprises and in certain cases directly by the government agencies.

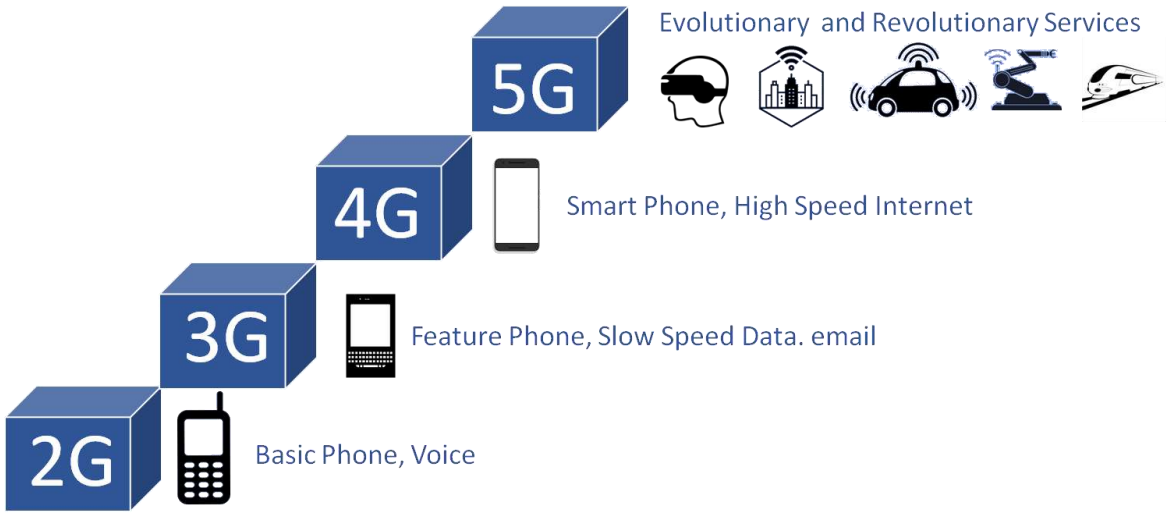

Fig. 1: Evolution of Mobile Networks in India

5G Trials

More than 150 pre-commercial 5G trials are underway around the world. A major showcase was in South Korea, where Korea Telecom, working with Samsung Electronics, Intel and Ericsson demonstrated a 5G network during the Winter Olympics in PyeongChang. In the US, Verizon and AT&T are carrying out 5G trials (both mobile and fixed access) across several cities and plan to launch 5G services in 2019.

Several trials are also underway in China. In Europe, several trials are underway with a focus on delivering services to high speed vehicular subscribers like cars on motorways and intercity trains.

However, so far, 5G trials are yet to begin in India.

5G Deployment Timeline

The vendor eco-system for 5G is maturing. Nokia, Ericson, Huawei and ZTE have production ready equipment in trials based on 5G-NR standard. China Telecom is doing a pilot deployment in six cities ahead of the full 5G commercial launch in 2020. Several other countries have announced deployment schedules.

5G deployment can be classified into three phases.

- Phase 1 – Fixed Wireless Access services in the millimetre-band with 0.5 to 1 Gbps links by 2019. And mobile services in the < 3 GHz band by 2020. By 2021, many countries across the world will have deployed 5G broadband services.
- Phase 2 – 5G based IoT technology is expected to begin around 2021. While small IOT networks built around earlier technologies like NB-IoT, LoRA and Cat M have been deployed, the entry of 5G IoT will accelerate these trends.
- Phase 3 – Low latency and highly reliable wireless services will debut in 2022 and offer new applications like car platooning, remote machinery control, drone navigation, and tele-surgery.

In India, 5G deployment strategy faces conflicting considerations. If we go for early adoption, the equipment is likely to be more expensive and being early, it will also be glitchy needing costly maturing. On the other hand, early adoption will fast track the country's embrace of 5G's benefits and increase opportunities to develop innovative use cases that support Indian needs. Balancing these conflicts needs study.

It is also important to note that even after the entry of 5G into the Indian networks, the earlier generation mobile technologies - 2G, 3G and 4G, will continue to remain in use and it may take 10 or more years to phase out.

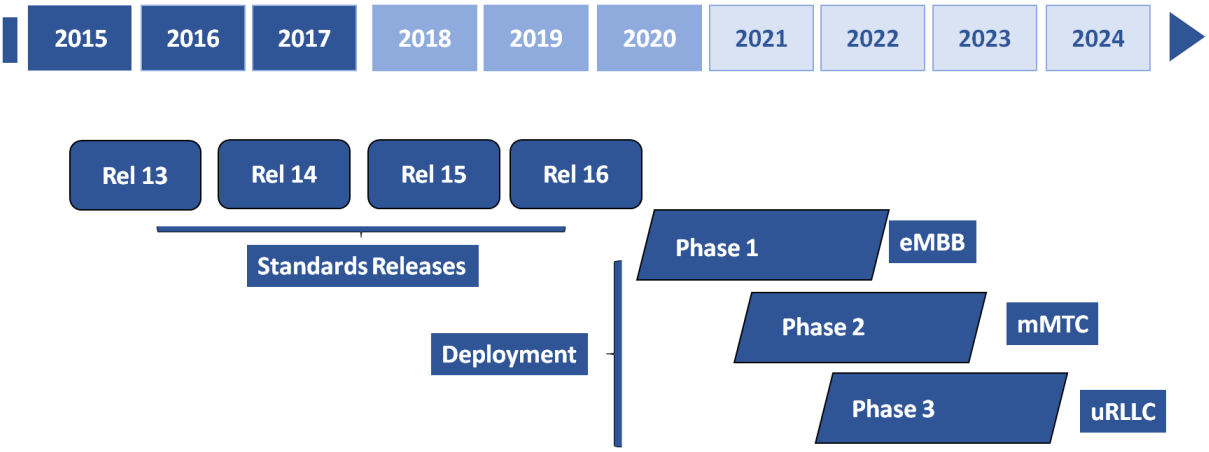

Fig. 2: Roadmap of 5G Standardization and Deployment

5G Initiatives in India

The Government has launched a program titled 'Building an End-to-End 5G Test Bed' to advance innovation and research in 5G. This three year program began in March 2018, with a budget authorization of Rs 2,240 million. The program has been awarded to IIT Madras, IIT Hyderabad, IIT Delhi, IIT Kanpur, CEWIT, SAMEER and Indian Institute of Science (IISc), Bangalore. The program envisages close collaboration between the universities and small technology companies. The goal of the program is to build proof-of-concept 5G prototypes that are broadly compliant with the 3GPP standards. Several smaller academic R&D programs around 5G themes have also been funded by DST and MEITY.

Ericsson has installed the first public access 5G test bed at IIT Delhi in July 2018 for developing applications in the broadband and low latency areas providing access to the industry and institutions to work on India specific usage scenarios and applications. The industry is encouraged to take lead and establish more public test beds in the country.

On the standards front, DoT and TSDSI in collaboration with the IITs have been successful in getting the Large Cell Low Mobility (LMLC) use case accepted in the IMT 2020 requirements. LMLC reflects the needs of rural India and other similar countries. TSDSI is currently working with 3GPP to include specifications in Release 15 standard that support the LMLC use case.

5G Global Eco-System

5G is a new member of the vast global telecommunications eco-system. The four major components of this ecosystem are Standards Development, Equipment Design and IP Development, Manufacturing and Service Provision.

The standards development is dominated by international institutions with roots in US and Europe. Some examples of these are 3GPP, IEEE and IETF. Till around 2005, US and Europe heavily dominated standards process, but East Asian countries have since become very active in standards.

Equipment design / IP development is currently dominated by a few large global companies based in US, China, Europe and East Asia. Good examples are Qualcomm, Intel and Broadcom for semiconductors design or Nokia, Ericsson, Samsung and Huawei for OEM / system integration.

Manufacturing has two segments, the first is semiconductor fabrication plants (Fabs) which build semiconductor chips based on design provided by fabless semiconductor companies. These Fabs are now largely in East Asia – Taiwan, China, South Korea, Singapore and Japan, with TSMC in Taiwan and Samsung in South Korea being prime examples. The other manufacturing segment is Assembly and Testing where end products like phones or base stations are assembled. This segment is dominated by either dedicated plants like those of Samsung or contract manufacturing facilities like Flextronics that serve multiple clients.

The network operator or service provider segment have been less dominated by global players, and most countries, driven in part from regulatory pressure, have locally owned service providers. Sometimes, local TSPs have partnered with international TSPs to bring in capital and expertise. In India, the major TSPs are Airtel, Jio and Vodafone-Idea.

Indian Participation in the Global Eco-System

It is noteworthy that standards development, product design or IP development (semiconductor or systems) and semiconductor manufacturing are now increasingly important and improving India's participation in this league must be a major priority for the country, at least from a national security angle.

In the case of building Design and IP based technology companies, the massive investments needed and difficulty in competing with established multi-national corporations has proved to be so far a significant barrier. Also, we should

understand that, 5G is just another end user technology vertical among a broad range of other ICT technologies that include cloud computing, optical and wired networking, WiFi, and office/factory automation. All these ICT technologies verticals rely on a base of core technologies like computing, communications, artificial intelligence, signal processing, security, and block chain. Growing India's participation in 5G technology will only be possible by growing its base capability across the core technologies that underlie ICT technology verticals.

Semiconductor manufacturing is automated and a high skill operation that demand both massive investments and skilled technologists. Given the highly competitive nature of this industry, it can also be commercially risky. Building a semiconductor manufacturing capability in India needs urgent attention to break into this segment either by attracting MNCs to India or to set up Indian or joint venture plants.

Assembly and Test segment of manufacturing is one segment where India has built reasonable capabilities, thanks to MNCs like Nokia, Ericsson manufacturing Telecommunications Network equipment and Samsung and Xiaomi operating smart phone assembly plants in India. C DoT licensed companies, other domestic companies such as Tejas, VNL, Coral etc., have already established base for telecom equipment manufacturing and R&D in the country with a few new generation SMEs appearing on horizon. There are now encouraging signs of growth in this sector and the increasing cost of labour in China and Taiwan presents an opportunity for India.

Given the barriers inherent to building India's capacities in Equipment Design with IP Ownership and Semiconductor Fabrication, India needs an Apex level policy initiative that can address this crucial national priority.

5G Relevance to India

5G has been designed for global adoption with flexibility to support wide number of applications. Its adoption in India will involve many use cases adopted widely in the world, but also some unique applications to suit India's needs. 5G's value for India may be even higher than in advanced countries because of the lower levels of investments in physical infrastructure. 5G may offer 'leapfrog' opportunities by providing 'smart infrastructure' that offers lower cost and faster infrastructure delivery. A good example of this leap frog effect, in the past, was in telephony. India's telephone density till the late 1990s remained small due to high cost fixed line telephony. However, the arrival of

mobile networks vastly reduced cost of service delivery and the country's telephone penetration went from less than 5% in 1995 to 95% by 2010, bringing striking benefits to the Indian economy.

A more recent example of a leapfrog effect is ride sharing made possible by wireless internet access on 4G smart phones. Shared ride hailing services have transformed the infrastructure efficiencies in utilization of shared cars, autos and motor cycles. Though still early in its growth, vehicle sharing promises significant infrastructure value.

5G technologies will offer even more opportunities in infrastructure efficiencies. For example, 5G will enable 'vehicle platooning', a technology that exploits 5G's low latency communication capability to pack vehicles into platoons with low inter-vehicle spacing despite travelling at high speeds. 5G will allow rapid coordination between the vehicles and keep the vehicles in the platoon safe. Platooning can double vehicle density in roads promoting efficient and safer use of the limited road infrastructure.

In manufacturing, 5G will enable use of robotics for precision manufacturing, particularly where humans cannot perform these functions safely or with the necessary precision. 5G can also enable better logistics to track goods from raw materials to product delivery and improved sharing of expensive design and manufacturing resources across the country.

In agriculture, 5G can enable improvement in the entire value-chain, from precision farming, smart irrigation, improved soil and crop monitoring, to livestock management.

In the energy sector, 'smart grids' and 'smart metering' can be efficiently supported enabling growth of alternate energy technologies. With the rise of renewable and storage technologies, low latency communications will be critical to manage these grids.

In health-care, 5G can enable more effective tele-medicine delivery, tele-control of surgical robotics and wireless monitoring of vital statistics.

With over 300 million in the Indian middle class living in urban areas, a variety of 5G business models for new services are likely to be successful. However, the economically weaker sections of the population will need special help to benefit from 5G technologies. Clearly, it is this segment of population living in smaller towns and villages that require special attention from India's 5G initiatives.

5G Network and Enabling Technologies

5G Network

ITU-R defined a series of requirements for 5G in the IMT 2020 vision and the 3GPP standards body has been defining the detailed standards to meet ITU requirements.

3GPP has proposed three main technology categories and corresponding use cases for the 5G.

- **eMBB** – Enhanced Mobile Broadband. This category supports ultra-high-speed connection indoors and outdoors, with uniform quality of service, even at the cell edge. These services should also support high user mobility on highways, trains and aircraft. The technology allows for more dynamic and adaptive delivery of real-time capacity and effortlessly supports new services like Virtual Reality and Augmented Reality. Outdoor data rates up to 2 Gbps and indoor of up to 20 Gbps are envisaged.

- **mMTC** – Massive Machine Type Communications. This supports a very large number of connected devices usually called Internet of Things (IoT), with varying quality of service requirements. The objective of this category is to provide very high density of connectivity where a single Base Station can support 10,000 or more devices providing an aggregate connectivity for more than a million devices per square kilometre at the network level. This category offers many applications like smart cities, smart power grids, smart-farms to mention a few.

- **uRLLC** – Ultra-reliable and Low Latency Communications. This category has stringent requirements such as latency of less than one milli-second and low packet-loss rates of better than one in 10,000 packets. This technology opens a brand new dimension to the application of wireless networks such as tactile Internet, emergency response, collaborative robotics, intelligent transportation, eHealth, drones, and public safety.

5G Enabling Technologies

For 5G to deliver on its promise, it will also need enabling technologies for deploying networks efficiently and flexibly. Some of them are IoT devices, Millimetric Band, Network Function Virtualization (NFV), Network Slicing (NS), MIMO, Software Defined Networks (SDN), Distributed or Edge Cloud Computing and Artificial Intelligence / Advanced Analytics.

These technologies (other than MIMO and millimetric bands covered in 3GPP) will be standardized by other SDOs like IETF, IEEE and ad-hoc Industry groups.

- The Internet of Things (IoT) is a generic term describing the practice of adding internet-connected sensors and actuators or controllers to objects, infrastructure or locations, and using the data to provide an improved service or capability. It is expected that the use of such devices, which can communicate with one another quickly and reliably, will automate a range of economic verticals including smart homes and smart cities. The deployment of IoT sensors is already well-advanced in some sectors, but 5G is expected to accelerate the uptake of IoT.

- Network Function Virtualization refers to use of high performance computing server farms to implement via software many functions of a wireless infrastructure like the physical and medium access layers that were earlier implemented by dedicated hardware / semiconductors. NFV will bring enormous savings and flexibility in rolling out 5G wireless networks.

- Network Slicing refers to the partitioning of 5G networks to provide dedicated capacity for technologies and applications. For example, network slicing in 5G could provide dedicated resources to IoT devices to ensure that they work effectively in particular areas or industries. Network slicing may also allow for sharing of a capital-intensive 5G network between many operators.

- Software Defined Networks: In traditional IP protocol networks, routers were placed at confluence points to route or switch the flow of packets to ultimately reach the destination node. The associated routing table was based on local knowledge of link congestion which may vary from time to

time and the routing logic was determined by the IP address of the destination node.

In SDN the routing tables are managed centrally by an entity which has a global view of the network link states. Also routing strategies can be more flexible than IP address of the destination node. These features allow much more efficient routing, and SDN will be a key technology for 5G.

- Millimetric Bands: Mobile technologies from 1G to 4G have been deployed below the 3 GHz band, with < 1 GHz band being the favoured due to higher coverage. Millimetric bands in 5G refer to its operation in the 24 to 70 GHz range. One advantage in these high frequency bands is availability of wider bandwidth channels. However, in these bands, the cell sizes also drop to < 200 Meters.

- Multiple Input Multiple Output (MIMO) wireless multiplies data rates by using multiple antennas both at the transmitter and the receiver to enable 'Spatial Multiplexing' that creates parallel data streams equal of the number of antennas. The technique requires special encoding of signals at the transmitter and corresponding decoding of the entangled signals at the receiver. MIMO therefore effectively multiplies the radio spectrum, a scarce and a very expensive resource. Current LTE and WiFi systems support eight MIMO streams. 5G networks are moving to millimetric band spectrum will allow the use a much larger number of antennas. This will boost MIMO leverage by 100X or more in the next few years.

- Distributed / Edge Computing: Traditional cloud computing offers many economic advantages from centralizing compute server functions particularly by sharing of resources. However, these server farms are often located at remote locations where cost of power and cooling are economically advantageous, which also means that applications that need rapid response / low latency are disadvantaged. Edge computing locates the shared compute resources much closer to the service endpoints like 5G base stations or NFV servers.

- Artificial Intelligence / Advanced Analytics: The number and variety of 5G links will increase by 100X over those supported in current 2G, 3G and 4G networks. This will both complicate network management, anomaly/ fault

detection and optimization. The role of machine learning and advanced analytics will vastly increase in 5G networks.

Taken together these features will allow operators to deploy at lower cost points, develop differentiated business models and better manage the networks for performance and reliability.

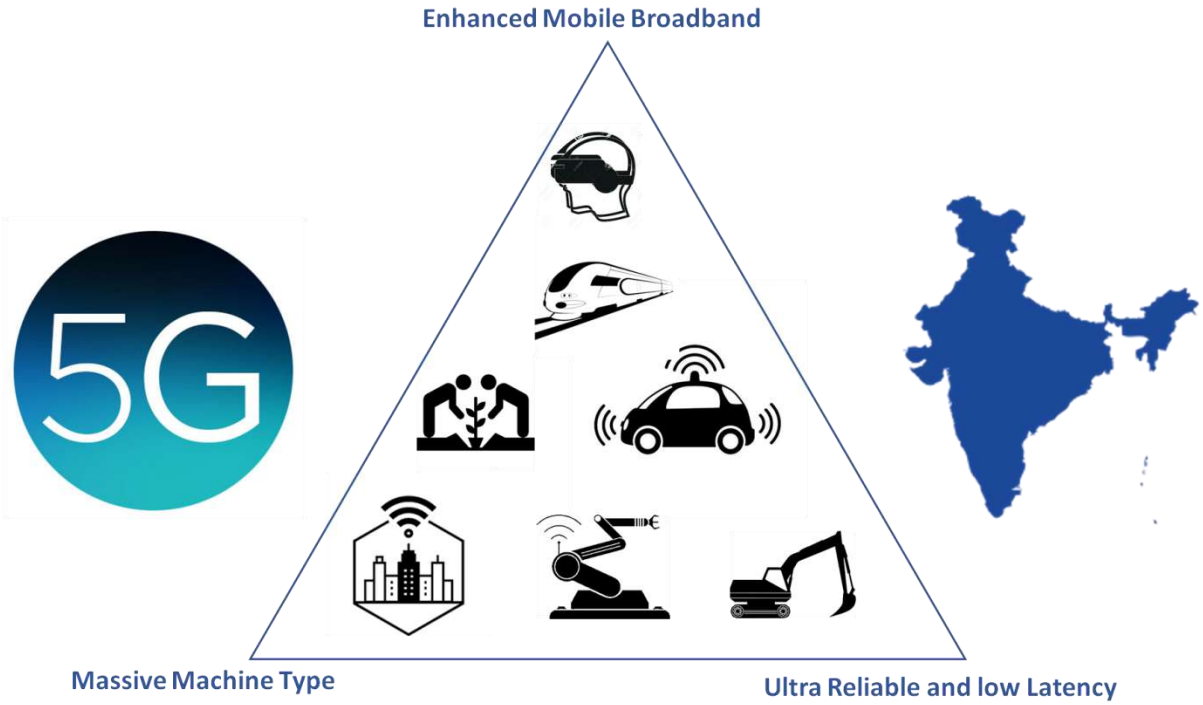

Fig.3: 5G Applications in India

Key Recommendations

We now discuss the key recommendations of the Committee to enable early, efficient and pervasive rollout of 5G in India.

These recommendations recognise the following underlying factors:

- 5G will serve a much broader range of consumers including many economic verticals unfamiliar with wireless technology.
- The 5G technology is currently aimed at applications in the developed countries, India will have to adapt 5G for the country's needs.
- India has begun to participate in the 5G eco-system and needs to catch up quickly.
- 5G must reach economically weaker and the rural segments of our society and be an inclusive technology.
- 5G needs new spectrum bands to operate effectively.
- 5G is a much denser network requiring regulatory support for rapid deployment.

The Committee's recommendations are a summary of those proposed in the following Task Force Reports.

- Spectrum Policy
- Regulatory Policy
- Education and Awareness Promotion Program
- Application & Use Case Labs
- Development of Application Layer Standards
- Major Trials and Technology Demonstration
- Participation in International Standards

Recommendations on Spectrum Policy

Chair: Prof. Abhay Karandikar, Director, IIT Kanpur

Radio spectrum is a scarce national resource, and spectrum policy is key to enable cost effective and quality wireless services. Due to the criticality of 5G networks for India, a supportive spectrum policy is important.

India's quantum of spectrum allocation needs a big fillip. For example, total licensed mobile spectrum is about 220 MHz as compared to 608 MHz in USA and 353 MHz in UK. Further, the cost of spectrum, relative to per capita GDP, is much higher than most countries. Both these factors drive up infrastructure costs. Also, in recent years, the high cost of spectrum has left large quantities of unsold spectrum. It is important that India correct these anomalies in 5G.

Another factor is spectral efficiency. This refers to data throughput delivered per unit of Hz of bandwidth. This is largely determined by the underlying 5G technology. However, wise spectrum allocation and high spectrum reuse in deployment also impacts spectral efficiency.

A Task Force was formed with Prof. A Karandikar as Chair to study and recommend a spectrum policy for 5G.

5G standards envisage services in different bands that range from below 1 GHz to 70 GHz. Each band has it unique advantages and disadvantages like available bandwidth and propagation characteristics, but together the collection of 5G bands should enable efficient delivery of 5G services.

To arrive at the spectrum policy recommendations, the committee took cognizance of the recommendations of international regulatory and standards bodies, availability of spectrum in the country, co-existence with other domestic services and the need to align India with the global market place to benefit from product eco-systems and support ease of international roaming.

The committee suggests that the release of 5G spectrum be done in three tiers of certitude.

a. Announce Tier – here certain bands are declared as being made available for 5G rollout, providing certainty to the eco-system.

b. Identify Tier – here bands are designated for potential 5G use which can be moved to the Announce Tier after coordination with other domestic users.

c. Study Tier – here bands are designated for exploratory studies for 5G use. These bands should be considered as only of potential availability for 5G networks.

The committee recommends the following spectrum allocations.

- **Radio Access Spectrum**

  The recommendations for radio access fall into three broad categories.

a. Below 1 GHz category where spectrum is limited, but has favourable radio coverage, making this band suitable for mMTC type services as well as high mobility eMBB broadband services.

b. The 1 to 6 GHz category that has wider spectrum availability but reduced coverage, makes these bands suitable for eMBB and uRLLC type services.

c. The millimetric Bands in the 24 to 41 GHz block that has plenty of spectrum but has limited coverage, making it most suitable for low mobility and Fixed Wireless Access (FWA) services.

These allocations will be under regular licensed regime except for one band for shared use. The recommendations at each tier are

- Announce Tier: 698-803 MHz, 3300-3600 MHz, 24.25-27.5 GHz, and 27.5 – 29.5 GHz. Of these, the two mm Bands should be opened free for two years to support rollout trials and indigenous R&D.
- Identify Tier: 617-698 MHz, 1427-1518 MHz, 29.5 to 31.3 GHz and 37.0 to 43.5 GHz. The 37.0 to 43.5 GHz bands should be opened free for two years to support indigenous R&D.
- Study Tier: 3600-3700 MHz. This is a becoming a shared band internationally and will require significant real time co-ordination technology to support sharing. This band should be released after this spectrum sharing technology is available.

- **Radio Backhaul Spectrum**

Radio backhaul connect base stations to core backend networks which in turn connect to the internet cloud. In 5G, due to use of small cells, the base

station density can reach 100 to 200 per Sq. Km. thus increasing back haul density. Since 5G supports high data rates, backhaul must support between 2 to 20 Gbps link speeds. High density backhaul makes fibre-based solutions unviable and instead, favours wireless technologies like Millimetric Band Distribution Networks. This will need wideband spectrum.

The committee recommends that 57-71 GHz be released as unlicensed spectrum for use in back haul and access links and further recommends the release the 71-76 GHz and 81-86 GHz under a light touch licensing regime.

- **5 GHz Wi-Fi Spectrum**

The 5 GHz band has been widely used in the world for Wi-Fi services with over 600 MHz being made available as unlicensed band. In certain countries, due to use of radars in this band, sharing between Wi-Fi and radars is done using the DFS (Dynamic Frequency Selection) protocol.

Currently, only limited bandwidth of 50 MHz is allocated as unlicensed band for WiFi in India for outdoor. The committee recommends that this allocation be expanded, with 5150 - 5350 MHz and 5725 - 5825 MHz bands be unlicensed for outdoor use, and the 5470-5725 MHz band be made unlicensed for indoor /outdoor use maintaining DFS compliance.

There is a necessity to build spectrum management skills and infrastructure in India to deal with growing complexity of spectrum use in India. The country has so far relied on studies from international bodies which do not always reflect India's needs and constraints. There is a need to complement Government's efforts to reduce delays in spectrum release and inadequate spectrum management. The Committee recommends setting up of a Standing Committee with a 5-year-term to advise the Government on building up India's Spectrum technology capability (spectrum management, coexistence studies and dynamic spectrum sharing, etc.) and bring it up to international standards. This will also enable India to be an effective contributor to spectrum studies and policy ITU and APT.

The committee further recommends that enhancing spectrum availability be coordinated with relevant ministries. The committee urges earliest possible allocations of 5G spectrum and reiterates the need to increase the quantum of spectrum availability and to lower spectrum pricing.

Recommendations for Regulatory Policy

Chair: Mr. RS Matthews, DG, COAI

5G offers a range of evolutionary and revolutionary services, which can have a transformative impact on Indian society. Along with spectrum policy, regulatory policy plays a crucial role by enabling telecom service providers to offer high value services quickly and as affordable as possible.

A Task Force was formed with Mr. RS Mathews as Chair to study and recommend 5G regulatory policy initiatives that can improve timeliness, economics and utility of these networks.

Many of the supportive regulatory initiatives can be done at the central government level while others will need to be implemented at the state or even local government (City Corporation, Municipality) levels.

The committee recommends following key initiatives to support 5G roll out

- **Permitting Process**

  5G will require massive addition of above and below ground infrastructure, both in passive and active categories. These range from backhaul radios, antennas, towers, street furniture, and ducts etc. 5G infrastructure densification can exceed 1,000 Base Stations per Sq. Km.

  Enabling policy and processes for right of approvals and clearances are critical for infrastructure densification. A friction free permitting process for 5G is essential. We recommend that the DoT create strict guidelines for the State and Local Governments in issuing clearances. These guidelines should also be promulgated uniformly nationwide. Some key improvements in permitting are - enabling online applications, reduced fee structures, single window clearance, and time bound permit decisions. Realizing India's 5G vision requires an improved permitting process.

- **Financial Support**

  Since 5G networks will need new business models, it will bring higher investment risks to service providers. Therefore, rapid deployment of 5G will benefit from some risk mitigation. We recommend that the Government offer a comprehensive support package. One example of support can be to

designate 5G networks as essential infrastructure and allow Telecom Service Providers access to capital at lower cost. Another example is to formulate a policy for public-private partnerships in innovative but high-risk 5G deployment. Yet, another example is to provide 'economic viability gap' grants for rural deployments using unutilized USO funds.

- **Spectrum Allocation**

  A separate Task Force is looking at spectrum. However, from the regulatory perspective, it is important to ensure that spectrum is auctioned at a reasonable price. It is important to study global trends and come up with suitable pricing for Indian market.

- **Smart Infrastructure**

  India will make large investments (estimated at USD 100 billion) over next 5-7 years to create nationwide 5G infrastructure. To improve deployment metrics like early deployment, aesthetics, physical impact and cost efficiency, several initiatives are needed. We recommend the Government create Guidelines on 'Smart Infrastructure' for State and Local Governments for uniform nationwide adoption. Some specific recommendations are:

  a. **Improved Infrastructure Sharing.** Several infrastructure elements can be easily shared with clear benefits to OPEX and TCO. We recommend promulgation of guidelines on infrastructure sharing spanning both passive (towers/ducts) and active (antennas, BBUs and OFC) infrastructure components.
  b. **Improved Aesthetics.** With the need to deploy new towers and enable site densification for 5G networks, the appearance of infrastructure, particularly at street level will be important. As building permits become more competitive, aesthetics should be an essential evaluation factor. Infrastructure Providers (IP1) must work with local bodies to install aesthetically designed infrastructure.
  c. **Use of Street furniture.** The high infrastructure densification in 5G will benefit from use of street platforms like lamp posts and utility poles for mounting infrastructure elements. We recommend promulgation of guidelines on release of street furniture to IP1s at reasonable rates.
  d. **Inside Building Infrastructure.** 5G will also be deployed for services within buildings. It is important that provisioning of 5G infrastructure

be mandated in building codes for large MDUs and Office buildings, and necessary guidelines may be promulgated.

e. **Common Telecom Infrastructure (CTI).** New civil infrastructure like highways, roads, canals and utilities (gas, electricity, water) lines should be mandated to provision CTI resources such as ducting and power junction boxes to support 5G infrastructure.

f. **Backhaul and Fronthaul.** 5G will require backhaul at much higher levels of densification and data throughput compared to 4G. Both fibre and millimetric Band wireless can support this need. We recommend promulgation of guidelines on backhaul infrastructure to enable ease of deployment.

- **Net Neutrality**

  A policy on this has been issued by the Government. The committee encourages wider consultations with all stakeholders.

- **Cyber Security Audit of Infrastructure**

  Security audits, a prerequisite for importing of equipment before deploying in Indian networks, needs to be simplified. While TSPs agree on the need for security audits, a more distributed and trust-based audit mechanisms should be created to speed up certification. We recommend revision of policy on this matter.

- **Privacy and Data Protection**

  This is a major concern to consumers and also poses public security vulnerabilities. Government should promulgate effective but easy to implement mechanisms to protect user data and privacy. Social Media has also created new vulnerabilities. We recommend urgent promulgation of stringent guidelines.

- **Physical Security of Infrastructure**

  The Government needs to promulgate policies to address incidence of vandalism and theft as it may get worse with high density 5G networks. We recommend promulgation of guidelines on vandalism proof design, installations and real time protection of infrastructure components.

- **Human Safety**

  Comprehensive international guidelines exist governing exposure to radio waves used as 5G frequencies. The limits have been established by independent scientific organizations, such as the International Commission on Non-Ionizing Radiation Protection (ICNIRP), and include substantial margins of safety to protect all people. Greater Indian participation in international forums is important to ensure implementation of best practices in the country.

The committee believes that the regulatory initiatives outlined above will help significantly advance 5G deployment in India.

Recommendations on Education and Awareness Promotion Program

Chair: Ms. P Kumar, DG, TSDSI

Since 5G will offer valuable applications to many economic verticals like agriculture, transportation, healthcare and manufacturing, it will be important that these consumers build knowledge and skill sets to make wise choices on 5G technology and drive innovative applications. Hence, there is a need for strong education and skills development program in the country promoting awareness on opportunities and benefits of 5G.

A Task Force was formed with Ms. P Kumar as Chair to study and recommend 5G related educational and skills development initiatives.

A summary of the recommendations follows.

- **Global 5G Events**
  High profile global 5G conference and trade shows offer learning opportunities on technology, business models and applications. Today, such events are held in advanced countries and India may also host such major 5G global events. While large Indian TSPs can attend such events abroad, most potential 5G users – a small municipality, a cooperative bank, or even a dairy cooperative, cannot afford to do so. It will therefore be useful if such global events are hosted in India as well. We recommend a strong effort be made to bring such events to India and distribute them across the major metros.

- **India Centred 5G Events**
  While a few global events should be attracted to India, we should also develop national level 5G events which can provide deeper reach to key consumers in the government, economic verticals, and academic institutions. These events should be geographically diverse and wherever appropriate, also support local languages. A clear emphasis, in these events, should be on 'inclusive 5G' where applications that address rural needs and those of the lower economic sections of society are highlighted. Another important aspect is to provide collaborative

platforms for the technical community (start-ups, SMEs, research labs and academia) to connect and engage in joint projects to build 5G solutions.

- **Skills Development**

  Apart from conference events, we also need structured skills development programs. The target audience will include university faculty, engineering staff, administrators and also address the up-skilling and re-skilling of workforce engaged in development, manufacturing, deployment and maintenance of 5G -solutions. These programs should be geographically (and perhaps language) diverse to reach a variety of 5G consumers.

  Skills development should address 5G applications, radio and network technologies, deployment and regulatory norms, and entrepreneurship. This will also require developing pedagogical material for dissemination beyond classroom settings, through hands-on lab projects, pilot and early deployment field projects, virtual labs, on-line tutorials and webinars. This initiative can also leverage existing Government programs such as GIAN and as well as programs available through ITU and UN.

  A good web portal that aggregates information and course material in an easily accessible format is essential.

Recommendations on Applications and Use Case Labs

Chair: Ms. P Kumar, DG, TSDSI

5G technologies vastly expand applications to go beyond those offered today on personal phones, to new classes serving different economic verticals. Also, many of these applications will be specific to the country's developmental, geographical and cultural differences. This is a very different situation from the 1G to 4G networks era where the same phone model, e.g., Samsung Model 9S, can be sold around the world and offer the similar services successfully. In 5G, the use cases relevant to India may differ in many respects from those in Japan, and the use cases in Japan may differ in some respects from those in the US. Therefore, India may require customization of use cases or even designing completely new use cases.

Applications and Use Case labs can provide many useful functions: Showcasing applications, testing interoperability, and promote development of innovative applications. Applications and Use Case labs can be used by industry verticals, wireless technology companies and application developers.

A Task Force was formed with Ms. P Kumar as Chair to study and recommend a framework for 5G related Applications and Use Case Labs (UCL).

A summary of the recommendations follow.

- **UCL Economic Verticals**

  UCLs should be set up in each economic vertical with the support of the corresponding ministry and public or private sector industries. In the first phase, we recommend Agriculture, Health, Banking and Railways UCLs. In the second phase, Education and Urban Development and finally in third phase, Manufacturing, Water and Power. The scope may be extended as other vertical ministries get engaged (eg. Defence, Transport, etc.)

- **UCL Business Models**

  Business models may differ depending on the vertical – for example a UCL for Indian Railways (a public sector entity) will be very different from a banking UCL, which has strong private sector participation. We need a 'learn-as-we-go' approach for business models.

- **UCL Schedule**

  The committee recommends we start with two UCLs (Railways and Banking) on a trial basis to better understand workable business models and management structures before expanding to other verticals.

  Each UCL may evolve in three phases of six months each. Phase 1 - design and set-up of the UCL, Phase 2 - conceptualize use cases based on demonstrations and simulations, and Phase 3 - offer proof of concept, interoperability and pilot testing.

Recommendations on Participation in International Standards

Chair: Prof. B Ramamurthi, Director, IIT Madras

Standards are essential to telecommunication networks. Standards serve many functions:

a. Micro Interoperability between devices that communicate with each other (e.g. a phone and a base station) or between one application to another application (e.g., Ola App and Location App).
b. Macro Interoperability of telecom systems dispersed across oceans and national boundaries.
c. Market Consolidation where telecom systems are expensive to develop and such investments are generally only sustainable when there is a large market size enabled by a common standard.

Standards Development Organizations (SDOs) in ICT have a long history, with ITU, IEEE, 3GPP, and IETF among the prominent bodies. Many nations also have national standards bodies that while aligning with global SDOs, also develop local standards and provide inputs to global SDOs. Some examples are ETSI (Europe), CCSA (China), and TIA (USA). India has also set up a national SDO, TSDSI in 2014.

Telecommunications technology has seen rapid advancement and breakthrough technologies like Internet, World Wide Web, MIMO etc. Telecom standards are therefore 'invention heavy' and companies or labs that are at the forefront of such inventions and innovations are key players in global SDO process and gain significant monetary value from their IP. If an invention is accepted and incorporated into a standard, the underlying patents become Standards-Essential Patents (SEPs), and perforce must be licensed by all manufacturers who build equipment based on the standard. Companies from major industrialized countries like US, Europe, Japan, Korea and lately China are very active and influential in global standards bodies. Large teams (40 or more) from these companies participate regularly in international standards forums.

India is among the world's largest markets for telecom equipment and has the world's second largest user base. There is a significant opportunity to participate in the global SDO process. On 5G front, in 2017, an effort has been launched for including a LMLC (Large Cell Low Mobility) concept in the IMT 2020 requirement.

This was successful and now efforts are underway to get 3GPP to support LMLC in its standard.

India's low key participation in SDO process comes with following implications:

a. India has no choice but to use telecom solutions developed to suit the needs of countries that dominate the standards process.

b. Potential impact on consumers of royalty payments to SEP holders (typically 5% of unit cost).

c. There are negative pressures on local technology eco-system which perforce must build standards compliant solutions but have no influence in the standards process.

It should be noted that most of the participants in SDO process are from companies building telecom products and for them the participation in standards process have significant benefits – Accumulation of SEP IPR, Aligning standards to support IPR assets, and Aligning standards to reflect their technological strengths and market positions.

These advantages are all vital to their survival. The participating companies command multi-billion USD revenues, so they can afford significant investments in the standards process. India requires to establish this industrial substrate through government interventions to kick-start the virtuous cycle complementing corporate-based standards process.

A Task Force was formed with Prof. B Ramamurthi as Chair to study and recommend a policy for India's participation in Standards Bodies.

Given the scenario outlined above, the committee recommends that the Government fully fund a national initiative in SDO participation and increase India's profile in global standards. SDOs for Indian participation may include ITU, 3GPP, IEEE, oneM2M and IETF. Priority technology areas are 4G and 5G standards, WiFi, Future Network, Smart Cities and Network Management.

The key recommendations are:

- **Focussed Projects Teams**

  To kick-off immediate enlargement of India's participation in SDOs, collaborative teams of 3-4 experienced engineers and researchers drawn from industry, government and academia, may be formed. A single project team must have continuity of personnel for about 2 to 3 years.

Three project teams can begin in year one and scaling up to ten teams by year three. This will give India about 25-30 dedicated engineers involved in the standards process. Though, still small it will, at least, be a start.

There are issues to be clarified on this structure - protecting the promotion and career factors of participants in their own home institutions, avoiding conflicts of interest and constructing equitable IPR ownership and sharing mechanisms. These should be addressed prior to launching the initiative.

- **Funding Enhancement**

  Organizations like TSDSI, CEWIT and several IITs and IISc participate in global SDO meetings. Government may initiate or increase targeted funding to these organizations to allow them to expand their standards initiatives.

- **Expert Committee**

  Effective participation in 5G and broader information technology standards and acquiring SEPs is vital to support the larger technology goals of India. In the longer term, this will need a broad based effort that identifies all the resources in the country and makes a strategic plan for their optimal use. We recommend an expert committee be constituted to develop a 10-Year national plan for participation in 5G and Information Technology standards.

Recommendations on Technology Demonstration and Major Trials

Chair: Ms. A Sundararajan, Secy. DoT

Globally, over 154 operators and 66 countries have announced or conducted 5G trials**.** The most advanced trials are in the US and in the APAC region. A few of these trials, dubbed as 5G, are for MIMO enhancements of 4G.

5G trials serve multiple purposes such as

a. Increasing awareness of 5G applications particularly in the new segment of users in the different economic verticals.

b. Stimulate local R&D ecosystem to develop innovative applications tailored to Indian needs.

c. Help local TSPs better understand technology and business models for 5G.

d. Encourage OEMs to better target 5G applications for local needs.

India, being the second largest user base of mobile subscribers (after China), provides an opportune market for 5G trials.

A Task Force was formed to attract major OEMs to conduct large 5G trials in India. Ms. Sundararajan, Secy. DoT, Chair has invited Samsung, Ericsson, Nokia, CISCO, NEC, Qualcomm and Intel to conduct major trials in India. The invitation letter is placed at Appendix 4.

The key recommendations of the Task Force are

- **Scope**
  5G has three technology buckets (eMBB, mMTC and uRLLC) with different maturity time frames. All three buckets should be covered in overall trials plan for India and the trials be conducted as and when these technologies are ready.

- **Trials Size**
  A typical eMBB trial should involve 3-4 eNBs and about 100 client nodes. The number of client nodes for mMTC and uRLLC will likely be much larger. The goal is to exercise all the dimensions of the technology – mobility, handoff, propagation variability etc.

- **Duration**
  Trials should be planned for six-month duration to allow for troubleshooting the different applications as well as collection and processing of relevant data.

- **Location and Siting**
  This could be planned in four zones across India, with one trial in each zone. Site selection should consider a range of locations - university campus, metro area and a village setting.

- **Spectrum**
  The Government may assign free of cost spectrum for trials, with a fixed duration to allow setup of the network. Given a six month active trials period, spectrum license may be provided for 12 months. Further, after the trials are completed, if the TSP wishes to convert the trials deployment into a revenue deployment, they may be provided favourable terms to purchase spectrum under the auction regime.

- **Local Partnerships**
  Each zone may have one or more OEM to partner with a major TSP. Given India's service provider profile, BSNL, Jio, Airtel and Vodafone-Idea may opt for a zone each. The major TSPs should partner with smaller TSP like WISPs, and with local equipment vendors, universities, city governments etc.

- **Financial Support**
  The Government may provide financial support to the TSPs related to deployment - backhauls, site acquisition, civil works and trials manpower and related OPEX costs. Additional financial support to ISPs, technology companies, local governments and economic verticals to effectively participate in the trials may also be provided. Partial financial support for CAPEX to the OEMs may also be considered based on equitable risk sharing.

Recommendations on Development of Applications Layer Standards

Chair: Mr. KA Krishnan, VP & CTO, TCS

5G networks will usher in evolutionary and revolutionary services with many 5G applications that will break completely new ground. As is well known, telecom networks need standards to ensure interoperability and to avoid market fragmentation. The Application Layer Standards is the top layer of the standard stacks in telecom networks. Both deployment and technology investments in 5G will not take off without an adequate applications standards framework.

Application Layers are addressed within different technology verticals and unfortunately heavily fragmented. For example, IETF, 3GPP and IEEE, ISO, ETSI, IEC all address application layer standards within their verticals. With new set of applications becoming available through 5G, many SDOs and industry consortiums have started to address Application Layer Standards around 5G. Some recent examples are oneM2M and ISO / Smart City.

Given India's plan to deploy 5G widely, it is important that the country increase its awareness and participation in activities of Standards Development Organisations that work on the application layer standards.

A Task Force was formed with Mr. KA Krishnan as Chair, to study and make recommendations around 5G Application Layer Standards.

A summary of the recommendations follows.

- **Expert Committee**

  The development of Application Layer Standards relevant to 5G is a vast and a complex global enterprise. We recommend an expert committee be formed to develop an actionable 10-year-plan, for the country, on broader issues of participation in standards and SDO process in the Information Technology domain. This committee should also address the Applications Layer.

- **Applications Layer Forum**

  As an interim measure, an Application Layer Standards Forum can be created that will coordinate across the application domain and harmonize

the distributed and currently non-coherent activities. Within BIS, TSDSI, TEC etc.

- **Short Term Measures**

  At least 2 of the 10 standards project teams recommended under the 'Participation in International Standards' task force should be dedicated to Applications Layer standards.

  The action plan proposed under the 'Education and Awareness Promotion Program' Task Force should include the hosting of more international standards body meetings related to the applications layer in India

  The action plan proposed under the 'Application & Use Case Labs' Task Force should include support for interoperability testing of application layer technologies.

Action and Monitoring Plan

Organizational Framework

The committee recommends the following

- Create a 5G Implementation Oversight Committee with participation from Government, Academia, Industry and R&D Labs to supervise 5G program implementation and take corrective steps where necessary.
- Create a 5G Program Office within DoT, with a Program Lead and a supporting team to coordinate all 5G implementation issues among the three departments DoT, MeitY, DST.
- Appoint Expert Committees described below to advise the Government on carrying forward initiatives related to 5G.
- Create full time Special Program Coordinators (SPC) as described below, and based at an appropriate institution, to operationalize specific programs. The SPC will report to the 5G Program Office.

Action Plans

- **Spectrum Policy**

  The Government may announce its spectrum policy by December 31, 2018 and issue the necessary notifications.

  Further, since spectrum planning is a complex and evolving area, the Committee recommends setting up of a Standing Committee with a 5-year-term to advise the Government on building Spectrum Technology Infrastructure - Improved spectrum management, coexistence studies, safety studies and dynamic spectrum sharing technology.

- **Regulatory Policy**

  Appoint three Expert Committees be formed to formulate formal guidelines that can be promulgated by the Government.

  Expert Committee 1 – Business Enablement, Expert Committee 2 – Security and Privacy and Expert Committee 3 -- Smart Infrastructure

  The Committee further recommends that most guidelines on regulatory matters be promulgated by March 2019 to facilitate early 5G deployment.

- **Education and Awareness Promotion under DoT, MeitY, DST**

  Appoint a full time Senior Program Coordinator (SPC), one each from above departments, to implement the committee recommendations. The SPC will be responsible for pulling together resources from across various institutions concerned and will report to the 5G Program Office.

- **Application & Use Case Labs**

  Appoint a full time Senior Program Coordinator (SPC) one each from DoT, MeitY and DST, to implement the recommendations of the Task Force. The SPC will be responsible for pulling together resources from across various institutions and will report to the 5G Program Office.

- **Participation in International Standards under DoT, MeitY**

  Appoint a full time Senior Program Coordinator (SPC) within TSDSI, TEC under DoT, and a similar institution under MeitY, to implement the recommendations of the Task Force. The SPC will be responsible for coordinating project teams and will report to the 5G Program Office. Additionally, the Government may constitute an Expert Committee to make recommendations for a five-year initiative to define and plan India's strategy in SDO process (including Application Layer Standards).

- **Development of Application Layer Standards**

  Appoint an Expert Committee to define and plan India's strategy in the SDO process may also include recommendations for the Application Layer Standards.

- **Major 5G Trials**

  While the Government has issued invitations for 5G trials, significant follow-up is needed to ensure successful trials that advance India's 5G progress. The Government may constitute a Trials Oversight Committee for each of the major trial with representatives from the OEM, lead TSP and related entities. These committees should report to the 5G Program Office.

- **Budget Committee**

  As envisaged, 5G India programme requires a significant budgetary support from government complemented by investments from the

industry. Hence, there is a need to have a high level Budget Committee for synergetic engagement with MeitY, DST and user ministries to ensure adequate availability of necessary funding to accomplish the 5G India objectives.

Budgetary Recommendations

The 5G programs will require funding by the Govt. At present there are only notional figures available. The actual funding requirements can only be finalized once well-defined project proposals with budgetary justifications are submitted to DoT.

The committee recommends a broad planning estimate of INR 3000 million in Year 1, INR 4000 million in Year 2, INR 5000 million in Year 3 and INR 4000 million in year 4.

Conclusions

5G is the next generation of cellular communications technology with evolutionary and revolutionary services that can have a deep impact on Indian economy. It can unleash new economic opportunities and societal benefits giving 5G the potential of being a transformational force on society. 5G will enable the country to leapfrog traditional barriers to development like weak infrastructure and physical connectivity. 5G will also advance the 'Digital India' vision. The economic impact from 5G India can exceed one trillion USD by 2035.

Globally, 5G technologies will start entering service beginning 2019 and is expected to advance to a full range of services by 2024. By acting early to embrace the 5G opportunity, India can accelerate the 5G dividends and potentially also become an innovator in 5G applications.

A 5G High Level Forum was set up by the Government in September 2017, to articulate the Vision for 5G in India and to recommend policy initiatives and action plans to realize this vision. A Steering Committee was created with seven task forces on Spectrum Policy, Regulatory Policy, Education and Awareness Promotion Program, Application and Use Case Labs, Development of Application Layer Standards, Technology Demonstration and Major Trials and Participation in International Standards. Based on the deliberations of the High Level Forum and Task Forces, the Committee submitted its 5G report on Aug 23, 2018.

India's mobile networks are, undoubtedly, a success story in term of population reach and affordability. 5G will be an even bigger opportunity and will touch many economic verticals. But India also faces many challenges in 5G, given that the nature of the network is very different from previous generations and will therefore need significant learning and adaptation. Service provider business models may also change significantly.

Making 5G affordable and inclusive being the priority for the government, India has the big opportunity for innovation and to lead the world in 'Inclusive 5G' technology.

While this report makes many recommendations – some relating to policy matters which can be implemented by the Government, there are other actions of programmatic nature that require setting up of teams with organizational structures. We recommend that these structures be grown within existing

organizations maximally. Many programs will also require financial support from the Government.

Clearly, carrying out the Committee's recommendations and actions items will be complex undertaking and needs dedicated leadership at every level. We have recommended that a 5G Program Office be set up in DoT to drive implementation, along with an Oversight Committee to monitor progress and take corrective action.

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Appendices

Appendix 1 - High Level Forum Constitution Letter

No 6-33/2017 –IC
Government of India
Ministry of Communications
Department of Telecommunications
International Cooperation Division

Constitution of High Level Forum for 5G India 2020

5G is the next technological frontier. Digital Transformation through 5G will fundamentally impact other national Mission Mode projects. 5G will provide a new dimension to the Digital India, Smart Cities & Smart Village missions. 5G has potentially large contributions to Make in India and Start-Up India missions. The objective is to position India as a globally synchronised participant in the Design, Development and Manufacturing of 5G based technology, products and applications.

2. In order to steer 5G India 2020, a High Level Forum has been constituted vide OM No. No 6-33/2017 –IC dated 22nd September 2017 with the following Members: -

S. No.	Name / Designation	
1	Secretary, DoT	Chairperson
2	Secretary, MeitY	Co-Chairperson
3	Secretary, D/o Science & Technology	Co-Chairperson
4	Member (Technology), DoT	Member
5	Additional Secretary, DoT	Member
6	Sr. DDG (TEC), DoT	Member
7	Wireless Advisor, DoT	Member
8	Dr. A. Paulraj, Professor Emeritus, Stanford University, USA	Member
9	Mr Gururaj Deshpande - Chairman of Sycamore Networks, Sandstone, USA	Member
10	Prof Bhaskar Ramamurthy – Director, IIT Madras	Member
11	Prof Abhay Karandikar – IIT Mumbai & Chairman, TSDSI	Member
12	Prof Uday Desai –Director, IIT Hyderabad	Member
13	Prof Anurag Kumar – Director, IISc Bengaluru	Member
14	Prof Ramgopal Rao – Director, IIT Delhi	Member
15	Mr. Sanjay Mashruwala - MD, Reliance Jio	Member
16	Mr. Gopal Vittal – MD & CEO Bharti Airtel Limited & Chairman, COAI	Member
17	Mr Ashwani K Aggarwal – Chairman, IESA	Member
18	Mr Ananth Krishnan, CTO, TCS	Member
19	ED, C-DoT	Member
20	DDG(NT), DoT	Member
21	DDG(Security-Assurance), DoT	Member
22	DDG(IC), DoT	Member Secretary
23*	Mr. Anupam Shrivastava, CMD, BSNL	Member
24*	Mr. T. V. Ramachandran, President, Broadband India Forum	Member

Chairperson may co-opt any expert as deemed necessary.
Member at Sl.No 23 & 24 included vide OM of even number dated 31st October 2017

3. The Term of Reference of the High Level Forum for 5G India 2020 shall be: -

a) Vision Mission and Goals for the 5G India 2020, and
b) Evaluate, approve roadmaps & action plans for 5G India 2020.

4. The International Cooperation (IC) Division of DoT along with TCOE India (a PPP of Government, Academia and Industry) will service the Forum. The Forum may constitute Steering Committees of Members for various domains. The Forum shall finalise the Report on 5G Vision, Mission and Goals by March 2018.

4. This is issued with the approval of Hon'ble Minister of Communications.

(Brajesh Mishra)
Director (IC)
Tel: 23717542
Email : brajesh.m@nic.in

To

All the Members of the High Level Forum

Copy for kind information to:

PS to Hon'ble Minister of Communications

Appendix 2 - Task Force Members

Spectrum Policy

Chair: Prof. A Karandikar, IIT Kanpur

Mr. B Bhatia, ITU_APT	Mr. P Kar, Qualcomm	Mr. R Sinha, DoT
Mr. R B Prasad, DoT	Mr. A Pandey, DoT	Mr. K Babu, DoT
Mr. L D Meghwal, DoT		

Regulatory Policy

Chair: Mr. RS Matthews, COAI

Mr. A Shrivastava, BSNL	Mr. M P Singhal, TEC	Mr. V Tyagi, C-DoT
Mr. S K Gupta, TRAI	Mr. R K Pathak, DoT	Mr. T R Dua, TAIPA
Mr. H Krishnan, Cisco	Mr. B Dayal, Indus Towers	Ms. S Rangachari, Sterlite
Mr. TV Ramachandran, BIF	Mr. M K Singh, Indus Towers	Mr. A Jain, Sterlite
Mr. S Singh, Cisco		

Major Trials and Technology Demonstration

Chair: Ms. Aruna Sundararajan, Secretary, DoT

Prof. AJ Paulraj, Stanford Univ.	Mr. TV Ramachandran, BIF	Mr. CS Rao, Quadgen
Mr. N Sivasailam, DoT	Mr. R K Pathak, DoT	Mr. Kishore Babu, DoT

Development of Application Layer Standards

Chair: Mr. KA Krishnan, TCS

Co-Chair: Ms. P Kumar, TSDSI

Mr. R K Pathak, DoT	Cdr. A Vibhuti, TCOE	Mr. V Tyagi, C-DoT
Dr. P Balamuralidhar,TCS	Mr. M Parshad, TEC	Dr. R Shorey, TCS
Mr. R Pitchiah, MeitY	Prof. B Ramamurthi, IIT Madras	Ms. D Tyagi, TEC
Mr. UK Nandwani, MeitY	Prof. A Karandikar, IIT Kanpur	Mr. S Kumar, TEC
Mr. RS Mani, NIC	Mr. K Aravamudhan, Star India	Dr. JK Milleth, CEWiT
Mr. Babu NKJ, CEWiT	Mr. V Madan, TSDSI	Mr. A Rana, Facebook
Mr. S Kumar, TEC	Mr. DC Sharma, ETSI	Mr. S Malhotra, Nasscom
Mr. G N Nath, DoT	Dr. N Rai, Intel India	Mr. Brajesh Mishra, DoT

Participation in International Standards

Chair: Prof. B Ramamurthi, IIT Madras

Prof. A Karandikar, IIT Bombay	Ms. P Kumar, TSDSI	Mr. B K Badola, TEC
Mr. V Raghunanthan, DoT	Mr. J Singh, Qualcomm	Mr. V Tyagi, C-DoT
Mr. A K Mittal, TSDSI	Mr. B Bhatia, Motorola	Mr. DC Sharma, SESEI
Mr. U K Nandwani, Meity	Mr. R Pitchiah, Meity	Mr. B Narayanan, CEWIT

Education and Awareness Promotion Program

Chair: Ms. P Kumar, TSDSI

Mr. R K Pathak, DoT	Cdr. A Vibhuti, TCOE	Mr. Ramakrishna, IMC
Mr. D C Sharma, SESEI	Mr. S Gaur, Indo-EU	Mr. TV Ramchandran, BIF
Mr. H Mysore, IEEE	Mr. R Prakash, C-DoT	Mr. V Tiwathia, COAI
Mr. K Babu, DoT	Mr. V James, Qualcomm	Mr. B Mishra, DoT
Mr. V Raghunandan, DoT	Mr. S Mitra	Mr. B Srivastava, TSDSI
Mr. R Prakash, C-DoT	Mr. U Das, BBIF	Mr. M Bhardwaj, Airtel
Mr. S Malhotra, Nasscom	Mr. S Gaur, Indo-EU	Mr. R Prakash, C-DoT
Ms. Deepa Tyagi, TEC	Mr. S Devar, Ericsson	Mr. B Narayanan, CEWIT
Ms. S Arora, MeitY	Ms. Neena Pahuja, ERNET	Ms. R Soni, DoT
Mr. P Rathod, Intel	Mr. PK Jaswal, TSSC	Mr. M Kulkarni, DST
Ms. V Srivastava, COAI	Mr. S Chitturi, Samsung	Mr. N K Goyal, TEMA
Mr. A Paventhan, ERNET		

Application & Use Case Labs

Chair: Ms. P Kumar, TSDSI

Mr. RK Pathak, DoT	Cdr. A Vibhuti, TCOE	Mr. K Babu, DoT
Mr. N Nath, DoT	Ms. D Tyagi, DoT	Mr. N Ahuja, ITRA
Mr. B Mishra, DoT	Mr. R Pitchiah, Meity	Mr. R Prakash, C-DoT
Dr. M Kulkarni, DST	Mr. D Chanduka, BBNL	Mr. G Patnaik, NASSCOM
Mr. A Gupta, C-DoT	Ms. S Rangachari, Sterlite	Mr. DC Sharma, SESEI
Mr. V Tiwathia, COAI	Mr. Ravikiran, IEEE	Mr. JP Devassy, CDAC
Mr. BS Chauhan, TSDSI	Ms. A Iyer, Fraunhofer India	Mr. M Saeed, Keysights

Appendix 3 – Letter from Secy. DoT on 5G trials

अरूणा सुंदरराजन
सचिव
Aruna Sundararajan
Secretary

सत्यमेव जयते

भारत सरकार
संचार मंत्रालय
दूरसंचार विभाग
Government of India
Ministry of Communications
Department of Telecommunications

DO No 6-33/2017-IC

Dated the 3rd July, 2018

Dear

The Department of Telecommunications appreciates contribution in developing telecom sector in the country. As you may be aware, the Government of India is strongly committed to early, efficient and pervasive deployment of 5G mobile networks in India. We believe that 5G will have transformative role in Indian society.

The Government led 5G High Level Forum (5G HLF) led by the three Secretaries to the Government of India (Telecom, Department of Science & Technology, Ministry of Electronics & IT) and eminent members from Industry, Academia has been constituted to promote the deployment and use of 5G in India.

The purpose of the trials is mutual learning – your company can better understand the Indian market needs and commercial opportunities across industry verticals, while the stake holders within India can build a deeper appreciation of 5G technology, it's deployment needs and the many applications it can support. I would like to add that our Government's vision for 5G is driven by inclusivity, wherein rural and underprivileged populations can also benefit from 5G services. Our aspiration is that India will foster innovation in inclusive 5G and become a global leader in the area. Your engagement will promote the development of use cases from India relevant to global needs.

I have attached a brief Note on our broad thinking on the proposed trials. We would particularly like this trial to break new ground in terms of technology and applications by focusing on emerging economies.

For conducting the trial, we would request your company to provide the infrastructure and resources including equipment, basic client devices and the manpower to conduct the trial. The Government of India would be willing to provide the necessary mobile access and backhaul spectrum for the trials for a period upto one year. Any other resources support you may need to facilitate trials could be further discussed and DoT is open to consider your inputs to enable early large scale

Contd...2/-

संचार भवन, २०, अशोक रोड, नई दिल्ली - ११०००१ / Sanchar Bhawan, 20, Ashoka Road, New Delhi-110001
Tel. : 011-23719898 Fax : 011-23711514, E-mail : secy-dot@nic.in

trials. We understand that you may wish to tie up with any Indian Telecom Service Providers (TSPs) and if needed, DoT could facilitate engagement with TSPs. The Government will facilitate and enable the participation of local industries, local government, and major verticals like transportation, agriculture and others in the trials.

I look forward to your interest and engagement with us as we embark on this journey of opportunities.

Best regards,

Yours sincerely,

(Aruna Sundararajan)

A Brief Note on Purpose of 5G Trials

To build understanding of all stake holders: Equipment suppliers, TSPs, Local Governments, User Verticals and Local Tech companies, in the technology, deployment, applications and efficient exploitation of 5G networks

Scope

Since 5G has three technology buckets (eMBB, mMTC and uRLLC), we would like to see all the three buckets to be covered in the trials as and when they are mature enough. The size / scale of the trials will need to be mutually agreed upon. However, we would like to see 3-4 eNode B and 100 client nodes for the eMBB trials. Clearly the number of client nodes for mMTC and uRLLC will be very much larger.

Schedule

We understand that eMBB technology is rapidly maturing and an early trial may be possible. Clearly mMTC and uRLLC will require more time. We can agree on a mutually acceptable schedule.

We are also keen on one eMBB trial in 4Q 2018 by one of the OEMs.

Duration

We are thinking of a 6-month duration for the trials to allow for fine-tuning the operation, troubleshooting the different applications and collection of relevant data that can be used for more efficient full scale deployments later.

Location

The trails may be large enough to facilitate techno-commercial replications. Sites such as university campus, a small metro area, a village clusters etc. are some suggestions. We look forward to discussing these options.

Local Partnerships

Each OEM may wish to partner with a TSP. We would like to see other partnerships like local equipment vendors, top universities, city governments etc. DoT will play an enabling role to forge these partnerships.

Deployment Support

The Government would be willing to provide the necessary mobile access and backhaul spectrum for the trials. Any other resources support you may need to facilitate trials could be further discussed and DoT is open to consider your inputs to enable early large scale trials. DoT could facilitate engagement with TSPs and access to its resources. The Government will facilitate and enable the participation of local industries, local government, and major verticals like transportation, agriculture and others in the trials.

Appendix 4 – 5G Oversight Committee Letter

File No. 6-33/2017-IC
Government of India
Ministry of Communications
Department of Telecommunications
International Cooperation Division

12th Floor, Sanchar Bhawan, New Delhi
Dated the 6th August, 2018

OFFICE MEMORANDUM

Subject: 5G India 2020 - Setting up of Implementation Oversight Committee for 5G India.

The High Level Forum (HLF) is likely to submit its recommendations on roadmaps for 5G India 2020. Implementation of 5G India roadmap would require multi-dimensional collaborative approach by DoT, MeitY & DST in collaboration with User Ministries, academia, start-ups and industry.

2. Accordingly, the following Implementation Oversight Committee for 5G India is constituted to facilitate implementation of 5G India roadmaps:

1) Secretary, DoT	-	Chairperson
2) Secretary, MeitY	-	Member
3) Secretary, DST	-	Member
4) Joint Secretary (T), DoT	-	Member
5) Chairperson, Implementation Cell of DST	-	Member
6) Chairperson, Implementation Cell of MeitY	-	Member
7) DDG(IC), DoT	-	Member-Secretary

The Chairperson may co-opt more Members / Experts as deemed necessary.

3. Implementation Oversight Committee will work under overall mentorship of Prof. Paulraj, Member of HLF & Chair of 5G Steering Committee. TEC, C-DoT and TSDSI shall act as Resource Organizations for DoT.

4. **The Terms of Reference:**

(i) Oversee the implementation of 5G Roadmap including funding requirements to be met by 3 Ministries/Departments, User Ministries & Industry;

(ii) Work towards convergence of opportunity, knowledge, infrastructure, funding and schemes spread across various Ministries for optimum utilization of National resources;

(iii) Demonstrate, under the guidance of three Secretaries, a few early wins to Government & industry to mobilize the eco-system;

(iv) Any other activity as decided by the Chair.

-2

5. **Focus Area:**

Sl. No.	Work Area & Related Activities	Lead Departments/Nodal Officer
1	Spectrum Policy	DoT / DDG (Policy)/WA
2	Regulatory Support	DoT / JS (T)
3	Major 5G Trials	DoT / DDG(IC)
4	Application Layer Standards	MeitY, DoT
5	Promotion/Educational Awareness	MeitY, DoT, DST
6	Participation in Standards	DoT, MeitY
7	Use Case Labs and Info Hub	DST, DoT, MeitY
8	Start-ups promotion	DST, MeitY& DoT
9	Test Beds	DoT/DDG (NT)

6. **Government Budget/Fund requirements:**

The Implementation Oversight Committee shall work out the detail of activity-wise and Department-wise budget requirements and modalities for setting up of Implementation Secretariat / Strengthening of Implementation Cells.

7. **Setting up of Ministerial Implementation Cell:**

Since the 5G Roadmaps implementation with DoT / MeitY / DST may also require close day-to-day coordination among various divisions / organizations within the respective Department/Ministry, therefore, they may individually set up Implementation Cell, whose Chair will be part of Implementation Oversight Committee.

8. This is issued with the approval of Hon'ble MoSC(I/C).

6/8/2018

(R. K. Pathak)
DDG (International Cooperation)
Email:rajeshkr.pathak@nic.in / Tel: 011-23717542

To

1) **Secretary, DoT**
2) **Secretary, MeitY**
3) **Secretary, DST**
4) **Joint Secretary, DoT**
5) **Sr. DDG, TEC**
6) **DDG (NT) / DDG (Policy)**
7) **Executive Director, C-DoT**
8) **Chairperson, TSDSI**

Copy to:

Prof. A. J. Paulraj, Professor Emeritus, Stanford University, Member of HLF & Chair of 5G Steering Committee.

For kind information to:

1) **PPS to Member (T)**
2) **PPS to Member (F)**
3) **PPS to SS (T)**
4) **OSD to Hon'ble MoSC(I/C).**

File No. 6-33/2017-IC
Government of India
Ministry of Communications
Department of Telecommunications
International Cooperation Division

12th Floor, Sanchar Bhawan, New Delhi
Dated the 6th August, 2018

OFFICE MEMORANDUM

Subject: 5G India 2020 - Setting up of Implementation Cell for 5G India in DoT – reg.

The High Level Forum (HLF) is likely to submit its recommendations on roadmap for 5G India 2020. Implementation of this 5G roadmap would require multi-dimensional collaborative approach by DoT, MeitY & DST in collaboration with User Ministries, academia and industry.

2. Accordingly, the Department of Telecommunications has constituted an Implementation Oversight Committee for 5G India to facilitate implementation of 5G India roadmaps. Since the 5G Roadmap implementation may also require close day-to-day coordination among various divisions / organizations within the respective Departments/Ministry, these Departments/Ministry will individually set up its Implementation Cell, whose Chair will be part of Implementation Oversight Committee.

3. In respect of the Department of Telecommunications, the Implementation Cell for 5G India is constituted with the following members:

1) Shri Amit Yadav, JS(T)	-	Chairperson
2) TEC representative at DDG level	-	Member
3) Wireless Adviser, WPC	-	Member
4) Shri Saurabh Tiwari, DDG (Finance)	-	Member
5) Shri Rajeev Sinha, DDG (NT)	-	Member
6) Shri Kishore Babu, DDG (Policy)	-	Member
7) Shri VipinTyagi, ED, C-DoT	-	Member
8) Ms. Pamela Kumar, DG, TSDSI	-	Member
9) Shri Anurag Vibhuti, DD, TCOE India	-	Member
10) Shri Rajesh Kumar Pathak, DDG(IC)	-	Member Secretary

The Chairperson may co-opt more Members/Expert as deemed necessary.

-2

4. **Terms of Reference: -**

1) Overall responsibility of implementation of 5G roadmaps in telecom sector in collaboration with MeitY, DST, User Ministries, academia and industry;
2) Day-to-day close coordination among various divisions / organizations within the Department;
3) Function under the mentorship of Implementation Oversight Committee for 5G India;
4) The Chair of the Implementation Cell for 5G India in DoT shall also be the member of the Implementation Oversight Committee.

5. TEC, C-DoT and TSDSI shall act as Resource Organizations for DoT. IC / IP Divisions shall jointly provide secretariat assistance to DoT's Implementation Cell.

6. This is issued with the approval of Hon'ble MoSC(I/C).

6/8/201

(R. K. Pathak)
DDG (International Cooperation)
Email:rajeshkr.pathak@nic.in
Tel: 011-23717542

To

All Members of the Implementation Cell for 5G India

Copy to:

1) **PSO to Secretary, DoT**
2) **PPS to Special Secretary, DoT**
3) **PPS to Secretary, MeitY/ PPS to Secretary, DST**
4) **PPS to Sr. DDG, TEC**
5) **Chairperson, TSDSI**
6) **Executive Director, C-DoT**
7) **Prof. A. J. Paulraj, Professor Emeritus, Stanford University**
8) Director, TCOE India cc

Copy for kind information to: OSD to Hon'ble MoSC(I/C).