Department of Telecommunications
Ministry of Communications
Government of India

9th International Conference on ICT & Digital Economy
INDIA TELECOM 2016
"Transforming India"

FICCI

Broadband Infrastructure for Transforming India

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Deloitte.

Foreword from Secretary, DoT

India today is amongst the largest telecom markets in the world with over a billion subscribers and more than 80% mobile penetration. The growth in mobile telephony in the last two decades has been, in the true sense, game changing. We have achieved significant progress in the wireless voice narrowband space and we are now at the threshold of a digital revolution with focus on delivering quality broadband to the masses and leveraging its significant potential for economic growth and social inclusion.

While the economic impact of broadband connectivity is immense and has been proven time and again, it also has the potential of having a cascading effect on other sectors as well. From education and health to disaster management; from financial inclusion to e-commerce; from public safety to entertainment; broadband connectivity has the power to make services and applications available to all to transform our country into a digitally empowered society and knowledge economy.

Our Prime Minister's vision of Digital India with high speed broadband as basic infrastructure for every citizen; provision of government to citizen services online; and empowerment of citizens to give them a say in governance lays out a roadmap for us. We need to work with focus and determination to make this vision a reality.

We envisage developing a state-of-art, future-proof fiber optic network in rural India by undertaking a phased implementation of BharatNet, the national optical fiber network project connecting all 2,50,000 gram panchayats by 2018.

We continue to release spectrum to telecom operators in a transparent and competitive manner, and pursue reforms with respect to spectrum management. The recent spectrum auctions, which ended an era of spectrum scarcity for the Indian telecom industry, preceded by harmonization of spectrum to enhance its efficient use have been path breaking best practices for facilitating deployment of various wireless broadband technologies such as LTE and result in improved data access for our citizens.

A host of measures are being undertaken to spread digital awareness and the government has been digitizing its service offerings to ensure fast, reliable and effective delivery of services and increase digital literacy to bridge the digital divide.

To accelerate the impact of ICT and broadband in India, we need to work cohesively to liberalize our telecom market, promote digital skills, incentivize roll out of infrastructure, including through greater utilization of resources from the Universal Service Obligation Fund (USOF), and encourage development of relevant content.

On the occasion of India Telecom 2016, the Department of Telecom is pleased to release this report on 'Broadband Infrastructure for Transforming India'. Compiled by Deloitte and FICCI, it reflects the views and needs of industry while also providing insights into the role of broadband for achieving India's national objectives. I am sure it will serve as a useful reference document for development & implementation of our broadband strategy.

J.S. Deepak
Secretary,
Department of Telecommunications,
Ministry of Communications,
Government of India

Foreword from FICCI and Deloitte

The Federation of Indian Chambers of Commerce and Industry (FICCI), and the knowledge partner Deloitte Touche Tohmatsu India LLP, in association with the Department of Telecommunications, Government of India, are delighted to present the report **-'Broadband infrastructure for transforming India'** on the occasion of India Telecom 2016.

The world is on the cusp of the 4th industrial revolution, which encompasses cyber-physical systems, cutting-edge research in artificial intelligence and biotechnology, robotics, etc. It has the potential to cause massive disruption in our day-to-day lives and has the capability to empower individuals and communities, as it creates new opportunities for economic, social and personal development. India needs to capitalise on the opportunity presented in the digital revolution by ensuring rapid, scalable and reliable broadband network deployment. Currently, we are at a nascent stage of broadband growth in India with ~150 million subscribers with ~12% penetration rate. And even though our mobile broadband subscribers have increased by 2.5 times over the last two years India's broadband growth story is beginning to unfold.

Telecom sector liberalisation began over 25 years ago when private sector was invited into telecom manufacturing in 1991 and bid documents for cellular licenses in metros were readied in 1992. At this milestone in telecom sector reforms, we are presented with an opportune time to review and draft a new telecom policy. This policy may focus on delivery of Broadband and emerging technologies such as Internet of Things (IoT) and Machine-to-Machine (M2M) communications so as to lead the 4th industrial revolution.

By means of this report, we aim to highlight the framework and engagements to achieve ambitious but realistic targets for key performance indicators of broadband, define initiatives to facilitate ease and efficiency of rollouts and generate demand awareness.

We would like to express our gratitude to DoT for providing us with this opportunity to collaborate with India Telecom 2016 summit. It is an honor to present this report. We hope you find it useful.

Dr. A. Didar Singh
Secretary General, FICCI

Virat Bhatia
Chairman, FICCI ICT and Digital Economy Committee

Hemant Joshi

Contents

1. Executive Summary

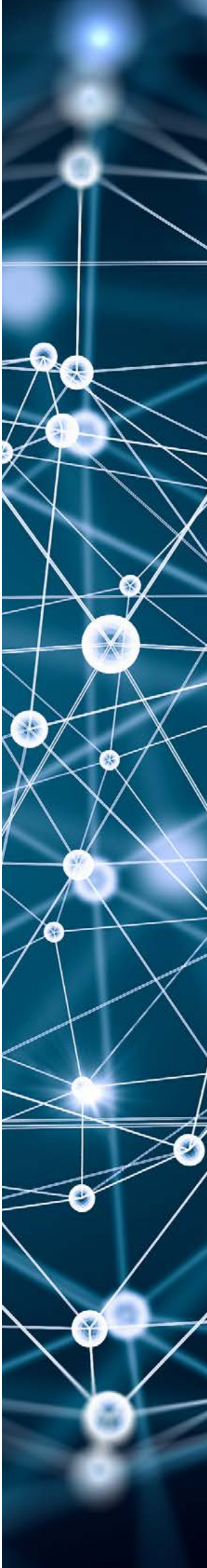
We, as a nation, have come a long way from the initial post-independence era where, the focus was on securing our economy (agriculture sector accounting for 55% of the GDP in 1951[i]) and building competencies to our emergence today as a strong knowledge-based economy. We are amongst the fastest growing economies of the world, having progressed at 7.6% GDP growth rate in 2015-16[ii].

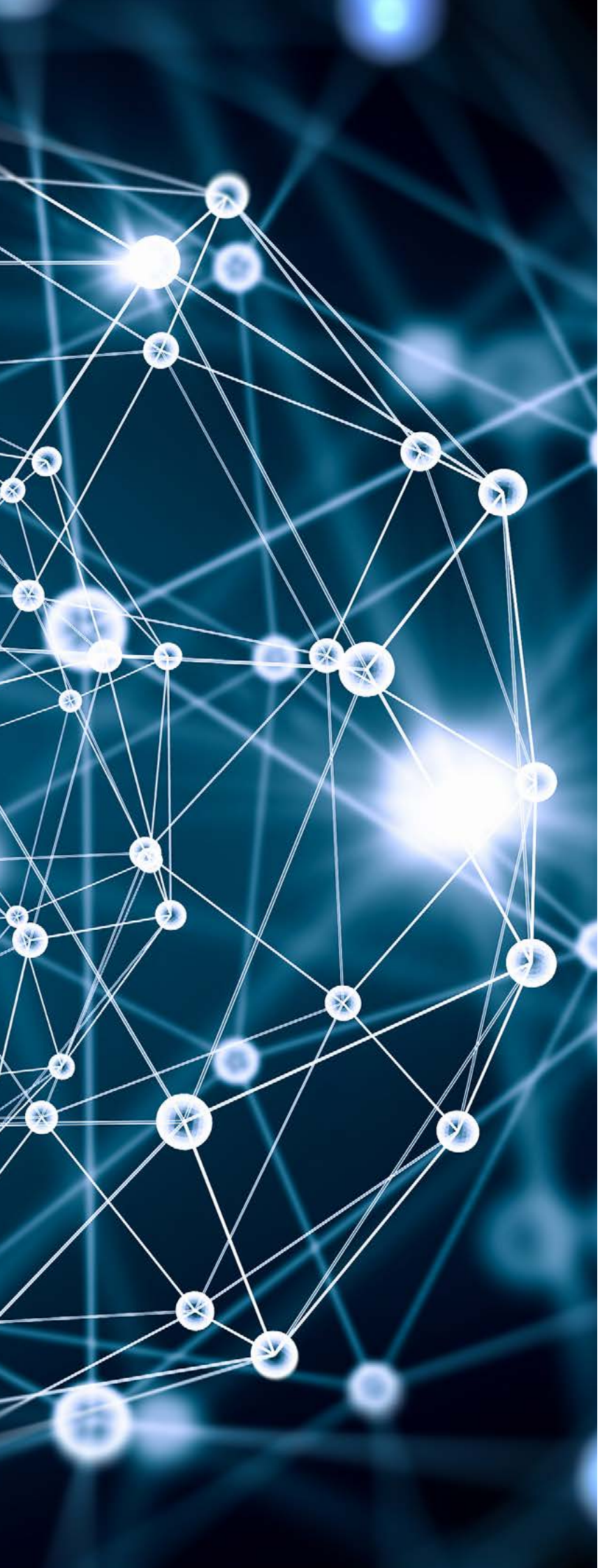
The Indian telecom sector has contributed significantly to the country's overall growth - India is amongst the largest telecommunications market in the world with over 1 billion subscribers (as on March 16) and ~80% mobile penetration[iii]. While India represents ~13% of global telephony subscriptions, they account for only ~2.7% of global revenues[iv].

Our internet subscriber base stands at ~343 Mn. (as on March'16) and is growing at a rapid pace. With broadband subscribers growing at a CAGR of 56% over the last 2 years (March '14 – March '16)[ii], India has ~150 Mn. broadband subscribers at a penetration of ~12% (as on March '16) ii. Our smartphone penetration has already crossed 220 Mn (as on January'16)[v] and is also growing rapidly. Market studies conducted across geographies show that as smartphone penetration reaches 25-30%, data growth becomes exponential[vi]. A visual medium is better for communicating with the masses, in a multi-lingual country like India. Considering this, we are on the cusp of significant data growth[vii] as mobile based video is expected to touch over 50% of the overall data traffic by 2020.

'Access to broadband' has become critical, making the development of its infrastructure a priority for the Government and the industry. Significant efforts need to be made in order to reduce the digital divide in India, so as to unleash the power of the 67% rural population as well as strengthen the productivity of India's urban populace[viii]. We must now replicate our success in voice telephony and develop a broadband ecosystem to enable universal access for our citizens. Rise in broadband penetration to 60% in India is expected to translate into a 5-6% increase in the country's GDP; to the tune of ~USD 135 Bn[ix]. Additionally, it will help achieve the goals set as part of the Government's strategic programs such as Digital India, Skill India, e-Governance, etc. Increasing broadband penetration is expected to help accelerate social inclusion, drive our leadership as a knowledge-based economy, foster entrepreneurship and jobs and reduce the parallel economy through increased transparency and governance. High speed internet plays a pivotal role in enabling these programs. Broadband needs to be considered as a growth lever, else we are at a grave risk of losing competitiveness to other countries.

Countries around the globe have acknowledged the role of broadband in their economic and social progress, and have therefore defined ambitious broadband targets. For example, US[x]: minimum download speeds of 25 Mbps, coverage of 100 Mn households (>80%) by 2020; China[xi]: minimum download speeds of 50 Mbps in urban areas and 12 Mbps in rural areas, coverage of 98% of administrative villages by 2020; UK[xii]: minimum download speeds of 24 Mbps, coverage target of 95% by 2017. Currently, 151 countries have rolled out ambitious national broadband plans. Due to the importance of fiber to data networks, global demand for fiber has increased from 334 Mn fiber km to 392 Mn fiber km, which is the highest growth in fiber consumption over last 5 years.





In order to further our global competitiveness, it is imperative that broadband in India is ubiquitous, is of high quality, is affordable for the masses, and is reliable. To abide by these key broadband principles, infrastructure build-out is required to become a key focus area for all ecosystem players.

We can initiate this process by setting aspirational goals.

01. Set aspirational goals: 600 Mn. broadband subscribers, in the next 5 years

Currently, India has the 2nd highest number of citizens online in the world, accounting for ~10% of the world's internet population, and it aspires to connect 800 Mn. new citizens by 2020, of which 600 Mn. would be broadband users. As we define our aspirational goal of universal access, it is critical to align performance indicators of the network with expectations of the customer. Customers would expect a high quality, high speed and high reliability network as they access videos and other high bandwidth applications as well as conduct transactions on the network. It thus becomes imperative to align our broadband performance indicators with global standards, in order to provide a superior and reliable customer experience. Moreover, providing universal broadband access is the key to driving inclusive growth. This will not only reduce the digital divide, but also allow the masses of India to participate in the digital revolution. India will require a fresh look at the overall pace of development and the regulatory policy environment[xiii].

Broadband ecosystem players, the Government along with the Regulator, need to work cohesively in their journey towards achieving the above mentioned goals.

It is important to incorporate learnings from growth of broadband in other countries as well as from practices/ models of other infrastructure providers in India.

02. Learnings from national broadband plans of other countries and infrastructure providers in India

2.1.Learnings from national broadband plans of other countries/ best practices:

Countries across the world have defined ambitious national broadband plans and implemented/ are in the process of implementing them to achieve

significant results. The Government in these countries has played a significant role by increasing investment outlay for building infrastructure or facilitating private players in creating infrastructure. For example:

- China[x] **(GDP/Capita – USD 7,925):** China is spending USD 320 Bn. over a 5 year period (2015-2020) on infrastructure, in order to bring broadband coverage and penetration to OECD levels. This Government funded infrastructure has set a target of delivering broadband services at download speeds of 50 Mbps for urban areas and 12 Mbps for rural areas
- US[ix] **(GDP/Capita – USD 55,837):** The US established a Connect America Fund–II (CAF-II) to incentivize both roll-outs and uptake. Despite being a predominantly fiberized country, significant efforts are being taken to further develop their broadband infrastructure and investments worth USD 70-75 billion per year are being made
- UK[x] **(GDP/Capita – USD 43,734)[i]:** The Regulator worked with BT to create OpenReach to ensure rapid outreach. Segregation of infrastructure ownership and service provisioning was successful in driving broadband growth. However, other service providers had concerns over non-discriminatory access since it was largely controlled by BT
- Singapore[xiv] **(GDP/Capita – USD 52,889):** Consortium named OpenNet was formed to design, build and operate the infrastructure. The Government supported this initiative by providing a grant of up to SGD 750 million. Here again, infrastructure ownership (NetCo and OpCo) and service provisioning (ServCo) were segregated to drive broadband growth
- Australia[xv] **(GDP/Capita – USD 56,328):** nbn Australia is a Government funded national broadband initiative that has earmarked AUD 41 Bn. over a 7 year period (2013-2020) for broadband proliferation. The initiative has targeted to deliver download speeds of up to 100 Mbps
- Kenya **(GDP/Capita – USD 1,377):** The GDP/capita of Kenya (with a population of ~46 Mn.) has remained lower than that of India. However, their internet penetration has grown significantly higher from 39% in 2013, to 45.62%[xvi] in 2015 -75% higher internet penetration than India. This has been enabled by Government policies such as reduction of spectrum and usage charges levied on service providers. The regulator is now proposing free-of-charge access to 4G spectrum to enable rapid deployment of broadband in select areas of the country
- Malaysia **(GDP/Capita – USD 9,766):** Malaysia has an internet penetration of over 70%[xvii](as of 2015). This has been possible owing to the Government's initiatives to ensure the deployment of broadband infrastructure. PPP agreements with select private players have helped drive the adoption of broadband services.

Source: GDP/Capita data from 2015 at Current USD Rates as presented by the World Bank

- **2.2. Learnings from other infrastructure providers in India:**
  Broadband roll-out in India can learn from roll-outs carried out by other infrastructure providers in the country. Deployment of infrastructure such as roads, electricity, etc. solves social issues and has a positive impact on the nation's GDP. Similarly, Broadband, as established by various empirical studies (OECD, ITU, GSMA, etc.) brings social benefits by reducing the digital divide and acts as a GDP multiplier.
  - **Investment:** The Government invests in infrastructure build-out that is required for the masses, in order to aid the country's socio-economic development. Similarly, investment in broadband needs to be viewed as a measure to help achieve national objectives as well as improve our global competitive positioning. Given that broadband growth helps bridge the digital divide, and is a GDP multiplier, it is important to have a substantial increase in the funding of the infrastructure and to use the current USOF optimally, for broadband proliferation
  - **Implementation, including RoW:** RoW policies are critical across all infrastructure providers and much needs to be learnt and strengthened to ensure more transparency, faster deployment and ease of doing business for the industry. It is important that RoW for broadband infrastructure build-outs are seamless and time-bound
  - **Implementation models:** For the build-out of other critical infrastructure in India (roads, power, water etc.), multiple Public-Private Partnership models are being followed – Innovative models such as the deferred payment Hybrid Annuity Model can be applied for broadband as well, where initial infrastructure investment and risk is borne by the Government and private players drive the roll-out once the demand kicks in.

03. Possible framework for accelerating broadband growth

The Government of India is required to play a key role in the build-out of broadband infrastructure, with following areas needing careful consideration:

A. Increase planned budgetary allocation and effective use of USOF:
The Government of India can consider an increase in the country's annual budget for financing universal broadband access and simultaneously increase efficiency in the utilization of the USOF.
China has committed ~3% of its annual GDP[xviii] to broadband infrastructure growth. India can allocate

a percentage of its GDP in the annual budget as an investment towards the development of this critical infrastructure.
The focus needs to be not only to increase reach, but also to future proof the networks, such that they are resilient to next generation technologies. Emphasis must be laid on rolling out infrastructure basis specific standards, which ensure environmental sustainability and guarantee durability of the network. While this will entail increased capital expenditure, it will be offset by increased life of assets

B. Infrastructure roll-out and service provisioning:
Given the focus on growth of data networks, development of broadband infrastructure becomes essential. Dedicated focus on infrastructure and service provisioning will bring better results, as roll-out in India needs to be strengthened across all layers of the infrastructure (towers, fiber, and other active elements)

C. Models for broadband infrastructure:
Different ownership approaches can be followed for different regions.
   i. Rural broadband
   a. Public and private telecom service providers for facilitating rural broadband:
   Success of various initiatives targeting growth in rural areas hinges on the demand for broadband, which has remained low. Both Government-led and private-led models could be adopted to facilitate rural broadband growth. However, for the private-led model, the Government needs to consider incentivizing private players to invest in rural infrastructure – incentives could be provided to them through other innovative revenue sharing methods to cover rural connectivity, incentivize and leverage the use of existing infrastructure of telecom service providers. For example, implementation adoption models, where operators are asked to adopt rural areas/ gram panchayats for deployment of broadband infrastructure through suitable incentives

   b. BharatNet for facilitating rural broadband:
   The BharatNet project, of the Government of India, aims to connect 250,000 gram panchayats by 2018. In order to ensure faster deployment, segregation of infrastructure ownership, implementation models and maintenance responsibilities is required

Infrastructure Ownership	Government owns the infrastructure asset and leases the dark fiber to service providers
Implementation model	Currently, the implementation is led by CPSUs. To ensure faster deployment across the country, they can be complemented by involvement of private sector (EPC model) participation on a pilot basis in phase II and for full-fledged implementation in phase III
Maintenance responsibilities	Maintenance partners could also be prequalified to ensure adherence to quality. Additionally, infrastructure deployment partners can be responsible for maintenance as they may have clarity on methods used for broadband deployment. Currently, BSNL is responsible for maintenance of fiber while the maintenance of electronic equipment is to the responsibility of the procurement vendor

   ii. Urban broadband: These networks are predominantly owned by telecom service

providers who are currently focusing on capacity enhancement and deploying high capacity networks (enhancement of backhaul infrastructure to include fiberization and high capacity microwave links). A healthy competitive environment driven by market forces will enable growth of urban broadband

iii. Smart cities: To ensure self-sustenance of smart-cities, various models can be considered. For example, a Government supported SPV may own and maintain the network. Outsourcing end-to-end deployment and maintenance of this network will further strengthen its sustainability

D. Policies and guidelines to facilitate ease, efficiency and sustainability of roll-out of broadband networks:

Keeping in mind the need for advancing ubiquitous broadband, the National Telecom Policy needs to be revised with deeper focus on strategic direction, increased clarity around policy actions to be implemented and a robust governance framework. Multiple workgroups, which include the industry, with defined KPIs and timelines, can drive the broadband roll-out process. Inter-ministerial involvement in defining the strategic direction is critical to the success of this policy document.

i. Address regulatory and policy barriers: The regulatory levies on the Indian telecom sector (in the range of 25-29% of AGR[xix]) are significant and therefore a long term sustainable policy ecosystem which is favorable for the orderly growth of the system should be facilitated. The existing USOF fund must be optimally used to further broadband penetration in the country

ii. New RoW & tower policy: Policy aspects include inter alia, a defined RoW and tower policy (pricing, timelines), single window clearances, dig-once policy, awareness and guidelines on deployment standards for fiber roll-out, deployment of judicial mix of overhead vs. underground, etc.

iii. Refresh building codes: Mandating buildings by adding broadband to the building codes to provide infrastructure for ensuring broadband readiness and incentivizing other infrastructure providers for facilitating broadband

infrastructure, could encourage broadband growth

iv. Encourage use of utility corridors: For the establishment of utility corridors, players such as NHAI may be asked to provide ducting for all new road projects. Specific standards must be set by the Government in concurrence with NHAI and other authorities responsible for State highways, piped natural gas, water, sewage and electricity as well. These must be enforced with penalties for non-compliance. Policy should be laid down to secure fiber network by defining guidelines such as 'call before you dig'

v. Create conducive environment for private sector investments: Create enabling policies to encourage private sector investments for broadband. The Government needs to consider incentivizing private players to invest in broadband infrastructure

vi. Constitute governance framework: The Government could look at instituting an empowered government-industry joint working group to work on various aspects of the policy, including long to medium term direction, short term tactical fixes and quick wins. This team should have adequate participation from various ministries, private sector and experts to continually evolve the policy

E. Define an architecture for inter-play of diverse and emerging technologies and role of fiber:
The policy should be technology agnostic so as to enable and promote orderly growth by fostering a robustly competitive environment. The choice of optimal technologies may vary from urban to semi-urban to rural markets.
Fiber is critical to drive various broadband technologies, including wireless and is technology agnostic. However, India continues to remain highly under-fiberized, with cumulative fiber-deployed-to-population ratio at ~ 0.1x (v/s United States: 1.2x and China: 0.7x[xx]) and only ~30% of towers (in major cities) currently fiberized v/s the required ~70-80% to support 4G today and 5G in future[xxi]. A well-defined policy is needed to drive investment, both in fiber and high capacity wireless infrastructure, in order to future proof networks. In areas with difficult terrain, satellite connectivity can be explored.
Additionally, as the demand for bandwidth is expected to grow significantly, telecom operators will need to invest in networks that can cater to the demands of users. Conventional static architecture is not optimally positioned for the evolving dynamic computing and storage needs, due to complexity, scalability and vendor dependence constraints. Software Defined Networking (SDN) and Network Function Virtualization (NFV) can enable the TSPs to migrate to a software-centric network architecture that is dynamic, manageable, cost-effective, and adaptable.

F. Augment BharatNet:
A new approach to implement BharatNet, to address its dynamic nature and its focus on multiple facets of deployment, maintenance of rural infrastructure and service delivery has been developed. It is suggested to strengthen the existing network from SHQ to DHQ and de-risk the network through ring architecture. Another suggestion is to start laying fresh fiber across linear lines especially from DHQ to BHQ, as well as BHQ to FPOI, where fiber life is dated. Currently, 24 core OFC is being deployed in phase I, the fiber count from BHQ to GP should not be below 48 core and from BHQ and above should be not less than 96 core. In order to ensure faster roll-out across the country, CPSUs can be complemented through end–to-end deployment by private partners through an EPC model.

G. Sustainable infrastructure deployment:
It is critical to deploy networks based on specific standards such as GIS mapping, fiber deployment of 1650mm below the ground, duct/conduit size, inner-duct installation standards, method of installation, route definition and bends, and usage of defined tools and materials. These standards will ensure increased life span of the assets.

H. Securing the network
Considering the importance of the broadband infrastructure laid, it's critical to identify ways to prevent fiber cuts due to other infrastructure layouts. 'Call before you dig' is recommended.

Opportune time for new policy after 25 years of reforms

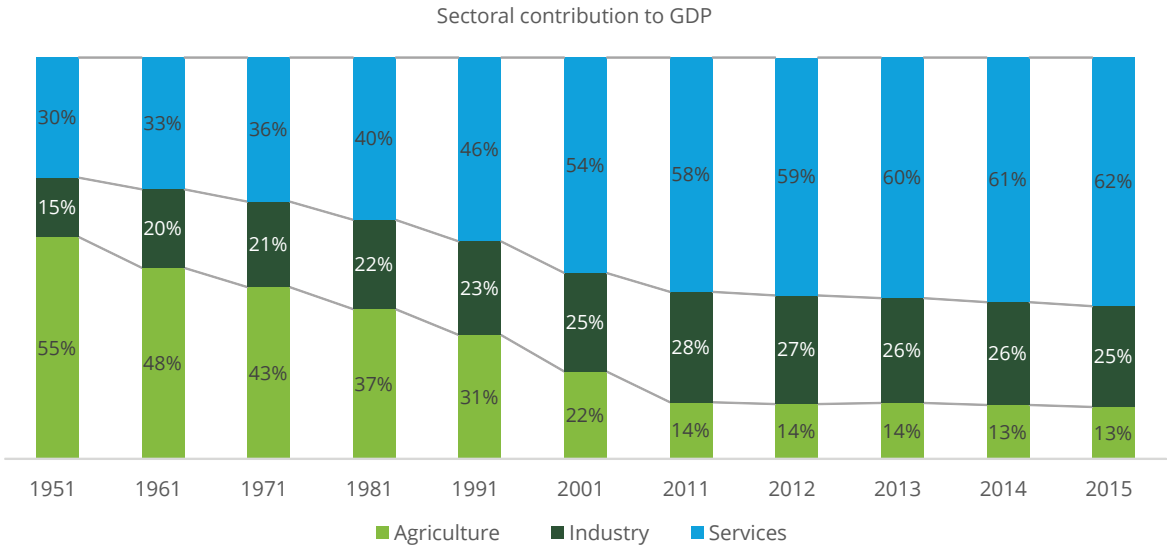
The Government opened up private sector investment in telecom equipment, and invited bids for cellular licenses in the years 1991 and 1992 respectively. Thus we are, in effect, completing 25 years of telecom sector liberalization. At this milestone in the journey of telecom sector reforms and synergies between the Government and the players, we are presented with an opportune time to review and draft a new telecom policy. This policy may focus on emergence of broadband infrastructure and emerging technologies such as Internet of Things (IoT) and Machine-to-Machine (M2M) communication.

2. Importance of Broadband

Globally, we are on the cusp of the 4th industrial revolution, which encompasses areas such as cyber-physical systems, cutting-edge research in artificial intelligence and biotechnology, robotics etc. These technologies have the potential to bring about a positive and yet disruptive change to our day-to-day lives. They have the capability to empower individuals and communities by creating new opportunities for economic, social and personal development.

We, as a nation, have come a long way from the initial post-independence era where the focus was on securing our economy (Agriculture sector accounting for 55% of the GDP in 1951[i]) and building competencies to our emergence as a strong knowledge-based economy. It is important that we now capitalize on the opportunity presented in the 4th Industrial revolution to continue our growth on the socio-economic front.

Figure 2.1: Sectoral Contribution to India's GDP



Source: Open Government Data Platform in India (data.gov.in), Deloitte analysis

We are amongst the fastest growing economies of the world, having progressed at 7.6% GDP growth rate in 2015-16.

Sustaining and enhancing this economic growth, while bridging the divide between various sections of society, are the key national objectives for India today. The Government has also launched multiple ambitious programs to achieve these socio-economic objectives. Having established our presence in the wireless voice space, we are now on the cusp of a data revolution with our increasing smartphone penetration (220 Mn. subscribers as on Jan 16[v]), young and aspiring population, and increasing demand for mobile videos, which is expected to account for over 50% of the overall data traffic in India by 2020[vii].
Globally, broadband has been identified as one of the key drivers for achieving a country's socio-economic objectives. Studies have provided empirical evidence of the direct impact of broadband coverage and speeds on the GDP growth of countries. Additionally, broadband drives the transformation of lives of people by enabling services such as healthcare, education, other development programs by the Government etc.

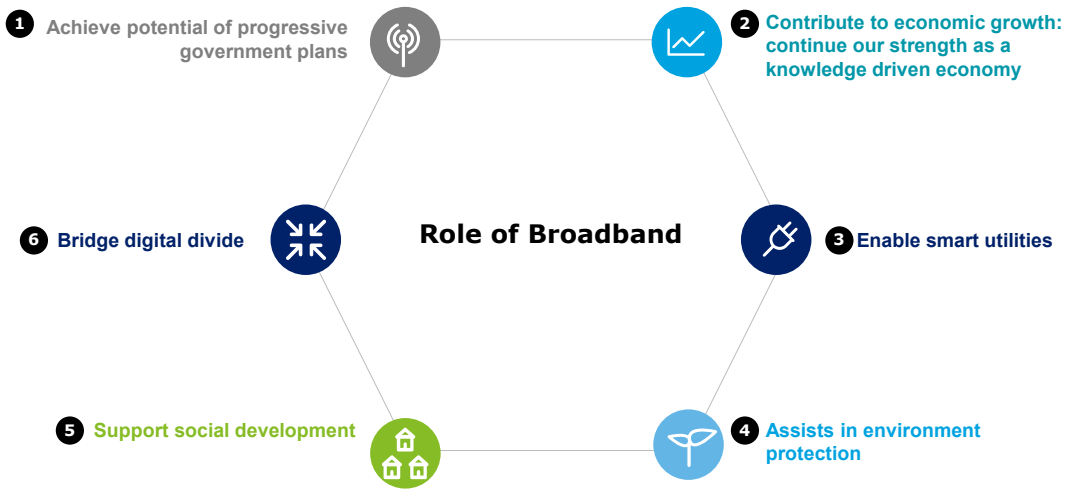
Broadband has far reaching implications and has been leveraged to achieve national objectives by multiple countries. Countries such as the US, the UK, China, South Korea, etc. have used fulfillment of national broadband plans to achieve one or more of their national objectives. For India, it is expected to not only contribute to the socio-economic development but also enable the Government's ambitious plans and strengthen our position as a knowledge-based economy. **Rise in broadband penetration to 60% in India is expected to translate into a 5-6% increase in the country's GDP; to the tune of ~USD 135 Bn.** [ix]

Honourable Prime Minister Shri Narendra Modi quoted,

"Cities in the past were built on riverbanks. They are now built along highways. But in the future, they will be built based on availability of optical fiber networks and next-generation infrastructure."

Broadband is relevant to the Indian context along multiple axes as illustrated in the figure below (Fig. 2.2):

Figure 2.2: Role of Broadband in India



As India strengthens its position as the world's fastest growing economy, it becomes imperative for the country to use broadband as a lever for growth. This becomes even more important as we consider the amount of investment and resources various countries are committing towards broadband proliferation. We cannot afford to lose our strength as a knowledge-based economy, thus making broadband growth even more important for us.

Exhibit 2.1: Example: Broadband China[xi]

In the pursuit of becoming a strong contender amongst knowledge-based economies, bridging the digital divide and more, China announced a highly targeted broadband strategy called "Broadband China" in the year 2013. This strategy document outlines various targets, steps and stakeholders who would be involved in the realization of their national broadband objectives.

Key targets of the "Broadband China" strategy are as under:

	2015 Targets	2020 Targets
Government Investment	2 Tn. Yuan (Approx. USD 320 Bn.)	
Penetration	• Fixed Broadband: 50% • Mobile Broadband: 32.5%	• Fixed Broadband: 70% • Mobile Broadband: 85%
Coverage	95% of all administrative villages to be covered by Broadband	98% of all administrative villages to be covered by Broadband
Speeds	• Urban: 20 Mbps • Rural: 4 Mbps	• Urban: 50 Mbps • Rural: 12 Mbps

Exhibit 2.2: Example: South Africa Connect

The Government of South Africa envisaged a long-term national broadband strategy called "South Africa Connect" in 2013. This strategy document outlines various broadband targets, ambitions and measures that need to be taken to ensure ubiquitous access to broadband for the masses.

One of the key advantages in South Africa is the presence of a 50,000 Km. long National Long Distance (NLD) fiber backbone network and a considerable core network infrastructure in metropolitan area networks.

	2016 Targets	2020 Targets	2030 Targets
Government Focus	The Government is focusing on Digital Development, Digital Readiness, Digital Future and Digital Opportunity		• 600 Mn. broadband connections
Speeds **Penetration**	• User: 50% at 20 Mbps	• User: 90% at 5 Mbps; 50% at 100 Mbps	• User: 100% at 10 Mbps; 80% at 100 Mbps

Source: South Africa connect broadband policy 2013

Exhibit 2.3: Example: India

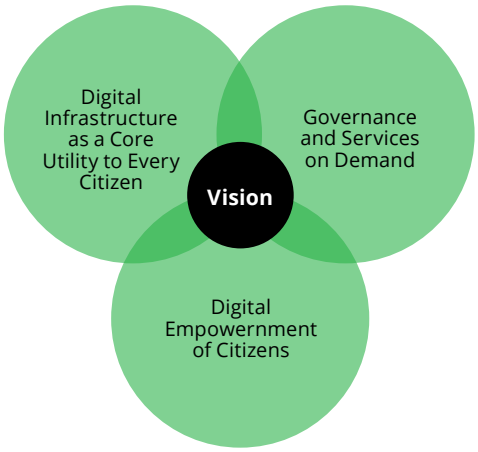
India, a strong contender among knowledge-based economies, has embarked on a transformational journey to increase its broadband connectivity and reach. Government policies have set ambitious targets for penetration and speeds. Additionally, the Digital India program of the Government considers broadband to be a key pillar for its success.

Key targets of India's "National Telecom Policy" are:

	2017 Targets	2020 Targets
Penetration	• 175 Mn. broadband connections	• 600 Mn. broadband connections
Speeds	• Aspirational speeds of 100 Mbps on demand	

The ambitious Digital India initiative was launched in July 2015 with the aim to transform India into a digitally empowered society and a knowledge economy. Digital India is a marquee initiative that involves multiple Government Ministries and Departments, with overall coordination being carried out by the Ministry of Electronics and Information Technology (MeitY). The vision of the Digital India initiative can be seen in the below Fig. 2.3.

Figure 2.3: Vision of Digital India initiative



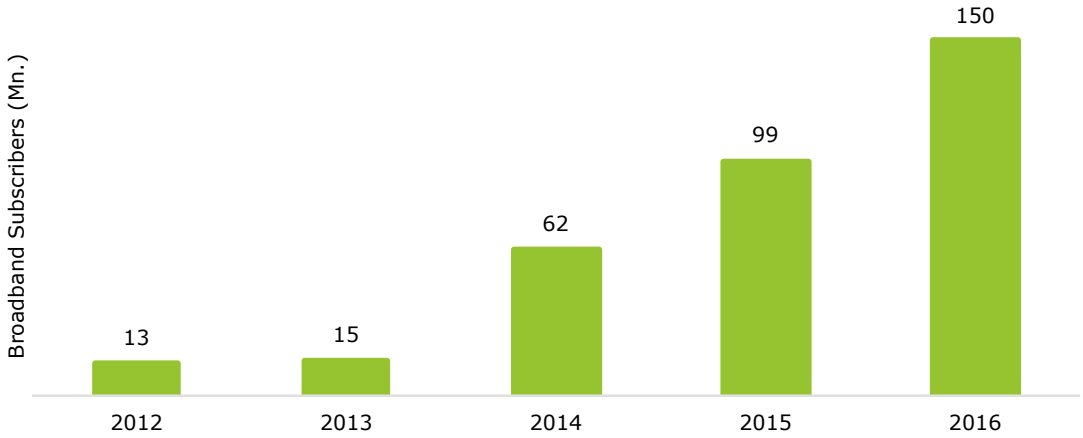
The accelerated implementation and resultant success of initiatives under Digital India, depend heavily on enabling broadband access to the masses without which either the programs would not be available for use or, the customer experience would be highly sub-optimal.

Source: NTP 2012, Digitalindia.gov.in

Current State - Broadband in India

The broadband subscriber base in India has been growing at a significant rate over the last 5-7 years. We have seen a growth of over 242% Compounded Annual Growth Rate (CAGR) between 2012 and 2016, with a total of 150 Mn. broadband subscribers as of March 2016 [xxii].

Figure 2.4: Growth of Broadband Subscribers in India



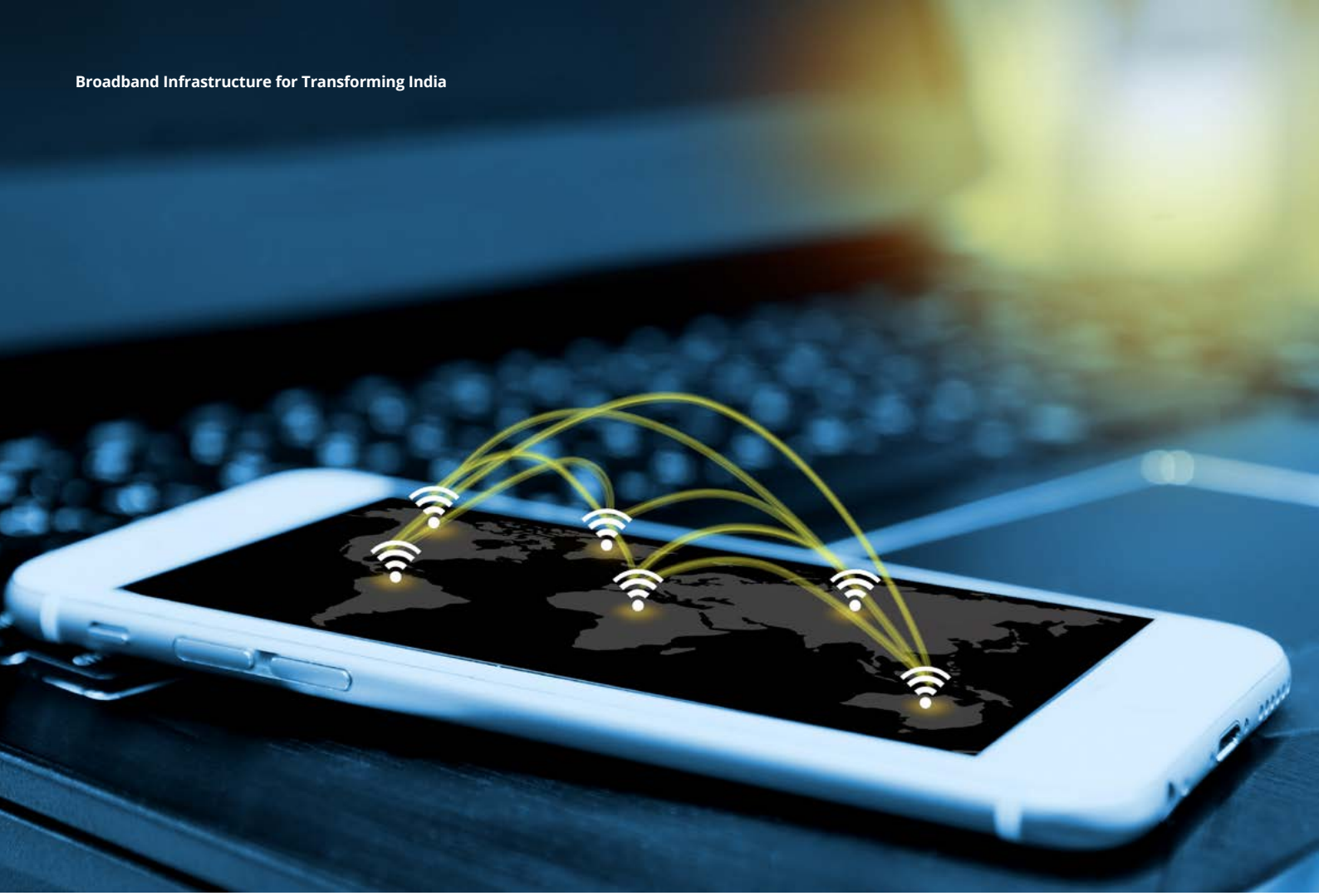
Note: Does not include Mobile 3G subscribers for 2012, 2013
Source: TRAI, Deloitte analysis

However, India continues to lag behind other countries significantly, both in terms of fixed broadband penetration and mobile penetration.

Major Challenges

Currently, India faces multiple challenges with regards to growth of the broadband ecosystem, spanning across strategic, operational and implementation scenarios:

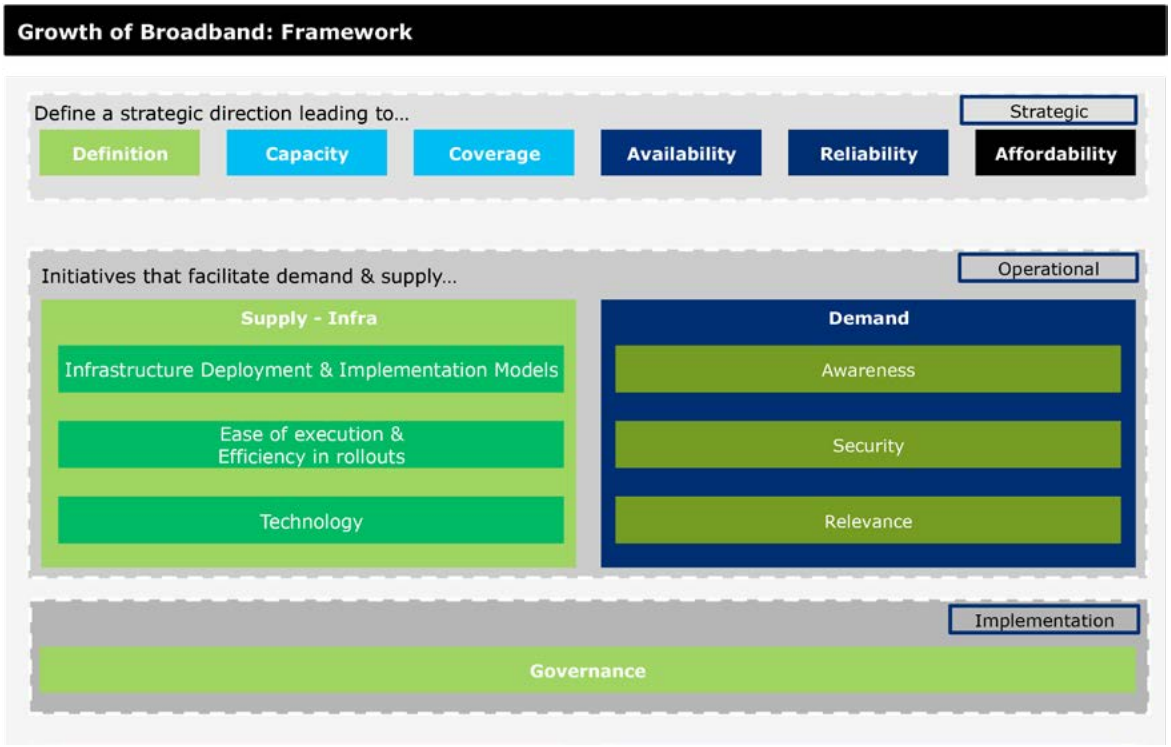
01. **Need for ambitious and strategic goals** for broadband investment, penetration, coverage and speed
02. **Need for broadband infrastructure both in rural and urban areas** due to viability issues and other significant bottlenecks in laying the broadband infrastructure - Right-of-Way, clearances, multiple digs, etc.
03. **Need for adherence to deployment standards; no GIS tracking system** on underground fixed line infrastructure
04. **Need to promote broadband demand;** currently limited vernacular content, digital literacy and purchasing power (Average telecom revenue per user is less than USD 2)
05. **Need for a comprehensive governance model** which entails inter-ministerial collaboration and involvement of all stakeholders



3. Proposed Framework for Broadband

Based on learnings from National Broadband Plans of other countries, it is recommended that targeted initiatives be undertaken across three distinct layers of thought and action (Ref. Fig. 3.1).

Figure 3.1: Framework for Broadband Growth in India



It is important to define a **strategic** direction for broadband in the country. This would include an aspirational goal of the **definition** of minimum speeds of broadband along with setting **capacity and coverage targets,** and the ambition to maintain certain minimum levels of **availability, reliability and affordability.**

Initiatives and actions need to be taken comprehensively, from both supply (infrastructure) and demand side, thereby covering the entire broadband ecosystem. Infrastructure initiatives would include deploying the most optimal infrastructure and implementation models, defining guidelines and regulations to facilitate **ease of execution** and **efficiency in roll-outs,** and defining the **technology** considerations. In order to foster demand for broadband services, actions would need to be taken to ensure **awareness, security** and **relevance**.

Further, the success of the plan and identified initiatives would depend upon establishing a strong **governance** model.

Key considerations and recommendations for India along the defined framework are mentioned in the forthcoming sections.

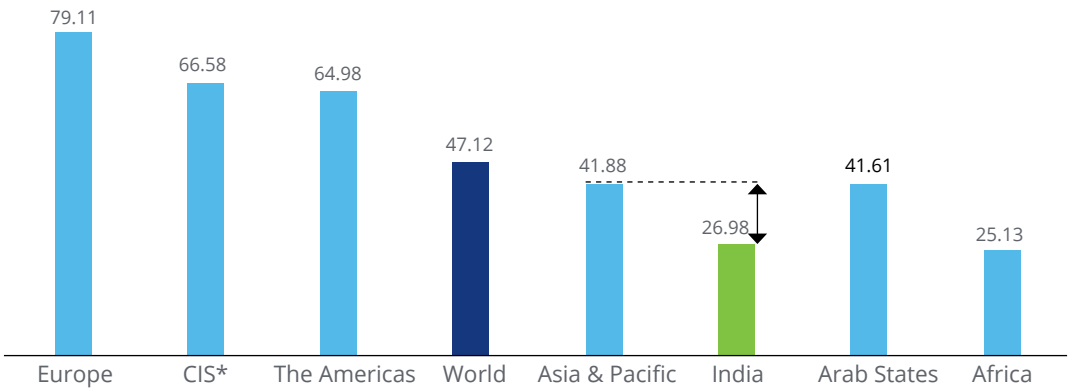
4. Broadband Framework: Strategic Direction

Overview

The foundation stone of inclusive broadband in India was laid down in past government policies. Key strategic goals that were enunciated in the policy include definition of broadband, target number of users, and ability to provide 'Broadband on Demand'.

However, India now needs to set aspirational goals in order to reach at least the Asia & Pacific average (41.88 individuals per 100 inhabitants) in terms of the individuals using the internet per 100 inhabitants.

Figure 4.1: Individuals using the internet per 100 inhabitants, August 2016



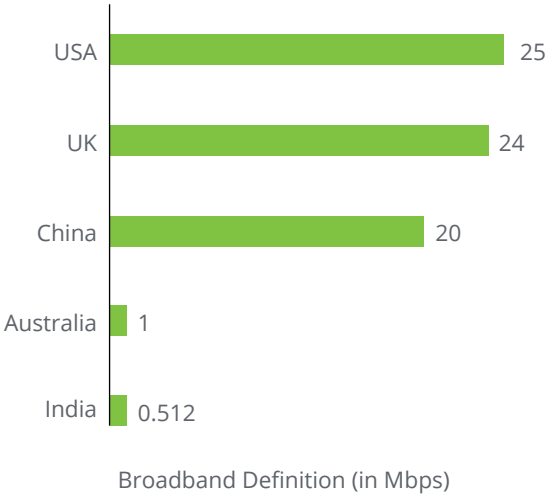
Source: ITU Statistic – ICT Data
*CIS – Commonwealth of Independent States

It is important to understand the definition and aspects of the broadband frameworks being used in other countries to arrive at recommendations for India's broadband strategic direction.

Broadband Definition

Developed countries, have defined broadband as a minimum of over 20 Mbps speed in their National Broadband plans & strategies. (Ref. Fig. 4.2 below).

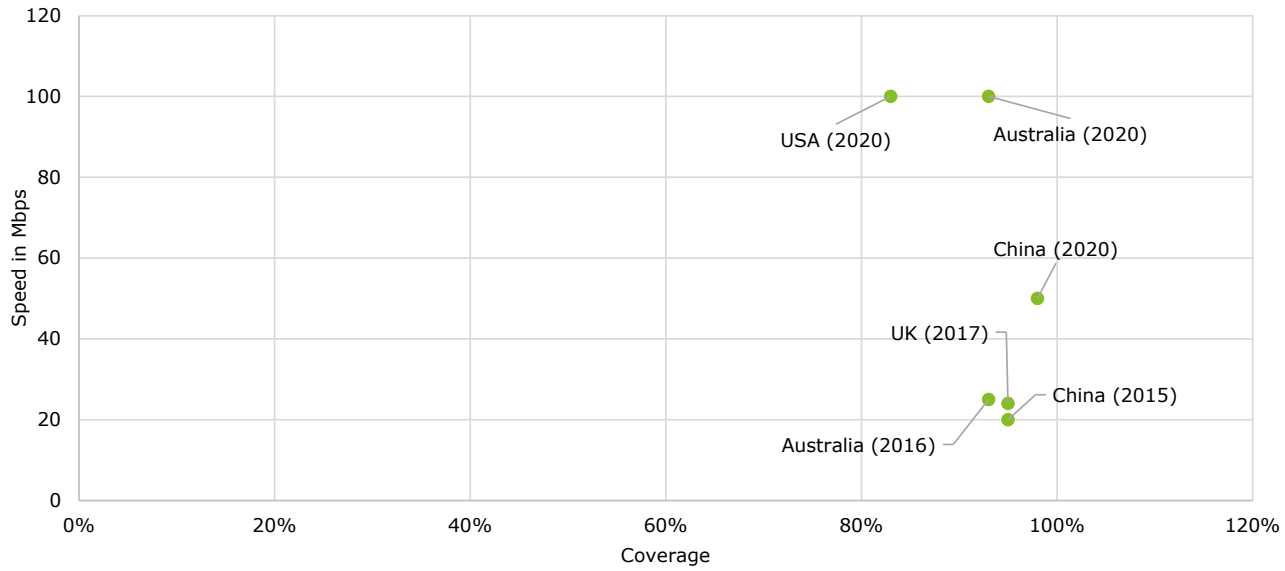
Figure 4.2: Definition of Broadband across major countries



Note: Minimum broadband speed for rural areas in China is 4 Mbps.
Source: National Broadband Plans of Countries; Deloitte Research

Countries have set targets for coverage and capacity (speed) as well. Some countries such as China and Australia have set phased targets which are closely linked to the progress of the backhaul data network roll-outs in their territories. **However, India is yet to define any clear targets for speed as well as coverage.**

Figure 4.3: Coverage and Speed Targets of Major Countries



Source: National Broadband Plans of Countries, Deloitte Research

Internet penetration in India (number of households) remains low. While mobile broadband is contributing heavily to the growth of broadband, household fixed-access can provide further connectivity to multiple members of the family. We must aspire to reach levels of Asia Pacific on the short-medium term while aiming for levels comparable to those of developing countries.

Key Recommendations

Based on learnings from other countries, emerging data requirements and customer expectations, strategic direction for broadband may be defined to ensure universal & sustained high-speed affordable access and reliable connectivity. This will not only reduce the digital divide but also allow the masses of India to participate in this revolution.

Figure 4.4: Key Recommendations on Strategic Direction

1 Definition
- Continuous revision of the definition of broadband may be undertaken in-line with growth of infrastructure
- A roadmap should be created to align definition with global standards

2 Coverage
Ensure that broadband services reach users across households, businesses and social institutions such as educational, healthcare and government offices

3 Capacity
Set targets for bandwidth capacities for each of the following to cater to all masses needs:
- Urban & Semi Urban Household Access
- Rural & Deep Rural Household Access
- EHBG Access

4 Availability
Ensure broadband availability without disruption beyond just the deployment of infrastructure. Broadband uptime being maintained is important to the positive proliferation of broadband

5 Reliability
Ensure highly reliable connectivity via broadband for fostering a sense of security while conducting important transactions online

6 Affordability
Ensure affordability of broadband for the masses across both cost of service and device cost to enhance uptake and promote universal access

EHBG: Educational Institutions, Healthcare Institutions, Businesses (SME, Corporate & Enterprise) and Government Offices & Establishments

5. Broadband Framework: Implementation

A. Deployment Models

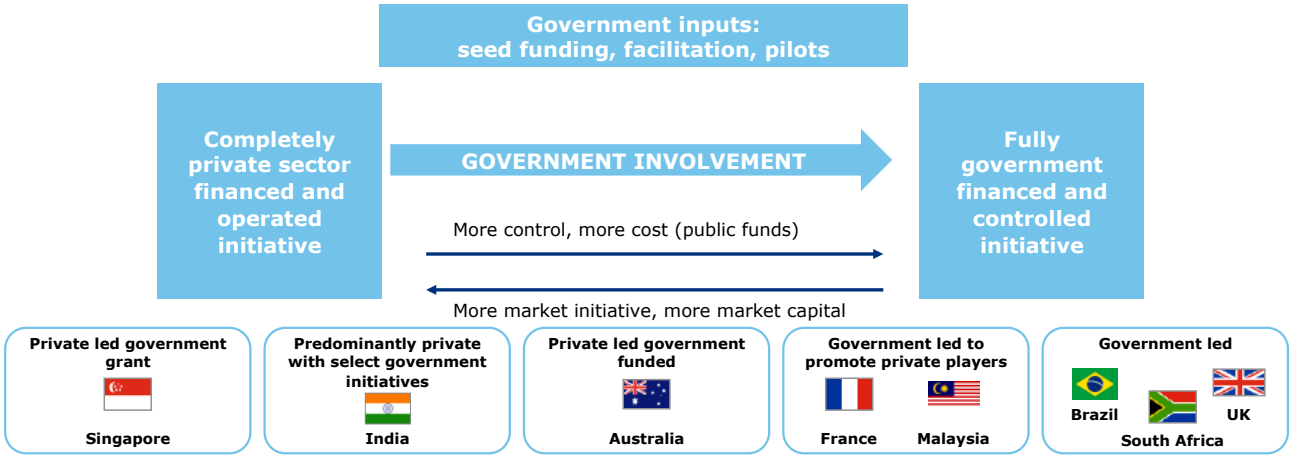
Overview

The access and backhaul layers of the network emerge as high priority areas for infrastructure build out across both urban and rural areas in India. The Government and the private sector need to strengthen these networks to ensure that the national objectives are met. It is important to incorporate learnings from other countries across the globe, and from utilities in India to arrive at recommendations for ownership structure and implementation models for broadband infrastructure in India.

Key Trends and Learnings from Global Best Practices

Globally, the extent of Government involvement in infrastructure deployment varies widely ranging from national broadband networks which are fully owned and financed by the Government to relying entirely on private players for rollout of infrastructure with the role of the Government being that of a facilitator only:

Figure 5.A.1: Government Involvement by Country



Source: Ericsson Report, 2014: Benchmarking 15 national broadband plans

Some of the key practices followed by countries in deployment of broadband infrastructure are as follows:

Table 5.A.1: Learnings from broadband infrastructure plans by country

Country	Learnings from broadband infrastructure plans
Singapore [xiv] GDP/Capita: USD 52,889	• The Ministry of Information, Communications of Singapore, outsourced the task of network deployment to a consortium named OpenNet (private players such as Singtel, Axia NetMedia Corporation, SP Telecommunications PTE were the primary owners) to design, build, operate the infrastructure such that it would meet the need of NextGen NBN of delivering 1 Gbps speed and beyond. The Government would support the cause by providing a grant of up to SGD 750 million • Infrastructure ownership and service provisioning were segregated to drive broadband growth
UK [xii] GDP/Capita: USD 43,734	• The UK Government initiated the OpenReach Network in the UK that aggregated the network of the service providers and is now responsible for services of fixed line connections, DSL and fiber optic broadband. It works on behalf of 537 communication providers to maintain local access network that covers 30 million customers • Infrastructure ownership and service provisioning have been bifurcated to ensure effective broadband proliferation
USA [x] GDP/Capita: USD 55,837	• The US established a Connect America Fund–II (CAF-II) to incentivize both roll-outs and uptake. Despite being a predominantly fiberized country, significant efforts are being taken to further develop their broadband infrastructure and they are investing USD 70-75 billion per year for the same
China [xi] GDP/Capita: USD 7,925	• China is spending USD 320 Bn. over a 5 year period (2015-2020) on infrastructure to bring broadband coverage and penetration to OECD levels. This Government funded infrastructure has set a target of delivering broadband services at download speeds of 50 Mbps for urban areas and 12 Mbps for rural areas • This initiative is being spearheaded by the Government to ensure that 98% of the administrative villages are covered under broadband by 2020
Kenya [xxiii] GDP/Capita: USD 1,377	• The GDP/capita of Kenya (with a population of ~46 Mn.) has remained lower (USD 1,376) than that of India (USD 1,581). However, their internet penetration has grown significantly higher from 39% in 2013, to 45.62%[xxiv] in 2015 -75% higher internet penetration than India. This growth in penetration has been enabled by Government policies such as reduction of spectrum and usage charges levied on service providers. • The regulator is now proposing free-of-charge access to 4G spectrum to enable rapid deployment of broadband in select areas of the country
Malaysia [xxv] GDP/Capita: USD 9,766	• Malaysia has an internet penetration of over 70% (as of 2015). This has been possible owing to various initiatives carried out by the Government to ensure the deployment of broadband infrastructure • PPP agreements with select private players have helped drive adoption of broadband services. An example of such a project includes a 10 year long deployment of High Speed Broadband Network (HSBB), which is a technology-hybrid deployment of FTTx, VDSL2, HSPA (mobile) and WiMAX

Source: World Bank Data (GDP/Capita at Current USD Rates)

Broadband roll-out in India can benefit from learnings of other infrastructure providers in India:

- **Investment:** The Government invests in infrastructure build-out that is required for the masses and aids the country's socio-economic development. Similarly, investment in broadband needs to be viewed as a measure to help achieve our national objectives as well as improve our global competitiveness. **Broadband growth acts as a GDP multiplier** and helps bridge the digital divide, thereby ensuring accelerated growth for the country. Thus, it is important that broadband infrastructure build-out is not viewed as an immediate return on investment, but as a long term play.
- **Implementation, including RoW:** RoW policies are critical across all infrastructure providers and much needs to be learnt and strengthened to ensure more transparency, faster deployment and ease of doing business for the industry. It is important that RoW for broadband infrastructure build-outs are seamless and time-bound.

Keeping in view the learnings from other countries and other infrastructure build-outs in India, the ownership structure of the broadband infrastructure in India, budgetary outlay recommendations, and the Government's role along with potential implementation models for both rural broadband and urban broadband have been outlined below.

Key Recommendations:

01. Infrastructure roll-out and service provisioning:
Given the focus on data networks, broadband infrastructure growth becomes essential. Further strengthening of both layers, i.e., infrastructure (towers, fiber, and other active elements) and service provisioning is required.

02. Ownership models for broadband infrastructure:
Ownership models may vary depending on the type of market the infrastructure is being deployed in.

i. Rural broadband
The success of many initiatives targeting growth in rural areas hinges on the demand for broadband, which has remained low. Both Government-led and private-led models could be considered for rural broadband growth. However, for the private-led model, the Government needs to consider incentivizing the private players to invest in rural infrastructure through innovative revenue sharing methods to cover rural connectivity. For example, use of implementation adoption models, where operators are asked to adopt rural areas/gram panchayats for deployment of broadband infrastructure

a. BharatNet for facilitating rural broadband: The BharatNet project is owned and controlled by the Government. In order to ensure faster deployment, segregation of infrastructure ownership, implementation models and maintenance responsibilities is required.

Infrastructure Ownership	Government owns the infrastructure asset and leases the dark fiber to service providers
Implementation Model	Currently, the implementation is led by CPSUs. To ensure faster deployment across the country, they can be complemented by involvement of private sector (EPC model) participation on a pilot basis in phase II and for full-fledged implementation in phase III
Maintenance Responsibilities	Maintenance partners could also be prequalified to ensure adherence to quality. Additionally, infrastructure deployment partners can be responsible for maintenance as they may have clarity on methods used for broadband deployment. Currently, BSNL is responsible for level 1 maintenance of fiber while the maintenance of electronic equipment is outsourced the responsibility ofto the procurement vendor

ii. Urban Broadband
These networks are predominantly owned by telecom service providers who are currently focusing on service quality improvement, capacity enhancement and making networks future ready (fiberization of backhaul and move towards full-IP). A healthy competitive environment driven by market forces will drive growth of urban broadband.

iii. Smart Cities

To ensure self-sustenance of smart-cities, various models can be considered. For example, a Government supported SPV that may own and maintain the network. Outsourcing the end-to-end deployment and maintenance of this network will further strengthen its sustainability.

03. Role of Government in infrastructure deployment in rural and urban areas:

i. Rural Broadband

Access to broadband is limited for 67% of India's population, which lives in rural and remote areas. As of March 2016, only ~4% of the rural populace were broadband subscribers[xxvi]. In order to reduce this large digital divide, availability of widespread, non-discriminatory broadband infrastructure access with quality services at affordable prices, is critical in rural areas.

Overview of BharatNet

The NOFN project (now BharatNet), was initiated to provide broadband connectivity to Gram Panchayats (GPs) is now being implemented in the country. While Tthe project was approved in 2011, however the physical infrastructure roll out commenced in the latter half of 2014. The project entails connecting all 250,000 gram panchayats (GPs) via optic fiber cable (OFC). The NOFN project in its essence, wasaimed to lay underground incremental OFC from the Fiber Point of Interconnect (FPOI) to GP, in other words the missing link to connect GP.

With the advent of the Digital India initiative in 2015, the scope of NOFN has evolved from the focus of laying just incremental underground OFC to creating a seamless backbone towards realization of Digital India. In consonance with this broad objective, NOFN was renamed BharatNet in April 2016.

Accordingly, the strategy and timeline of BharatNet was redrawn in April 2016. This modified approach entails connectivity to GPs by all media (underground OFC, overhead OFC, Radio and Satellite), Rreplacement of lossy fiber before FPOI to pave way for seamless provision of services in villages in on a non-discriminatory basis, operation and maintenance mechanism, and setting up of minimal last mile architecture to provide initial fillip to the service provision in rural areas, which can later be taken over by service providers. To help realize the vision of Digital India with the objective of providing technology enabled services to empower citizens. The Government of India revised the strategy to base the network on the principle of, to enableing service providers in the last mile on a non-discriminatory basis. The intent is to ensure a futureproofed, robust and scalable rural infrastructure that delivers an enriched experience.

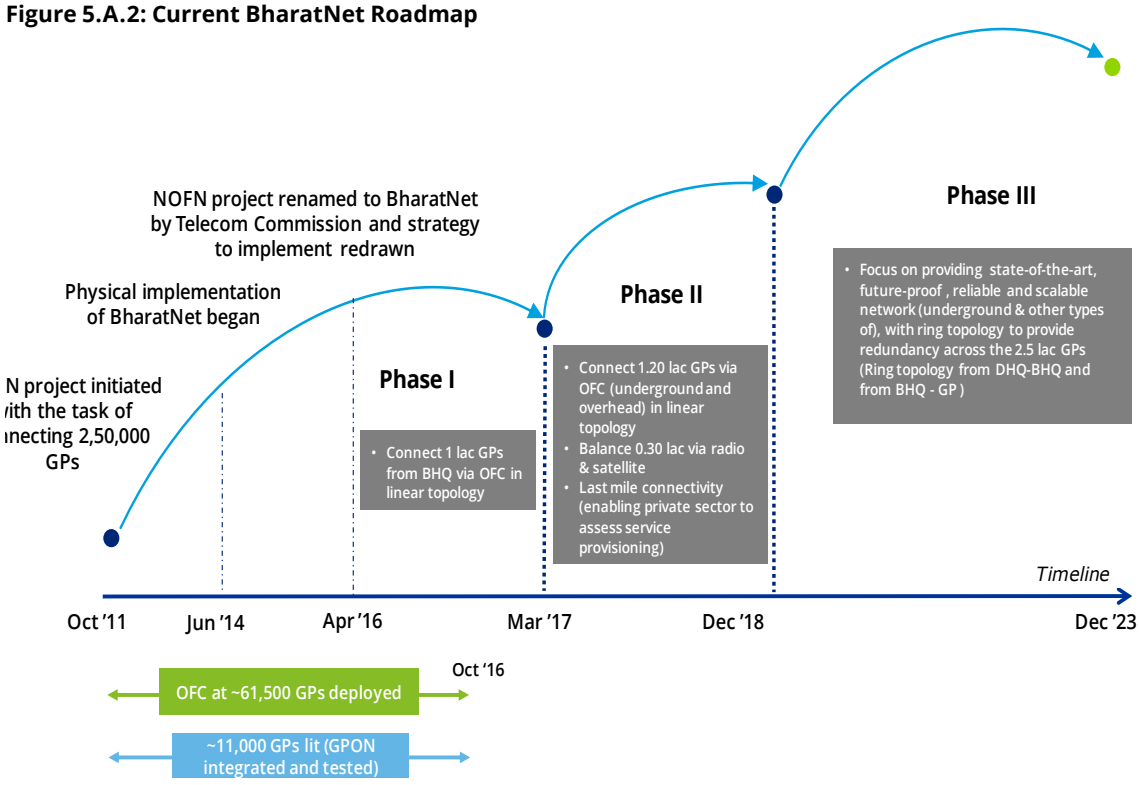
BharatNet by its size, spread and outreach is arguably one of the largest infrastructure projects implemented by the Central Government. Along with this the project also entails implementation by multiple agencies, multiple stakeholders, and service delivery to citizens, State Government, local government bodies, Central Government institutions and private sector. This imparts the dynamic nature to this project, where frequent and timely decisions are very crucial. Accordingly, the Project's implementation needs flexibility in decision making and execution approach, empowerment of the executing and implementing agency and effective and real-time monitoring of the project.

The new approach to implement BharatNet, to address its dynamic nature and address its multiple focus on manifoldmultiple facets of deployment, maintenance of rural infrastructure and service delivery has been has been addressed developed by redrawing the strategy in 2016.

Redrawing the strategy for of BharatNet in 2016:

- Implementation of BharatNet in three phases: the first phase to connect 1,00,000 GPs by underground OFC by March, 2017; second phase to cover the remaining GPs (all 2,50,000 GPs) by September, 2018 by OFC (underground, overhead, radio or satellite), setup infrastructure for last mile infrastructure in the form of wWi-fFi hotspots at GP level, in parallel setup internet access points to utilize existing BSNL fiber, strategy to connect government institutions by broadband: ; third phase to upgrade the network in ring, setup data center and fortify the network to meets the future needs and meet the requirements of 5G era in 5 years, 2018 onwards.
- Involving more agencies in the implementation of BharatNet; three existing CPSUs, other CPSUs with capacity to implement, State Government and its agencies, State Power Distribution Companies and private sector.
- Replacement of lossy fiber from BHQ to FPoI (Fiber Point of Interconnect) to strengthen quality of network for provision of seamless of service and optimal utilization of network.
- Evaluating a technology mix including Optical fiber, radio and satellite (for remote hilly locations), to ensure network availability across all terrains of rural areas
- Underground OFC as the preferred media, due to its durability and longevity, overhead OFC preferably on existing power lines in hilly areas and in such terrains where laying underground OFC is difficult and expensive. Radio and Satellite connectivity in sparsely populated, distant and difficult areas. .
- Inclusion of last mile connectivity framework and deployment for assess access of network by citizens and service providers.
- Increase modalities of operations and maintenance with a service driven objective for increased network reliability

Figure 5.A.2: Current BharatNet Roadmap



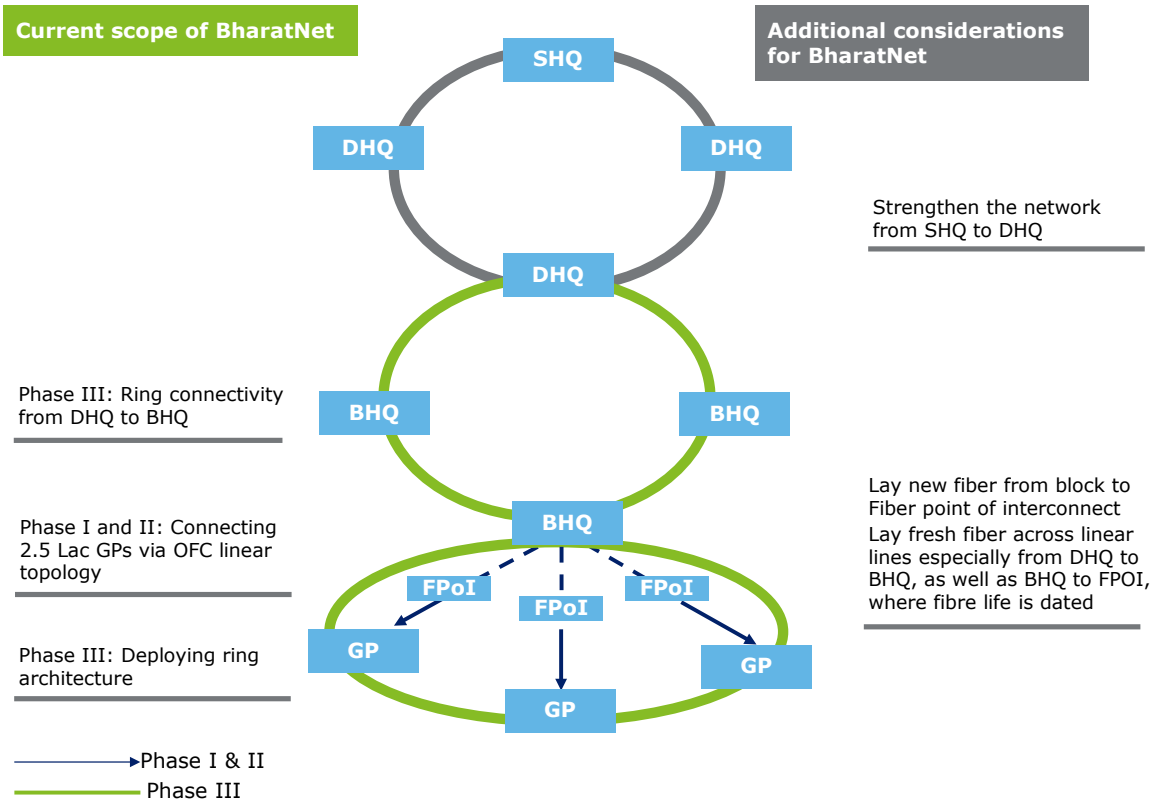
Source: Secondary research: BBNL website, Primary interviews

Key Considerations/Recommendations

The key considerations along the overall scope of the project, and timely and effective implementation are:

a. **Scope of BharatNet:** Current scope and discussion of BharatNet including Phase III is primarily focused on providing reliable and redundant connectivity till the Gram Panchayats by deploying ring architecture. It is suggested to expand the scope of BharatNet and include strengthening the existing network from SHQ to DHQ and also in parallel lay new fiber from block to Fiber point of interconnect. Another suggestion is to start laying fresh fiber across linear lines especially from DHQ to BHQ, as well as BHQ to FPOI, where fiber life is dated. Currently, 24 core OFC is being deployed in phase I, the fiber count from BHQ to GP should not be below 48 core and from BHQ and above it should be not less than 96 core

Figure 5.A.3: BharatNet: Current and proposed scope



Source: Primary interviews, Deloitte Analysis

The Report of Committee on NOFN (March, 2016) estimates an investment outlay of approximately INR 72,770 Cr.[xxvii] for deploying ring architecture, setting up of data centers at district headquarters and deployment of additional GPON equipment (electronics) and setting up of framework for last mile connectivity. Most of the investment is for the activities which were not considered and addressed in original NOFN framework. However, given the realistic considerations of utilizing the broadband network optimally this investment outlay is expected to increase even further.

b. **Implementation Models:** The Report of Committee on NOFN suggests use of either the CPSU-led model, State led or the Private sector led (EPC) model for infrastructure deployment. Currently, the CPSU led implementation model is being followed. This was based on utilizing existing OFC of CPSUs to have a seamless network. The roll out, though accelerated in last one year, has complexities on account of involvement of multiple agencies and a multitude of activities. This may lead to concerns regarding operations and maintenance of this long term asset. The implementing partner CPSU or the private sector player can take complete accountability of the end-to-end network with service criteria and can work with multiple agencies to ensure its execution.

In order to ensure faster roll-out across the country, CPSUs can be complemented by end–to-end deployment by private partners through an EPC model.

It is proposed that private players be identified within each region/zone based on a rigorous selection criteria encompassing technical, financial and organizational capabilities.

c. **Maintenance responsibilities:** It is in fact recommended that deployment partners take up responsibility of O&M based on service criteria as they may have clarity on methods used for broadband deployment and also to ensure better adherence to deployment standards.

d. **Pilot studies under Phase III:** To ensure effective implementation of Phase III, certain states can be identified as test beds to pilot Phase III and assess the challenges on a proof of concept basis, while simultaneously connecting GPs in Phase II.

Exhibit 5.A.1: Public Wi-Fi hotspots for rural broadband proliferation[xxviii]

Deployment of broadband infrastructure under the BharatNet Program and provision of high-speed internet access across rural areas must be utilized by the masses. With the push to disseminate G2C services, provide healthcare, education and other social programs to the populace, deployment of public Wi-Fi hotspots may be viewed as a means to enable access. It was estimated that 64.2 Mn. hotspots existed globally in 2015 - implying one hotspot for every 114 people. This number is expected to rise to ~430 Mn. by 2020. There are 31,000 hotspots in India which roughly translates to one hotspot for approximately 37,000 people. To match the global average of a hotspot for every 114 people, 11 Mn. hotspots need to be deployed. In order to ensure increased access and cater to affordability concerns of the masses, it is suggested that public Wi-Fi hotspots be deployed in rural areas.

	Public Wi-Fi Hotspots	Population	Citizens/Hotspot
World	64.2 Mn.	7.346 Bn. (7,346 Mn.)	114
India	31,000 (0.031 Mn.)	1.311 Bn. (1,311 Mn.)	37,000

ii. Urban Broadband

Subscriber growth is concentrated in densely populated urban areas, accounting for approximately 74% of the broadband subscriber base in FY16. However, as of March 2016, only ~25% of the urban populace were broadband subscribers[xxxi] and these are predominantly on wireless networks.

In urban areas, India has approximately 75% of sites on microwave for major operators and 80-90% for other operators. Indian operators currently rely on lower capacity microwaves, with large number of spur sites (up to 15) per aggregation site, linked by microwave. **Only ~30% in major cities are fiberized, primarily due to high investment requirements and operational bottlenecks [xix].**

Low fiberization restricts the capacity and scalability of the network, negatively impacting the peak performance, future readiness and user experience.

On account of emergence of next generation network technologies and high data traffic growth expected in the coming years, significant investments are required to upgrade the network in order to bring India at par with global players. **The bulk of investment lies in fiberizing the backhaul and high capacity microwave links, which is also most critical for making the network data ready.**

Figure 5.A.4: Comparison of India (Current State) with Global Leaders on Technology

Dimension	Current State in India	Global Leaders / Required Future State
Core	• Legacy 2G - 3G & 4G riding on 2G	• Full IMS, EPC, MDN, Real Time Communication, Big Data support • Virtual Core Components
Transmission Medium	• Microwave Intensive (80%) • Low bandwidth capacity	• Fiber Intensive • High Capacity Microwave (Giga bit)
Network Topology	• Greater fraction of spur sites (point to point) • Limited rings (>6-7 sites in case of MW)	• Ring- smaller ring size in case of MW • Hybrid & Mesh in case of Fiberized site
Network Protocol	• Circuit Switched / Packet Switched	• Full IP / E2E - MPLS
Traffic Movement	• Through macro sites	• Off-loading to micro sites for enhanced capacity • Small Cells, Wi-Fi etc.
Virtualization of Network Elements	• Physical Elements • Often proprietary hardware	• Virtual Elements • Uses generic hardware
Technology Dependence	• Technology Agnostic (2G, 3G, 4G)	• Technology Agnostic (2G, 3G, 4G support)

Source: Secondary Research, Deloitte Analysis

Key Considerations

Role of Private Players: Private players are recommended to lay down a progressive plan to fiberize ~77-80% of tower assets (currently only 30% sites are fiberized in major cities) from FY17-FY20 and thereby be at par with other developed nations in urban areas [xix]. **It is estimated that an investment of INR 54,000 Cr. would be required from FY17-FY20 for the same[xxxii].**

Role of Government: In case of urban areas, the Government should primarily play the role of a facilitator to support the funding, with ownership being borne by the telecom and infrastructure players. The Government is required to facilitate ease of execution and ensure efficiency in the broadband infrastructure rollout (Refer Section 5.B). However, the Government is expected to play a larger role for the success of the '100 Smart Cities' program.

iii. Smart Cities

In order to promote cities that provide for a clean and sustainable environment and improve quality of life via application of 'Smart' Solutions, the Government of India has launched the '100 Smart Cities' program. The foundation of these smart cities is based on building up of a robust telecom

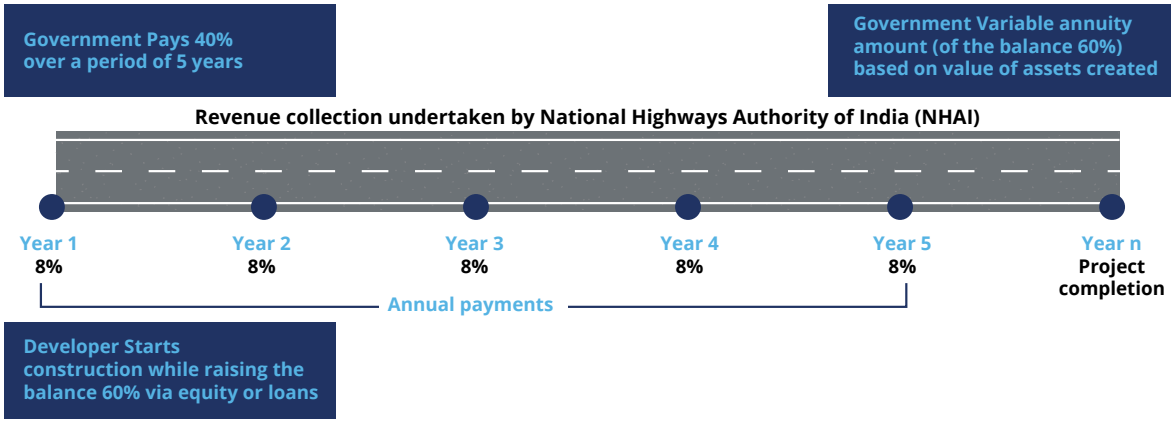
infrastructure. This initiative is expected to improve the efficiency of city management and enable local area development, driven primarily by technology-based interventions. Application of smart solutions (pertaining to m-governance, waste, water and energy management) will enable cities to use technology, information and data to improve infrastructure and services.
In order to successfully deliver on the '100 Smart Cities' program, the Government is required to play a larger role in the deployment of requisite broadband infrastructure. Multiple models could be considered for implementation of this program:

- **Enter into Public Private Partnership (PPP):** Variations of the PPP model like the Hybrid Annuity Model (as implemented by road developers) can be considered, whereby the Government and the implementation agency share the financial risk and the incentives are linked to timely completion of the project
- **EPC Model:** Under this model, while the ownership rests with the Government defined SPV, a selected vendor is entrusted with the task of establishing, operating and maintaining the network

Exhibit 5.A.2: Emerging business model for road developers in India

Hybrid Annuity Model (HAM): Under this model, the Government contributes 40% of the project cost in the first five years through annual payments. The remaining 60% is paid as variable annuity amount after the completion of the project, depending upon the value of assets created. The toll rights rest with the Government and the revenue collection would be the responsibility of the National Highways Authority of India (NHAI).

Figure 5.A.5: Hybrid Annuity Model



Advantage of HAM is that it provides liquidity to the developer with the financial risk being shared by the Government. While private partners continue to bear the construction and maintenance risks, they are only required to partly bear the financing risk.

Source: Secondary Research

04. Increased budgetary allocation for broadband

As discussed above, broadband has wide reaching implications that play a significant role in economic development. The positive outcomes of successful broadband deployment in developed nations and studies linking GDP growth rate to the speed and coverage of broadband, have incentivized several countries around the world to define ambitious Government plans and invest heavily in building a robust infrastructure.

Considering the multiple Government programs and transformation of society lies on the universal access and the robustness of the Broadband infrastructure,

The Government should consider a substantial increase of investment in the annual budget towards broadband access. Simultaneously the Government must deploy the existing unutilized USOF fund amounting to INR ~45,000 cr. for broadband proliferation.

The Government of China through their broadband strategy, has committed to invest ~3% of their GDP (~USD 320 Bn. in 3 phases) for broadband deployment[xi]. Other developed countries such as Australia have allocated ~2% (USD 22 Bn.) of their total GDP for the same[xv]. **India should also allocate a percentage of the country's GDP into the development of broadband infrastructure. The Budget allocated must reflect in the annual budget of the country.**

However, a detailed assessment of the existing planned budgetary allocation needs to be undertaken and additional requirements need to be assessed to ensure deployment of a robust and scalable network in all parts of the country. There exists a definite requirement increase the outlay from the USOF for successfully implementing BharatNet as well.

A key aspect that the Government may bear in mind as the budgetary allocation is decided, is that the focus needs to be not only at increasing reach of broadband but also on ensuring future-proof networks, so as to be resilient to next generation technologies. Emphasis must be laid on rolling out infrastructure on the basis of specific standards which ensure environmental sustainability and guarantee durability of the network. While this may entail increased capital expenditure, it will be offset by the increased life of the fiber.

B. Ease of Execution & Efficiency in Rollouts

Ease in the deployment of required infrastructure plays a significant role in the growth of broadband. Clearances and permissions from Central, State and Local authorities is a key enabler for the successful rollout of broadband networks, irrespective of the medium and technology that is used for propagation. Policies need to be drafted by the Government at both Center and State level, to ensure that rollouts are as smooth as possible, and within the planned timeframe. The aspect of adoption of efficiency in rollouts stems from the need to have defined standards for rolling out network layers, and methods that would not disrupt the way of life for the general populace.

India: As-Is Scenario & Challenges

In India, the rollout of networks for both fixed and wireless broadband have been slow due to multiple challenges. Efforts need to be made to ensure that ease of execution is experienced by the service and infrastructure providers. Additionally, efficiencies need to be brought about in network rollouts to enable sustainable and future-proof networks.

Deployment of Tower Infrastructure

Tower infrastructure is a key enabler for delivering broadband to the masses. However, the rollout of this infrastructure is faced with challenges across various areas such as availability of power, attaining permissions from various authorities in time, and lack of a uniform fee structure that could be applied across the country..

Deployment of Optical Fiber Cable and Infrastructure

Optical Fiber is the globally preferred technology to supply high-speed broadband to end users. This technology used in backbone and backhaul networks to support fixed and wireless broadband, is seeing steady uptake across the world in last-mile connectivity as well. However, multiple challenges related to Right of Way (RoW), lack of standards, unavailability of mapping

Table 5.B.1: Best Practices in Ease & Efficiency of Rollouts by Country

Area	Country	Learnings from broadband infrastructure plans
Right of Way	USA	• Policies have been put in place for cost & time management of RoW
	UK	• Standardization of terms of wayleaves over private property has been ensured for parity during deployments
	China	• Work is being done towards simple and specific RoW policies
Dig-Once	UK	• A Dig-once policy has been implemented along with access to other utility infrastructure; Promotion of infrastructure sharing has been done as well
	USA	• Dig-once policy has been implemented across major American states to ensure sustainability and reduce inconvenience and disruption to the public
GIS Mapping	North America, Western Europe, Japan, South Korea	• GIS mapping is used mandatorily for the deployment of new fiber
	China	• All fiber outlay in China as a part of the "Broadband China" strategy is to be mapped on a GIS system
	South Africa	• Private players with support of the Government, not only map but also display status of rollouts, using a real-time GIS rendition of fiber plans
	Bangladesh	• A nationwide GIS map of optical fiber deployment has been rolled out in 2016 with a view of supporting any public or private infrastructure project in the country
New Building Guidelines	UK	• Digital infrastructure provisions in new buildings has been mandated
	USA	• 'Wiredscore' has been implemented giving real-time ratings to buildings that have broadband compatibility and readiness in major cities

Source: Secondary Research, Deloitte Analysis

of data related to fiber, etc. impede the growth of optical fiber cable and related infrastructure.

Best Practices: Other countries and infrastructure players in India

It is important to understand the best practices followed by other countries and other infrastructure players in India, so as to arrive at next steps and recommendations to facilitate ease of execution and efficiency in broadband rollouts.

Practices of Other Infrastructure players in India

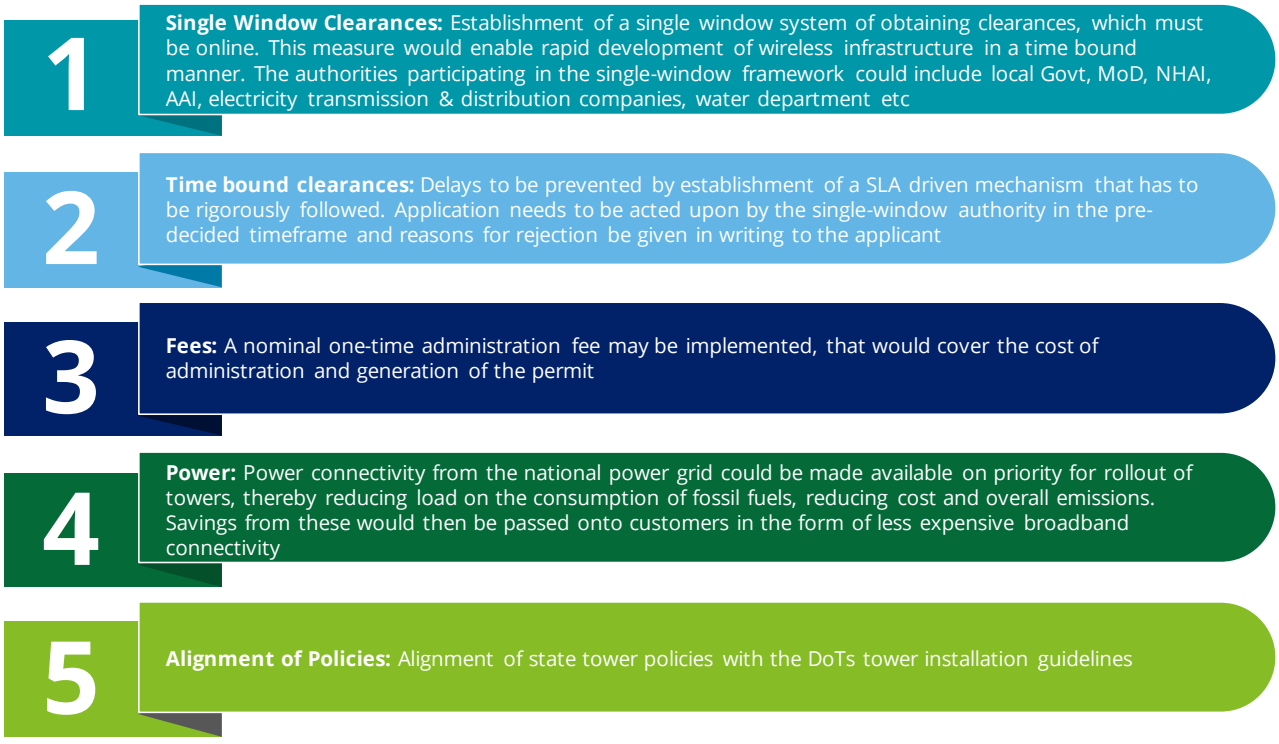
RoW permits, in case of NHAI, Railways as well as Forest & Wildlife departments are difficult to obtain and cause delays in the rollout of planned infrastructure. During BharatNet planning, most states have given free RoW permits for the deployment of fiber. More Other states can follow suit.

Recommendations:

1. Deployment of tower infrastructure

For the deployment of tower infrastructure, challenges around multiple authorities, fees and availability of power need to be overcome. It may be noted that the Ministry of Defence, along with the Railways, is one of the largest owners of real-estate across the industry, and needs to be leveraged. Recommendations for the same are as follows:

Figure 5.B.1: Key Recommendations on deployment of tower infrastructure

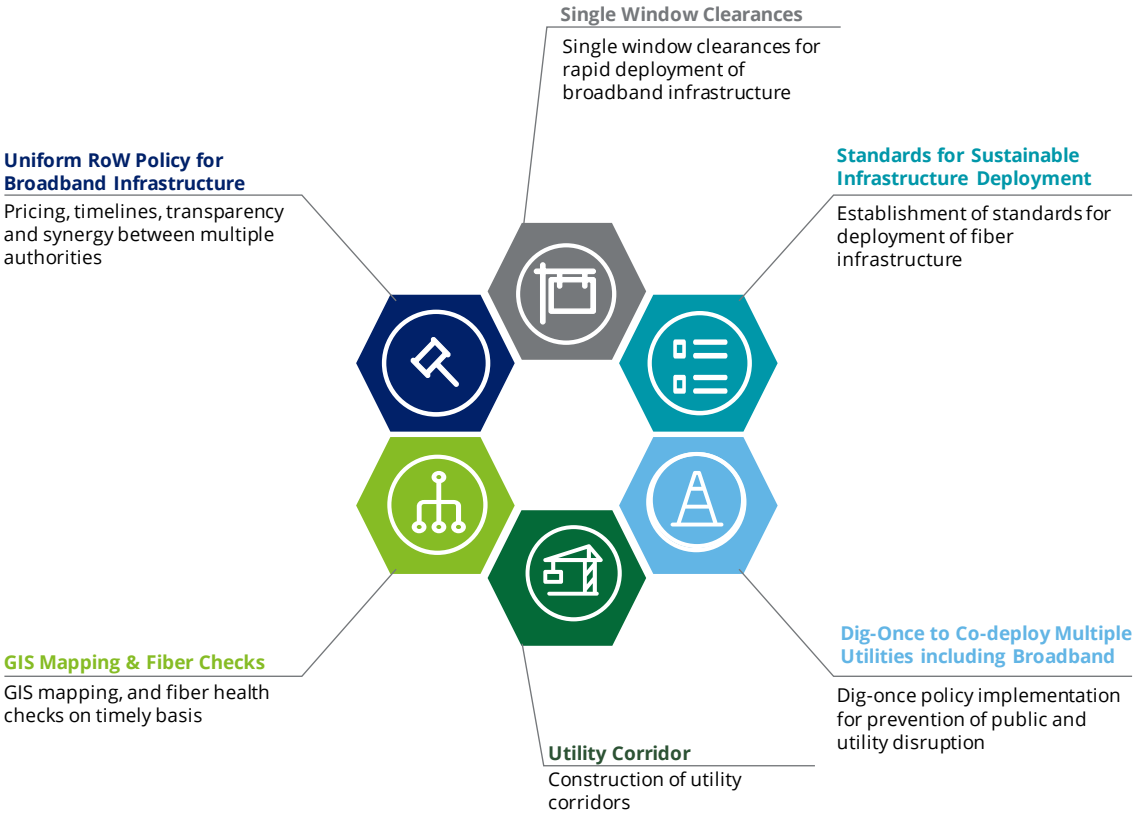


Source: Secondary Research, Deloitte Analysis

2. Deployment of Optical Fiber Cable and Infrastructure

Time bound permissions, fees, charges and uniformity of policy remain critical to the deployment of fiber-based broadband infrastructure. Implementation of best practices such as Dig-Once shall help increase reliability and security of the infrastructure.

Figure 5.B.2: Recommendations on deployment of optical fiber cable and infrastructure



Uniform RoW Policy for Broadband Infrastructure: Ambiguity around the process to obtain permissions, and delays caused due to administrative paperwork and complex processes highlighted by authorities at the local Government level, are major delay-causing factors. It has been observed, and often raised by industry players, bodies and other ecosystem stakeholders that Right of Way tends to be the biggest hurdle in the process of deploying networks.

- **Multiple authorities:** The current framework for obtaining clearances for infrastructure rollouts requires approaching a myriad of bodies (such as NHAI, Railways, oil PSUs, water boards, electricity boards, etc.) to obtain permits. A reason for the significant delays is the lack of coordination between them
- **Lack of uniform pricing policy:** While the policy for RoW is drafted at the center, the aspect of pricing of RoW permits remain at the discretion of local bodies. Lack of parity across geographies and demography (such as different prices for RoW in Delhi, Mumbai etc.) creates uncertainty and variations in business viability, thereby playing the role of a deterrent to network rollouts
- **Undefined or unfollowed timelines:** The process for granting clearances are recommended to have defined timelines. For instance, the outlay of fiber and related RoW permissions must be granted in a specific period of time. Delays in obtaining clearances lead to a direct impact on cost of deployment (Interest cost of borrowing for infrastructure/ equipment purchase, loss due to service unavailability to end consumer, loss due to network gaps in capacity augmentation etc.). These mounting costs either deter the deployment of the infrastructure or are passed on to the customer, making broadband affordability a concern

Key Recommendations

A uniform RoW policy must be instituted by the Government of India, and must be implemented by local government.

- This policy may rationalize costs depending on city type with arbitrary levies being stopped. Additionally, the only admissible charges could be towards reinstatement or charges directly linked to restoring the surroundings to their original state
- **A collaborative approach needs to be taken to create and execute a uniform RoW policy between all Government departments** such as Moe, MoD, Railways, Oil & Gas, NHAI, Power, Water and others

Single Window for clearances:

- The Government must institute a single window policy for clearances and approv
- **This process may be online and must have defined timelines with reasons for application rejections being given in writing to the applicant**

Standards for Sustainable Infrastructure Deployment:

To ensure a sustainable, scalable and reliable network asset that ensure network synergies across the country, it is critical to adopt global standards and customize them for infrastructure rollouts in India. Fiber optics networks (core, metro-core, backhaul and access) have the capacity to provide right connectivity for the broadband infrastructure to support subscribers with multi-gigabit speed, requiring very low maintenance, low latency and best-in-class reliability, scalability and future proof connectivity sustainability including 5G technologies with limited distance-dependent quality of service. Fiber-based backhaul networks play an important role in achieving broadband coverage and prepare the migration from high to very-high speed fixed and mobile services. These standards would include depth of trenching, size of ducts depending on the areas and type of cabling there is, deployment methods, etc. Additionally, setting standards enables the broadband infrastructure process to become sustainable from an environmental perspective.

The life and quality of the OFC network is critically dependent on the physical network design and installation practices. Global standards and scalable network design will optimize the network sizing and installation of the network. This also needs program management expertise to ensure longer asset life.

- **Duct/Conduit design:** Material and dimensions of conduit or duct that would be used for the purpose of fiber installation
- **Inner-duct installation standards:** Type of gaps in the placement of fiber, in the case of conduit based or direct underground deployment
- **Method:** Pulling and jetting are the predominant methods for laying OFC. Appropriate standards need to be set to ensure that the cable is not put through stresses in the process of laying
- **Digging and trenching:** OFC should be laid below 1650 mm in a flatbed trench to reduce attenuation losses due to undulations and sharp bends. Wherever the depth is not achieved due to strata conditions or any other terrain challenges, well-engineered physical protection should be given to the duct/cable
- **GIS Mapping:** To ensure traceability of the installed cable during the maintenance stage, the entire Installation parameters should be recorded in GIS and updated periodically during maintenance phase.
- **Tools & materials:** Specific tools and material need to be used to ensure that fiber laying and commissioning is incident free and long lasting
- **FTTH:** Standards to lay down the material requirement, design and constructional requirements, installation details

and methods of tests for Optical Fiber Cables for FTTH application is needed.

- **Skill & manpower development**: Training must be imparted to the technicians and laborers who deploy fiber and electronics. They may be further certified as well. These credentials may be used to qualify agencies for deployment of fiber and electronic broadband infrastructure.
- **Program Management**: Effective program management during installation phase will ensure faster deployment, adherence to installation guidelines and ownership based project management.

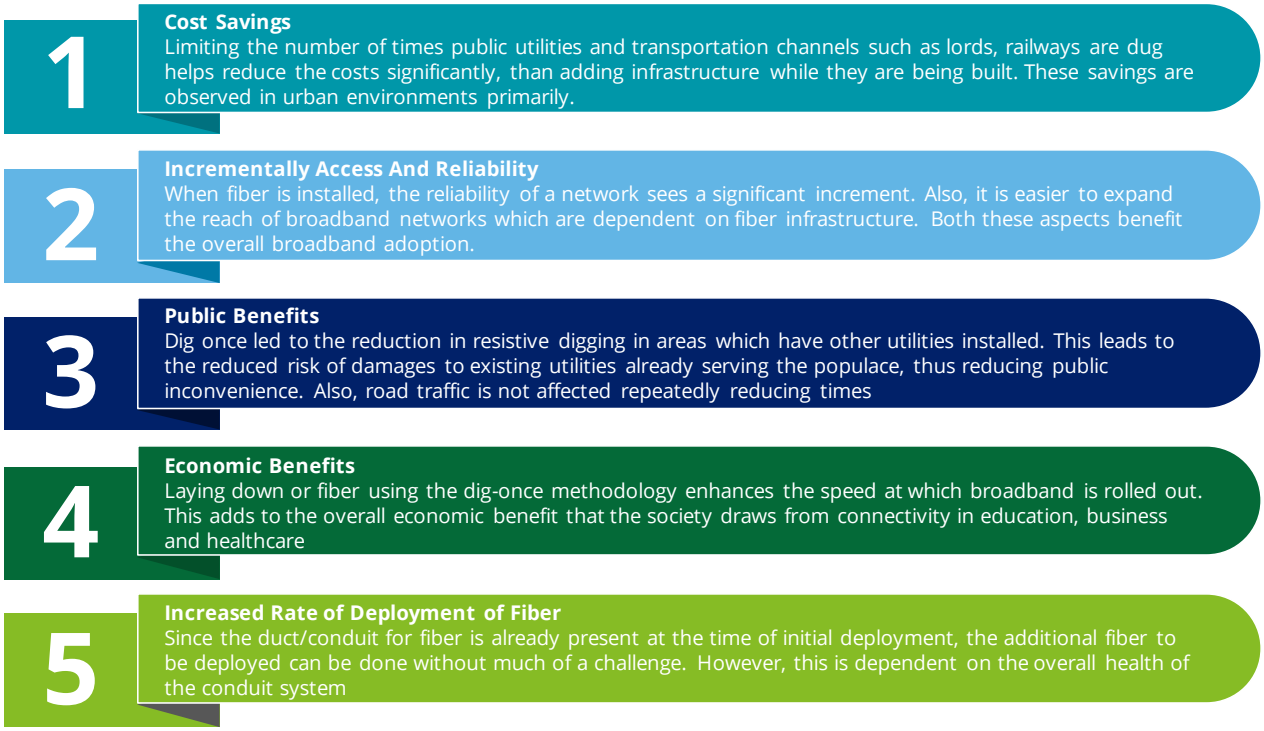
Deploying FTTx

FTTx deployments are gaining traction across the world fueled by the growing demand for data. While incumbent service providers are actively deploying fiber for internet access, new players are also participating in FTTx deployments. Real estate developers are among the new entrants that are actively leading FTTx deployments. These developers typically build large housing developments, apartment complexes and office premises. An emerging model of FTTx deployment is one where real estate developers are partnering with telcos and ISPs to roll out FTTx. The real estate developers usually have the Rights of Way (RoW) within their development area, while access providers provide fiber and access services to end users. The real estate developers provide manholes and carry out the ducting exercise, and the service providers provide fiber connectivity through these ducts to end users in the buildings

Dig-Once to Co-deploy Multiple Utilities including Broadband

Utilities such as roadways, water, gas lines and deployments of broadband do not follow a synchronized digging policy, which leads to significant cost from activities such as digging, trenching, RoW and other reinstatement fees. The risks in this methodology are numerous, of which disruptions to public life and utilities are the highest. One of the key measures taken by governments across the world is the development of a dig once policy in conjunction with laying new roads and widening some as well. The key benefits of Dig-Once are as under in figure 5.B.3.

Figure 5.B.3: Key Benefits of Dig-Once



- The dig-once policy must be implemented across the country with no exceptions
- Laws need to be created to ensure that adequate compensation is made and met in the event of any damages to fiber infrastructure, due to digging by other utilities and players

Utility Corridor

Repeated digging causes disruptions and leads to serious implications on the other infrastructure present in the area. **A key measure taken by governments across the world is the development of a utility corridor in conjunction with laying new roads and widening some as well. Multiple utilities, such as electricity, water, etc., use these corridors, thus significantly reducing the need to dig**. A utility corridor is a tunnel or passage that is built either under or over the ground which may be used by multiple utilities, such as electricity, water, etc. It serves the purpose of preventing repeated digs, which in turn reduce the cost of roll-outs and deployments.

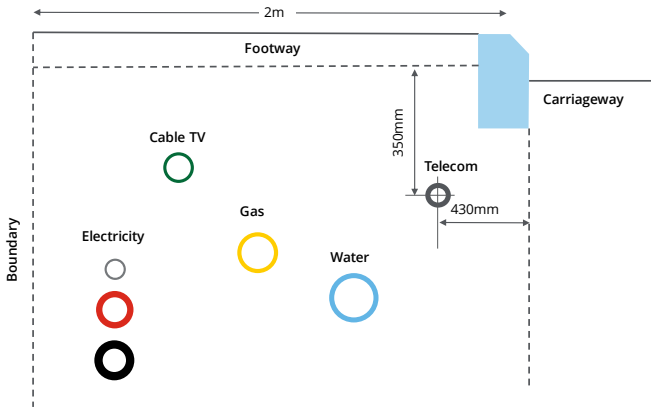
- For the establishment of Utility Corridors, players such as NHAI may be asked to provide ducting for all new road projects. Specific standards must be laid out by the Government in concurrence with NHAI, State Highway, piped natural gas, water, sewage and electricity as well, and these must be enforced with penalties for non-compliance
- Utility corridors must be established along the medians of major roads and avenues, as these constructions will allow for minimal disruptions during road-widening and construction activities
- Progressively, municipal corporations and municipalities could be asked to build these across major roads inside city limits thereby easing out urban broadband needs for infrastructure
- Policy must be laid down to secure fiber network by defining guidelines such as 'call before you dig'

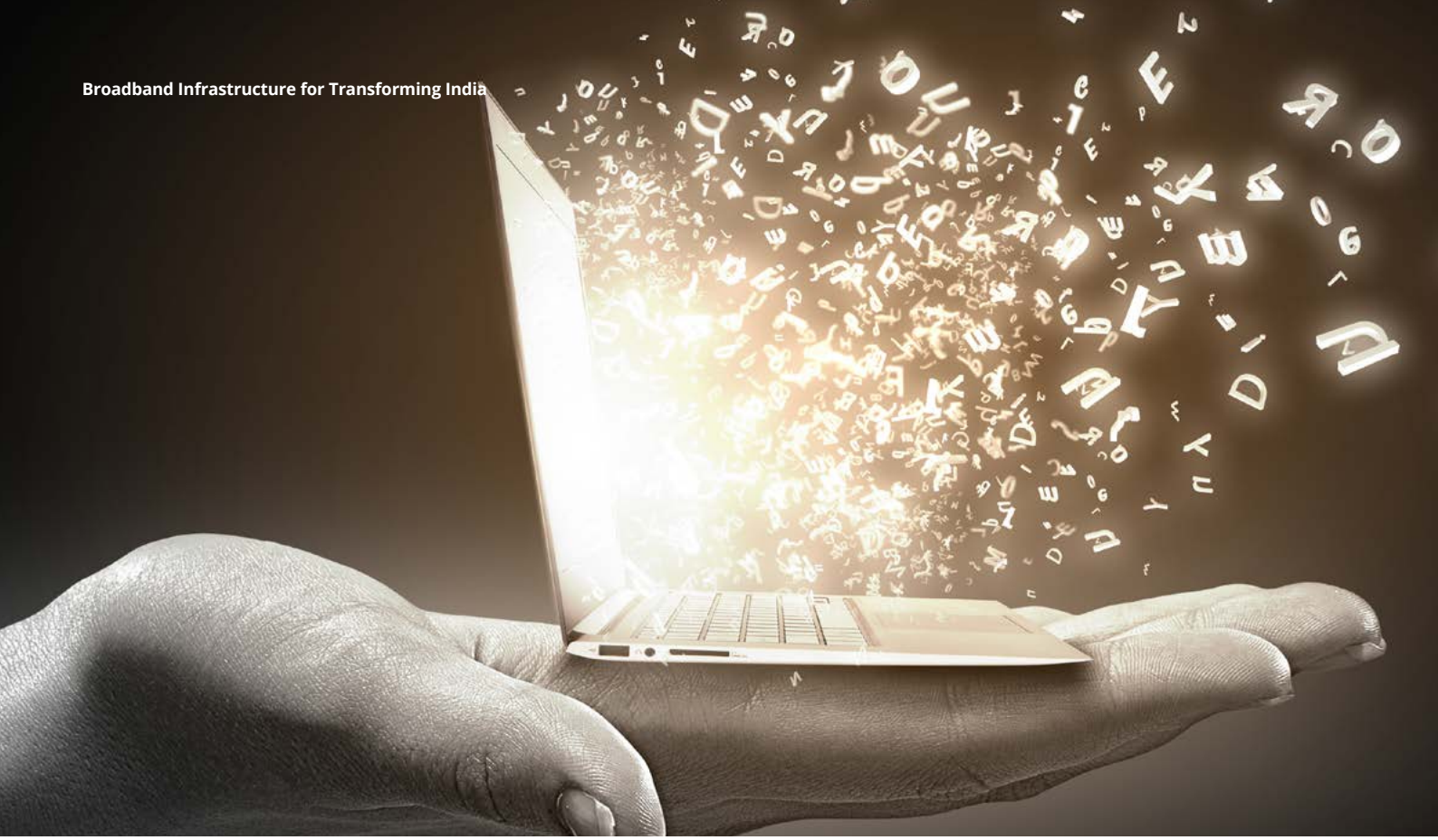
Construction of utility corridors in cities may be conducted through a 4-step process:

1. Information collection: Information on existing infrastructure projects, deployed utilities and standards & design guidelines followed by existing deployed infrastructure providers will be gathered in this step
2. Conceptual design development: A conceptual design needs to be created taking into consideration the planning and transportation requirements. This effort has to be conducted between the planners, transport engineers and utilities engineers to enable agreement on an optimized design of the roads and utilities that will meet the requirements of the intended use of the development.
3. Evaluation of design: At this stage the competent authority from the local government will select from the conceptual designs presented which are in line with RoW policies, road plans and so on. Changes, if any are asked to be made at this stage.
4. Final approvals: Final approvals may be given after design finalization. At this stage, all NoCs may be given to the utility tunnel contractor/designer through a facilitated single window process.

An example of the layout (cross-section) of a utility corridor is given below:

Figure 5.B.4: Utility Corridor in the UK[xxxiv]





GIS Mapping & Fiber Checks:

BharatNet (erstwhile NOFN) proposes to connect over 250,000 Gram Panchayats with high-speed broadband, primarily utilizing optical fiber cabling. Indian Government establishments such as BSNL, RailTel and PGCIL have already deployed optical fiber over the years. It would therefore appeal to BBNL, the nodal agency for BharatNet, to use existing fiber of these PSUs for the purpose of realizing their broadband goals. However, as identified by report of Committee on NOFN, the presence and health of the fiber remains questionable. This situation can be attributed to unavailability of data of mapping and health of fiber. Key recommendations in this area are:

- **GIS mapping for all new fiber must be instituted.** Attempts may be made, based on feasibility, to map existing fiber that continues to remain unmapped. Also, it must be noted that 10 states of the country have shown interest in GIS mapping of aerial fiber
- **Existing fiber must be checked on a periodic and regular basis to ensure its usage for a positive cost impact.** Mobile applications developed specifically for this purpose may be used
- To ensure traceability of the installed cable during the maintenance stage, **the entire Installation parameters should be recorded in GIS** and updated periodically during maintenance phase.

Securing the Network

Frequent disruptions in services such as telephony, mobile voice, data and broadband can occur due to careless digging of roads by public works contractors which leads to fiber cable cuts. These incidents are widely reported and have the potential to cause losses to the economies of cities and regions. Costs of restoration of such damages are generally borne by the service providers, which are then passed on to the customer. Countries around the world are working toward the prevention of these incidents with special guidelines to digging by introducing standards and procedures.

01. **Strong adherence to global deployment standards** of fiber layout below 1650 mm will ensure less disruption when other infrastructure roll-outs take place.
02. **GIS Mapping of fiber under road surfaces will ensure** a blue print to enable other infrastructure to be cautious of disturbing the network.
03. **Local Authorities can share the Fiber blue print** with other infrastructure roll out when they apply for ROW permission
04. **Security criteria around any willful disruption** of the network might also help.

Additionally, countries like the United States of America have state laws in place for the prevention and necessary action in the event of such damages. For example, the State of Florida through an act of their legislature have passed an act - "Underground Facility Damage Prevention and Safety". The provisions of this act contractors work closely with the service providers and the government to ensure that untoward damages are not caused. In the event of an incident causing damage to any underground utility, including cables, the contractor is liable to bear damages for replacement/repair, and may be liable to pay damages of up to USD 500,000 for losses as well. Given the large-scale deployment of fiber across the country under BharatNet, and large quantities of fiber deployed in urban areas as well.

C. Additional Strategic Considerations

With a view of ensuring broadband readiness in greenfield building constructions, thereby ensuring supply of broadband to end users, certain steps need to be taken at a policy level. One such step is the establishment of building codes.

Building Codes

Electricity and water are the only two utilities that are considered essential for residential and commercial spaces. There is a need to change building bye-laws, which currently deem only electricity, water and fire safety as necessary infrastructure. Broadband is required to be included by bringing 'broadband readiness' as one of the essential amenities as well. FTTx deployments are gaining traction across the world fueled by the growing demand for data. While incumbent service providers are actively deploying fiber for internet access, new players are also participating in FTTx deployments. Real estate developers are among the new entrants that are actively leading FTTx deployments. These developers typically build large housing developments, apartment complexes and office premises. An emerging model of FTTx deployment is one where real estate developers are partnering with telcos and ISPs to roll out FTTx. The real estate developers usually have the Rights of Way (RoW) within their development area, while access providers provide fiber and access services to end users. The real estate developers provide manholes and carry out the ducting exercise, and the service providers provide fiber connectivity through these ducts to end users in the buildings

Key recommendation in setting up building codes is as follows:

- **In-Building Infrastructure and certification by local Government:** An NOC as an integral part of the architectural approval/building code for greenfield buildings, commercial and residential should include Telecom/BB infrastructure as an essential requisite for building approval for occupancy. This proposes a distinct room to house terminations of equipment for broadband to facilitate a plug and play working model which must be provided on the ground floor for all multi-storey buildings. This room will be used for the termination of telecom fiber optic cables and to house telecom equipment, and for mobile and broadband. Such guidelines may be formulated at the level of the Central Government and certification granted by competent authorities at the state government.

Incentivizing other infrastructure build-out to include Broadband

Co-deployment of broadband infrastructure along with other public infrastructure can aid broadband roll-out and enhance connectivity. Such measures can be undertaken by incentivizing the existing public infrastructure providers. These steps will enhance proliferation of broadband.
Regulatory environment plays a major role in efficient use of public infrastructure with utilities. In developed economies, regulators have been incentivizing utilities to share infrastructure. For example, US FCC passed a regulation on pole sharing in 1978. In Europe, the European Commission has recommended the adoption of legislation that relies on sharing to help increase investment in next generation fixed networks Some of the ways in which infrastructure sharing across utilities for fiber deployment can be encouraged are:

- Include sharing obligations in building planning provisions when approving planning permissions and new buildings, governments could consider attaching obligations to ensure provision of ducts for broadband access are included in construction plans
- Include obligations to support duct sharing in cable laying and other public utility infrastructure. In increasing number of countries, operators laying fiber are required by regulation to make duct space available for other operators and also for government structures, particularly municipalities. This includes mandating larger cabinets or ducts, or through appropriate digging and network protection facilities and use of micro-ducts. This policy could be extended to transport, energy links and waterways

Create a cross sectoral infrastructure planning database of the existing and planned infrastructure of different sector utilities, such as Germany's Infrastructure Atlas which allows co-ordination of works across utilities at small additional cost

Best practices in FTTx deployment

As FTTx is gaining traction as access technology using fiber, service providers across the globe are adopting some of the practices for ensuring high quality and reliable connections, and optimizing deployment costs:

- **Use existing infrastructure:** In most cases, last drop revolves around digging and trenching for

burying a new duct. By sharing infrastructure, not only with other service providers, but also with utilities such as power, water and sewage, service providers can bring in efficiencies in deployment costs

- **Follow correct standards of fiber deployment:** Appropriate construction methods, such as micro-trenching, mole plowing or directional drilling should be adopted. This results in faster deployment at lower costs, and ensures longer life of fiber cables
- **Use the right equipment:** It should be ensured that the cable and duct used within last drop implementations meets the specific needs of deployment.
- **Adequately train the personnel deploying FTTx:** This will ensure consistent and high quality deployments, implemented quickly
- **Increase accuracy of network planning:** by using additional data, such as surface type of street, availability of existing and re-usable infrastructure, and suitable locations for POPs or fiber concentration points
- **Choice of FTTx fiber:** such as single mode or multi-mode fiber should be based on a number of factors such as network architecture, size of network, existing fiber type and expected lifetime of FTTx networks

Using cable infrastructure for delivering broadband

The number paid television subscribers is expected to grow from 152 million in 2016 to 183 million by 2025 as per Media Partners Asia. A large number of subscribers access paid television through the cable TV (CATV) network. CATV is also used for delivering broadband to end users extensively across the world using HFC cables. In India, broadband through cable networks is dominated by local cable operators (LCOs) and multi-system operators (MSOs)
The cable TV network deployed by the MSOs and LCOs were traditionally focused on the needs of delivering cable TV to residential subscribers. The CATV networks in India do not have adequate redundancies built in. The same networks are largely being used to deliver broadband. Hence these networks are not enterprise grade and may not be able to provide service levels in terms of speed, availability, up-time, etc. Additionally, LCOs being smaller players, may not have followed the standards in deploying cables for CATV and internet in the same way as service providers globally have.

D. Technology for Future Proofing

Overview

The internet value chain consists of 2 broad network components – the backhaul infrastructure and connectivity services and access services. These can be further broken into multiple network components – Undersea cables, Core national backbone, domestic transmission, backhaul, and access services for enterprises, SME and retail subscribers (Ref. Fig. 5.D.1). Technology plays a key role in every component of the broadband delivery network. Apart from other factors, data speed and capacity requirements play an important role in identifying the most suitable technology for any component of the broadband delivery value chain.

Figure 5.D.1: Broadband delivery value chain[xxxv]

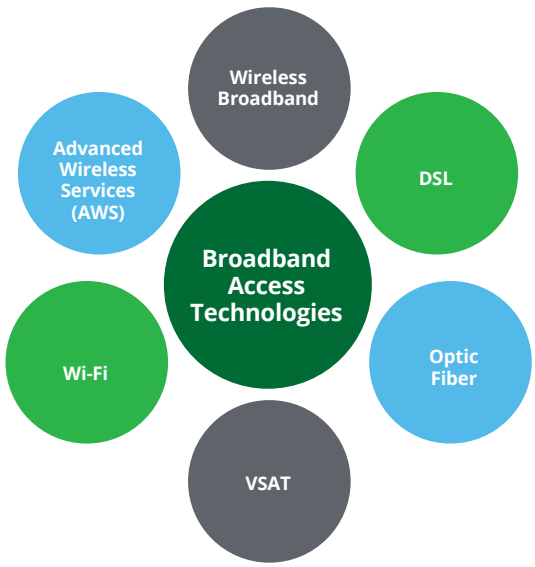
Value Chain

	Undersea Cables	Core National	Metro	Backhaul (FTTT)	Enterprise	SMEs	Retail
	Connect to submarine cables	*National Long Distance*	*Domestic Transmission*	*Fibre to Towers / POPs, AGs, etc.*	*Enterprise Connectivity*	*SME Connectivity*	*Retail Services*
	← Wholesale Infrastructure & Connectivity Services →			← Access Services →			
Dominant Technology	Fibre	Fibre	Fibre	Micro-Wave	Fibre	3G/LTE	3G/LTE
Competing Technologies	-	Copper	Microwave	Fibre	Copper, VSAT Micro-wave, WiMAX, LTE	VSAT, Copper, Fiber WiMAX, LTE	Copper, Fiber WiMAX, WiFi
Data speed and capacity requirements	Very high	Very high	High	High	Medium to high	Medium to high	Medium
Additional capacity need	· Low · Low fill rates · Existing capacity is under-utilized	· Low · Sufficient capacity in national backbone	· High · Growing data demand, reliability and uptime	· High · Growing wireless data demand, reliability and coverage driving fiberization	· Medium to high · Growing data demand · Higher SLAs, security and uptime requirements	· Medium to high · Growing bandwidth & reliability requirement	· High · Growing bandwidth & reliability requirement

Broadband Access Technologies

Broadband access networks consist of fixed-line and wireless links that provide end user connectivity. End users are enterprises, SMEs and individual retail users. As highlighted in figure 5.D.1, a mix of technologies is used to provide access services. With the evolution of fixed-line technologies and liberalization of spectrum usage in India, a number of broadband access technologies are currently being used for fixed-line and wireless broadband services (Ref. Fig 5.D.2).

Figure 5.D.2: Broadband access technologies[xxxvi]



- **Emerging technologies**
  - **Access:** Apart from existing access technologies, new technologies that have the potential to provide innovative means of broadband access in rural and remote areas are being developed and tested. Some of the key emerging technologies with significant potential are wireless broadband near power lines using "surface waves", Li-Fi using LEDs, miniature satellites, UAVs, millimeter wave, heterogeneous networks using multiple types of access nodes in a wireless network
  - **Network:** In networks, software defined networking (SDN) and network functions virtualization (NFV) are emerging architectures that can enable telcos to meet the increasing end user bandwidth demands in a scalable, cheaper and efficient manner.

Objectives

There are 4 key objectives behind technology choices across the broadband delivery value chain, as highlighted in figure 5.D.3.

It is imperative that specific actions be taken to also ensure readiness from the perspective of emerging and futuristic technologies such as 5G, M2M, Internet of Things, etc.

Challenges

Some key challenges in the expansion of broadband infrastructure in India are as follows:

01. Low investment in fiber

Optic fiber connectivity has emerged as the most optimal choice for domestic transmission, national backbone and international connectivity. As wireless broadband technologies evolve and adoption of FTTx increases for enterprise and residential broadband needs, demand for optic fiber deployment in backhaul and access is increasing across the world, as highlighted in table 5.D.1 below.

Developed as well as developing countries are promoting deployment of optic fiber across broadband delivery value chain since it is future proof - fiber is expected to be in a position to meet future bandwidth demand. Yet, India continues to remain highly under-fiberized, with cumulative fiber-deployed-to-population ratio at ~ 0.1x (v/s United States: 1.2x and China: 0.7x) and only ~20% of towers (for incumbents) are currently fiberized v/s the required ~70-80% required to support 4G today and 5G in future[1].

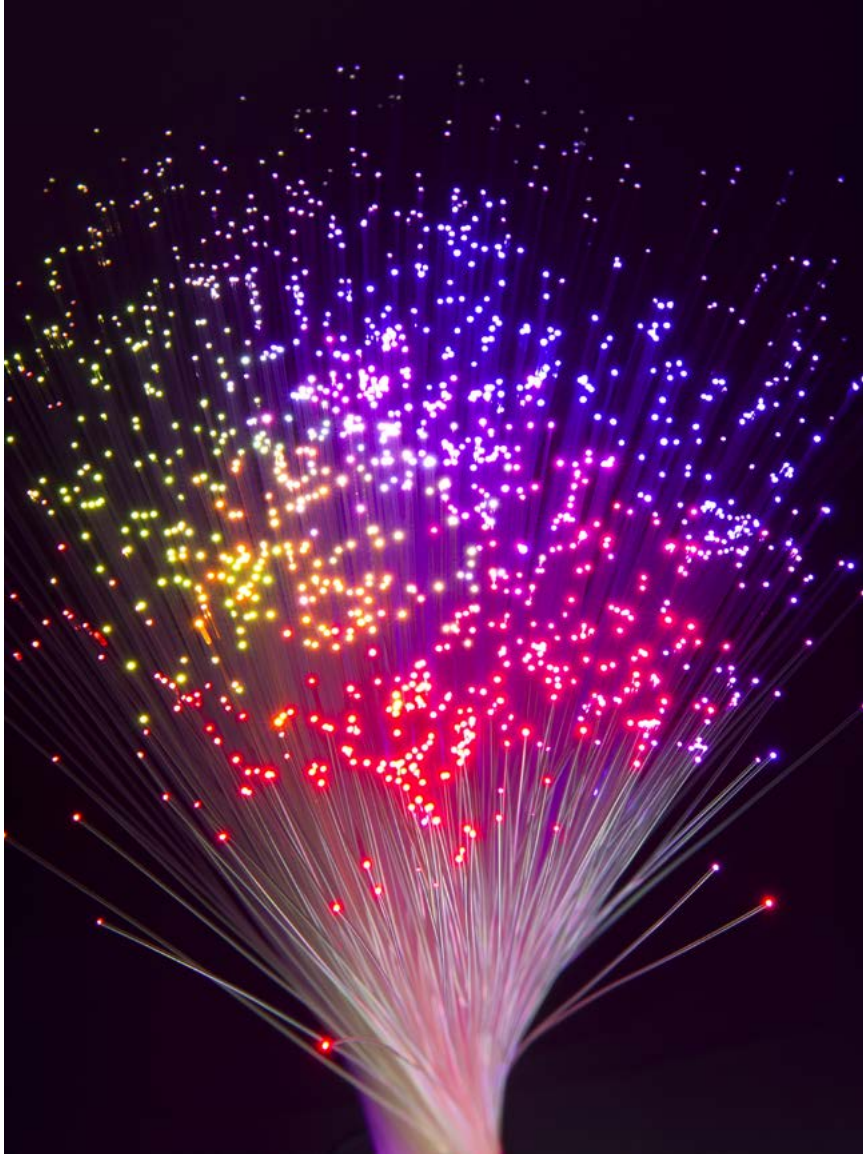
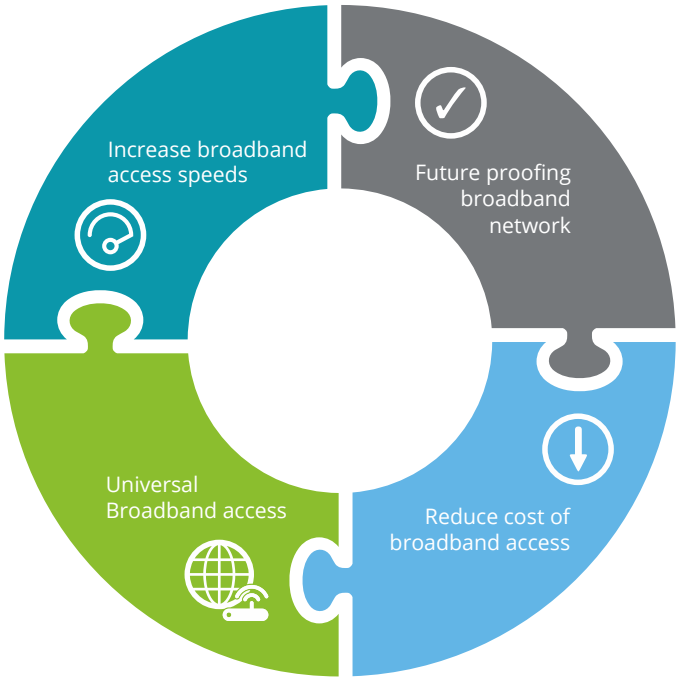


Figure 5.D.3: Broadband technology objectives[xxxvii]



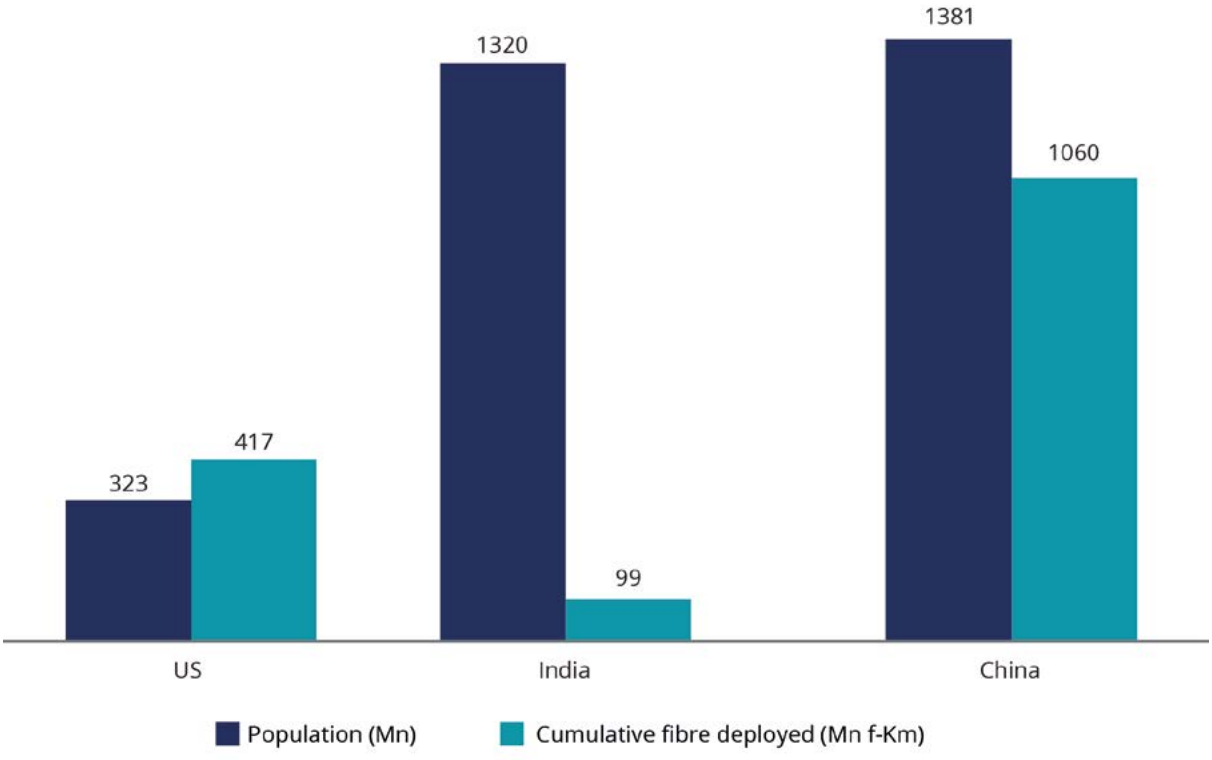
[1]India needs 50 million Km of new mobile backhaul fiber. See: http://spectrumfutures.org/india-needs-50-million-km-of-new-mobile-backhaul-fiber/

Table 5.D.1: Network components globally used for supporting broadband technologies[xxxviii]

Optimal connectivity to support data/bandwidth demand

Technology	Access	Backhaul	Domestic transmission	National long distance	International long distance
LTE/4G	IP Microwave (eNode B)	IP Microwave/Fiber (FTTT)*	Fiber	Fiber	Fiber
3G	IP Microwave (Node B)	IP Microwave/Fiber (FTTT)	Fiber	Fiber	Fiber
AWS/5G	IP Microwave	IP Microwave/Fiber (FTTT)	Fiber	Fiber	Fiber
DSL	Copper	Fiber/Copper	Fiber	Fiber	Fiber
FTTx	Fiber	Fiber	Fiber	Fiber	Fiber
Wi-Fi	IP Microwave (UBR)	Fiber/Copper	Fiber	Fiber	Fiber
VSAT	Satellite	Satellite	Satellite	Satellite	Satellite

Figure 5.D.4: Comparative analysis (Population vs Cumulative fiber deployment)



Source: CRU - MONITOR, 2016

02. Traceability and usability of existing fiber

The NOFN committee report published in March, 2015 had identified lack of quality and availability of existing dark fiber deployed by BSNL over 20 years back, especially from districts to blocks as a major roadblock in deployment of incremental fiber from blocks to GPs. The problem of poor health of existing optic fiber due to fiber cuts is magnified due to absence of GIS maps for tracing and correcting cable faults in the deployed dark fiber.

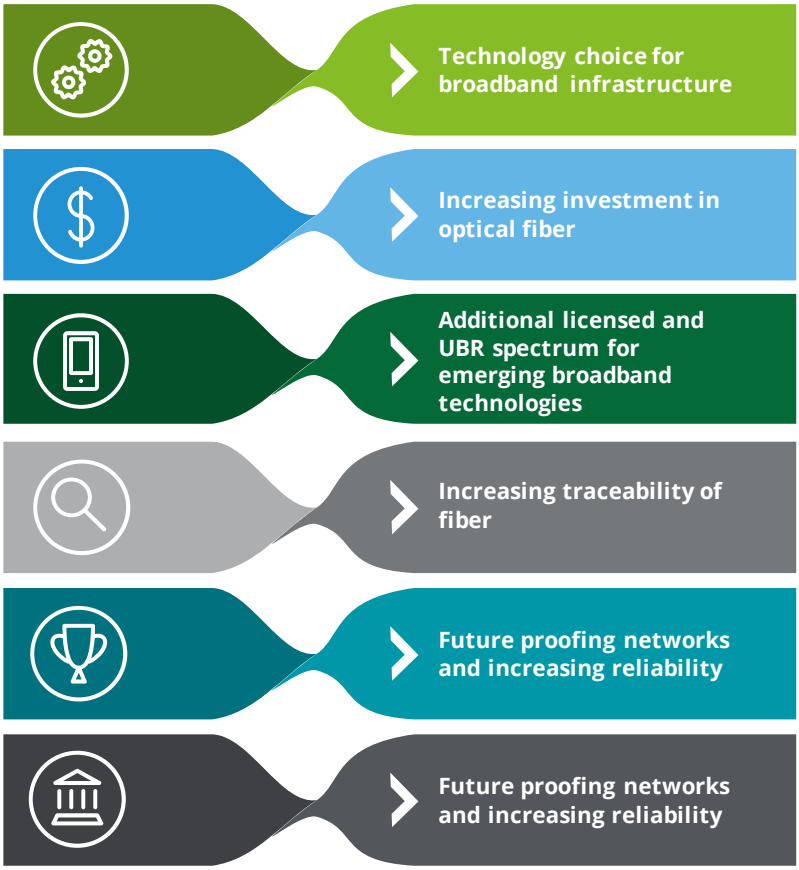
03. Lack of reliability of network

The existing network topology of the fiber from block to GP is largely linear, which is inadequate for providing network redundancy. Connectivity may be lost in events of link failures due to lack of alternate routes for routing traffic which is available in ring architecture. Hence, there is a risk of non-availability of backhaul network and lower than acceptable service levels to telecom operators and end users.

Key Recommendations

Technology related recommendations are categorised in 7 broad areas, as highlighted in figure 5.D.5

Figure 5.D.5: Broadband technology recommendations



01. Technology choice for broadband infrastructure

There are major technical characteristics to be considered for identifying the best fit solution for each type of infrastructure, as highlighted in figure 5.D.6.

Figure 5.D.6: Technology considerations for fixed and wireless solutions

Fixed Solution	Throughput (DL)	Protocol	Robustness	CAPEX	Scalability	Maintenance
FTTx (GPON)	> 1 Gbps	IP	🟢	🔴	🟢	🟡
xDSL (vDSL2)	< 300 Mbps	ATM/IP	🟡	🟢 (1)	🟡	🟢
HFC (DOCSIS 3.0)	< 400 Mbps	IP	🟡	🟡 (1)	🟡	🟡
BPL	< 500 Mbps	IP	🔴	🟢 (1)	🔴	🟡
Wireless Solution	**Throughput (DL)**	**Bandwidth**	**Range**	**CAPEX**	**Robustness**	**Interoperability**
LTE/LTE – A	< 100/300 Mbps	1,4 – 20 Mhz	5 – 100 km	🟢	🟢	🟢
Satellite	< 24 Mbps	1 – 40 MHz	100 – 6000 km	🟡 (1)	🔴	🔴
WiFi	< 433 Mbps[2]	20 – 160 MHz	35 – 115 m (indoor)	🟢	🟡	🟡
DC-HSDPA +	< 84 Mbps	5 – 20 MHz	< 50 km	🟡	🟡	🟢

Legend: 🟢 Better 🟡 Average 🔴 Worst

Notes: (1) If infrastructure already existent; (2) type AC600, 5 GHz band
Source: 3GPP specifications, ITU specifications, IEEE specifications

Best fit Solution
FTTx (GPON): Extreme reliability, high throughput, future proof technology
xDSL (vDSL2): Proven, cheaper to adopt and maintain technology
LTE: High throughput, good legacy interoperability, high mobility technology
Satellite: Global coverage, severe conditions appropriate technology

Technology choice is also significantly influenced by demand. Services to be provided need to be defined along with definition of each network layer i.e. last mile, access, backhaul, and core.

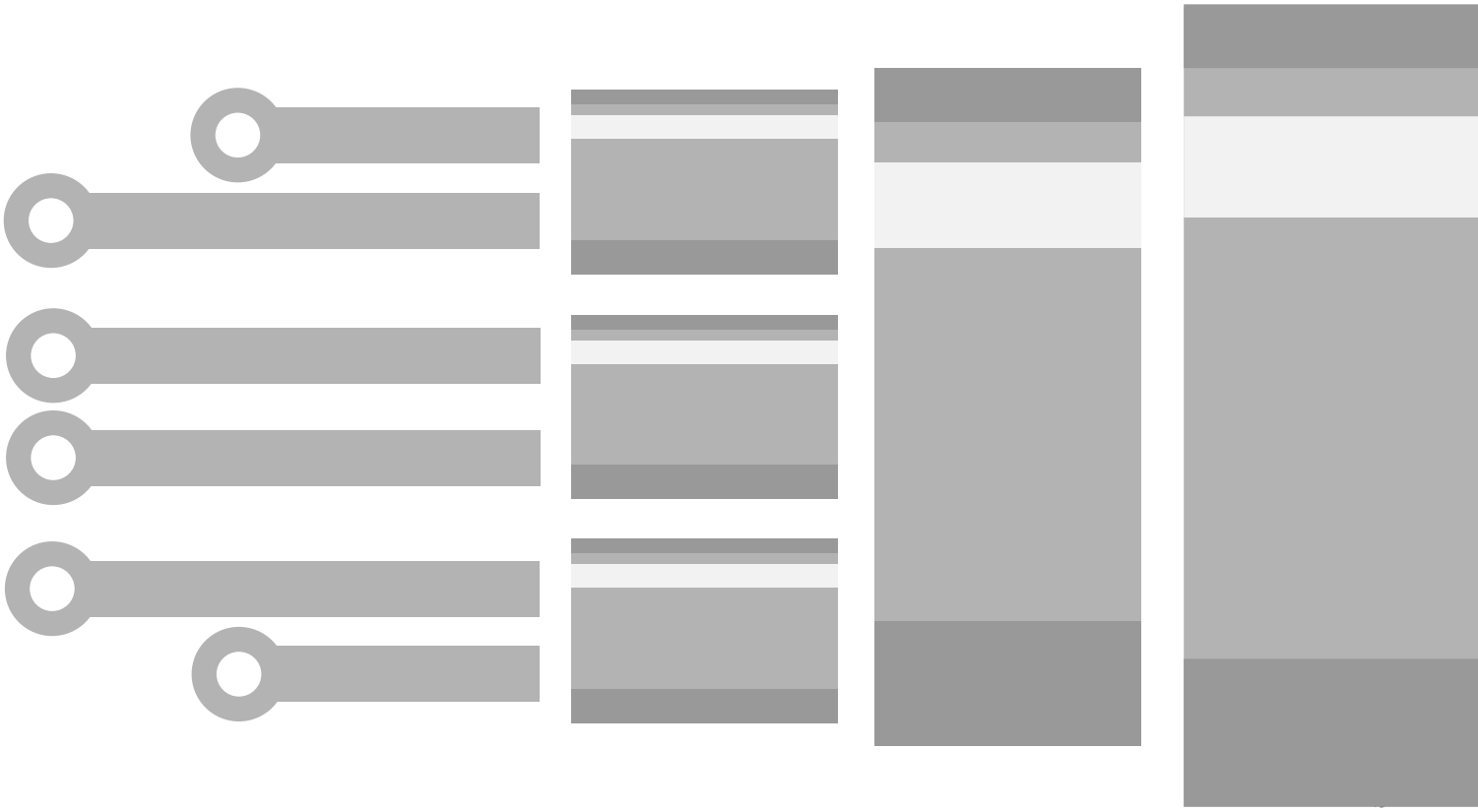
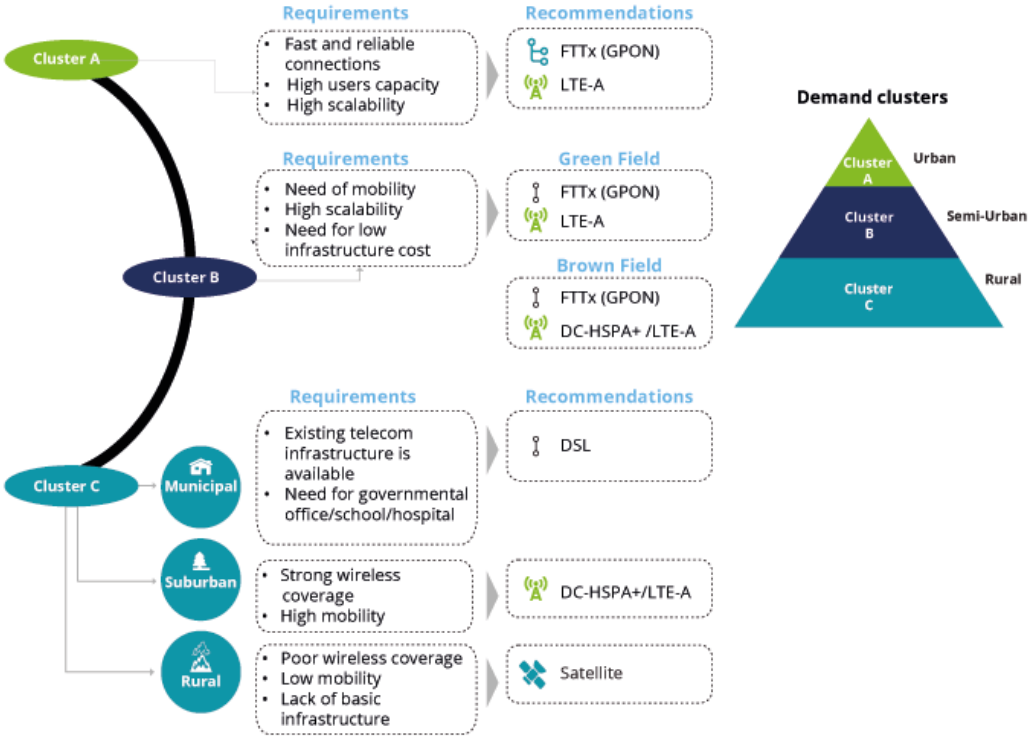


Figure 5.D.7: Technology Mapping by Demand Clusters:



As described in the figure above (Fig. 5.D.7), the choice of technology may vary depending on the feasibility of deployment, potential demand, topography and other such considerations. In India, the technology choice may vary from urban to semi-urban to rural areas.

02. Increasing investment in optical fiber

Increasing investment in optical fiber is essential to meet the growing demand for data as well as future proofing broadband networks across broadband delivery value chain.

- **Optical Fiber deployment – Underground vs. Aerial**

  There are primarily 2 types of optical fiber deployment – Underground and Overhead. Underground optical fiber deployment requires digging, trenching and laying OFC in ducts at appropriate depths. Overhead optical fiber deployment is done either as OF deployed in OPGW cables or as OF deployed in ADSS cables. OPGW refers to Optical Ground Wires that are used in high voltage power transmission lines, while ADSS refers to All-Dielectric-Self-Support cables that are strung along poles used for distribution of low voltage power. A comparison of underground and overhead optical fiber installation is illustrated in table 5.D.2.

  As explained in table 5.D.2, while cost of underground network is relatively higher than overhead network, total cost of ownership for underground installation is lower than that of overhead installation. Moreover, life of underground fiber is significantly higher than that of overhead cables, subject to deployment as per standards.

Some of the key observations regarding underground and overhead fiber deployment are:

- Although both methods are used globally, underground deployment is more prevalent due to long life, reliability and low total cost of ownership
- Overhead solutions are cheaper methods of deploying drop cables in the final link to end users
- Overhead deployment is done with special quality products

Fiber has the least down time, lowest cost per GB and can provide services to very high data usage customers. Fiber roll-outs in India need to match the surge in data consumption as well as digitization initiatives that are under-way.

Table 5.D.2: Comparison of Underground and Overhead fiber deployment

Attributes	Underground installation	Overhead installation
Resource availability for execution	Sufficient	Limited
Deployment speed	Moderate to High	Low in the case of OPGW High in the case of ADSS
Product availability	Standardized	Specialized
Reliability	High - immune to external conditions	Low - prone to damage due to external conditions, especially ADSS
Network life	High - ~20 years if deployed as per standards	Low - ~10 years with specialized cables
Pan-India ecosystem	Well developed	Nascent - present only in few geographies
Scalability	High - multiple cables can be installed in same duct. More ducts can be laid for scalability	Relatively low for OPGW cables - Towers costly Relatively high for ADSS cables - Poles cheaper
Operations & Maintenance	Minimal monitoring - typically during road widening	Frequent monitoring - cables are always exposed in open
Safety concern	Low	High
Network design dependence	High reliability in linear topology	Low reliability in linear topology
Cost of network	Relatively higher	Relatively lower
Cost of cables	Relatively lower	Relatively higher
Cost of accessories	Relatively lower - only JC required	Relatively higher - accessories required for hanging cables
Cost of installation	Relatively higher - cost of ducting and trenching	Relatively lower
Cost of maintenance	Low - if deployed as per standards	Low for OPGW High for ADSS
Total Cost of ownership	Lower	Higher

Source: Primary interviews, Deloitte analysis

- Electrical cable deployment under APDRP scheme has seen significant wastage due to poor overhead deployment on bamboo poles

It is recommended to have a mix of 70% underground deployment and 30% overhead deployment, only along transmission/distribution lines

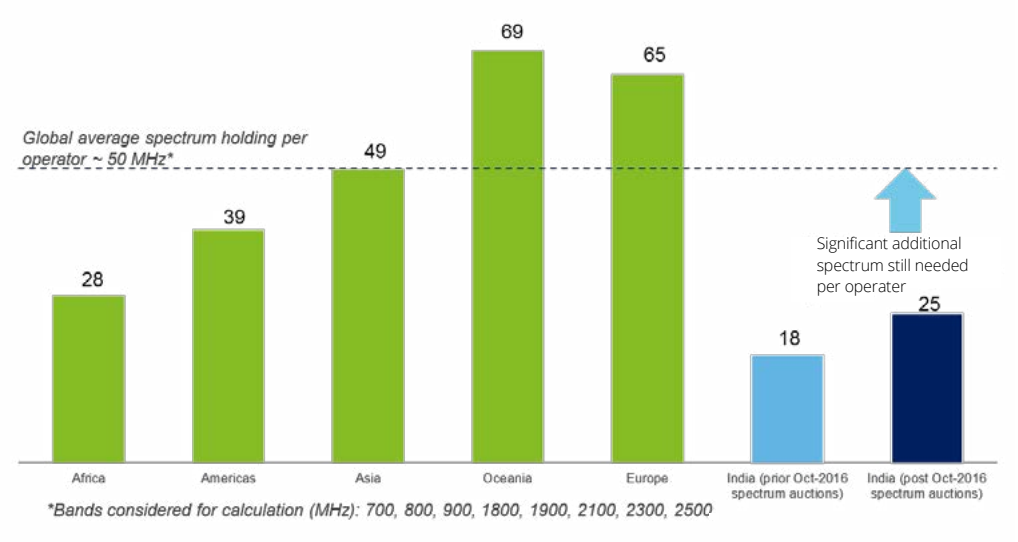
03. Spectrum specific actions

Spectrum band and technology usage is evolving to accommodate growing traffic and capacity requirements across the globe. Government of India has introduced policies around spectrum harmonization, spectrum liberalization and spectrum sharing & trading, which has enabled the deployment of various wireless broadband technologies. The Government, in 2016, released 2355 MHz of spectrum across various bands. This led to significant jump in spectrum per operator from 18 to 25 which is ~40% increase. Auctions need to be transparent and pricing should be continuously reviewed based on market dynamics.

Spectrum prices impact the affordability of services, as these charges are passed on to the customer. This action would play a critical role in achieving India's aspiration to connect over 600 Mn. subscribers to broadband by 2020

Telecom operators have been trying to meet the growing demand for mobile broadband data and support superior customer experience through network expansion and spectrum acquisition. However, intense data pricing competition and high levels of debt have placed limitations in the network and spectrum capex that operators can undertake. They are looking for alternatives to maximize the performance of existing networks and support rich customer experience. Carrier aggregation is a technique used to combine multiple component carrier bands across available spectrum to support wider bandwidth signals, increase data rates and improve network capacity and performance.

Figure 5.D.8: Global average spectrum holding per Operator



Source: TRAI, Qualcomm, Deloitte analysis

04. Increasing traceability of optical fiber

Geographic Information Systems (GIS) mapping allows companies to capture, store, manipulate and analyse spatial data of location of network assets including optical fiber. Location information consists of latitude, longitude and elevation and the GUI helps visualize the data.

GIS in optical fiber deployments are useful for system operation and maintenance, system planning and expansion, system analysis and visualization. Use of GIS in optical fiber deployment decreases the overall operating costs and improves performance of optical fiber network.

Hence, GIS mapping of existing underground and overhead fiber may be conducted, especially from districts to blocks to plug the gaps in location information. Additionally, GIS technologies may be extensively used for planning, designing of proposed optic fiber links – connecting blocks to districts and GPs to blocks.

05. Future-proofing networks and increasing reliability

It is essential to ensure that our networks are reliable and adhere to SLAs in order to support individual and enterprise data demand. Network topologies play a significant role in determining network reliability. Increasing domestic network redundancy increases reliability of our broadband networks. **Network redundancy can be increased by ensuring that we have an optimal mix of ring topology and linear topology.** Ring topology introduces alternate paths in the domestic network for routing internet traffic in the event of link failures. The largely linear topology of network connecting blocks to GPs can be transformed to ring topology by adding ring closure links, in a phased manner to form large rings initially, and progressively smaller rings going forward. Additionally, 'mesh' architecture could also be considered for select locations as a long run solution for increasing reliability, security and future proofing networks.

06. Policies to enable adoption of emerging technologies

A number of emerging technologies can potentially speed up roll out of affordable high speed, broadband network and services, especially in the rural and remote areas where it has not been feasible to deploy conventional networks. Additionally, as bandwidth demand from urban and enterprise users is expected to increase manifold, TSPs will have to invest in core networks. **Emerging software based network architectures like SDN and NFV can enable telcos to overcome the constraints of traditional static network architectures and meet the demands of high-bandwidth and dynamic applications in a cost-effective manner.** The existing policy and license regime needs to be suitably modified to embrace deployments of diverse and emerging technologies

6. Broadband Framework: Governance

Implementation of the identified initiatives to achieve the broadband goals requires an extensive governance model. It is pertinent to understand the governance models adopted by other countries, to define the model for India's broadband plan implementation.

Key Learnings from Global Case Studies

Countries across the globe have implemented robust governance models for broadband. Key learnings from these countries are:

Table 6.1: Learnings from Global Case Studies on Governance

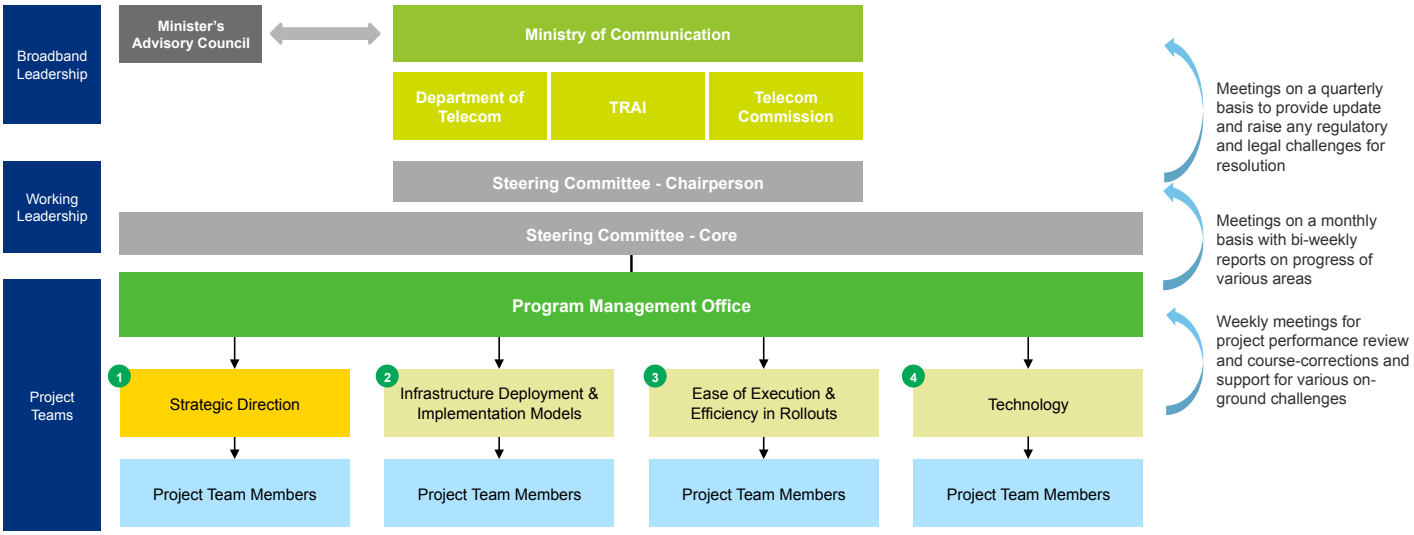
Area	Learning
Active involvement across stakeholders	Countries involve stakeholders across the broadband ecosystem in the execution of broadband plans and implementation of policies. The implementation requires perspectives and viewpoints of varied industry participants – supply infra players (such tower infrastructure providers, fiber providers), service providers (such as Telecom service providers, internet service providers, FTTH providers), demand side players (media, healthcare e-Governance service providers), and key enablers (FICCI, NASSCOM COAI, AUSPI, BIF, FTTH council) Government participants (such as Niti Aayog, PMO, MEITY, Finance)
Local community involvement	Involve local community in implementation and key decision making which would be critical for resolving last mile connectivity issues within the defined timeline
Commissioning of multiple project teams	Workgroups are commissioned consisting of stakeholders within the broadband ecosystem for execution of specific policy actions and plans – Designated list of tasks are assigned to each project team and its success is assessed based on pre-defined key performance indicators
Tiered governance model	Multi-tier model of governance has been adopted by countries (tiers are observed to vary from 3 to 5)

Source: Secondary Research, Deloitte Analysis

Key Recommendations

Governance Framework

For the realization of India's broadband vision and effective implementation of the same, a robust multi-tier framework needs to be implemented. Led jointly by industry participants and the Ministry of Communication and departments therein, this framework establishes a close connect with national leadership. The governance structure is recommended as below:



Salient features for successful implementation:

01. **Steering Committee:** The Steering Committee recommended to be a **joint working group would comprise Government and private stakeholders, who would consult and report to the Ministry of Communications on various policy actions.** This committee would also be responsible for providing guidance to the working group leadership.

02. **Interplay of ministries:** **Ministries across the value chain (Ministry of Road, Water, Power, Finance, etc.) need to work cohesively as a single unit whilst bringing together varied viewpoints pertaining to different industries**. These ministries are interdependent and it is pertinent for them adopt a collaborative approach towards broadband deployment and generating awareness, in order to ensure effective and timely implementation of the same.
03. **Broadband Champion:** A concept of 'Broadband Champion' can be considered, wherein an **identified individual within each Ministry would be the single point of contact for all broadband related matters.**

04. **Advisory Council:** To enable constant consultation with senior leadership of Broadband B infrastructure providers, private and public service providers, content ecosystem players and other key stakeholder organizations, an Advisory Council would be established. **This council would convene on a regular basis to highlight key issues on broadband proliferation to the Minister, and allow to confer with industry leaders on policies, programs and broadband objectives, thereby enabling cohesive development of broadband.**

Reforms already undertaken by the Government for broadband proliferation:

We are now at a threshold of a digital revolution that compels us to focus on delivering high quality, affordable and reliable internet to the masses and will help us emerge as a super power.
Considering this, the Government has undertaken several measures over the last couple of years, which have resulted in 200% growth in the broadband subscriber base to arrive at ~150 Mn. subscribers as on March '16.

- **Spectrum reforms:** Spectrum band is evolving to accommodate growing traffic and capacity requirements across the globe. To ensure deployment of various wireless broadband technologies, availability of adequate spectrum is pertinent. Therefore, policies around spectrum harmonization, and spectrum sharing and trading have been defined. Availability of higher spectrum

bandwidth will enable faster deployment of network which would further increase broadband proliferation.

- Trading & Sharing: Reforms by the Government in 2015 on the rules of spectrum trading and sharing have enabled operators to acquire more spectrum, thereby further reducing spectrum scarcity. This action will lead to more economical and efficient use of spectrum
- Harmonization: The harmonization of spectrum to create contiguous spectrum holding for each operator has led to an increase in available bandwidth for deployment of 4G services, and will continue to enable progressive technologies for mobile broadband. The spectrum holding was fragmented, as a function of legacy. However, harmonization may be conducted after every auction
- Adequate spectrum availability: 2355 MHz of spectrum was released by the Government in the auction of 2016. This move has indicated the Government's cognizance of the need for more spectrum for mobile broadband services. The DOT is in continuous consultation with other ministries to ensure that adequate spectrum be made available for commercial operations
- Transparent process: Spectrum auction process is currently driven by well-defined processes, where all documents and guidelines are made public. Participants are given opportunity to understand, engage and participate in the auctions as per laid guidelines. The Indian auction process is used as a benchmark by other countries as well

- **Passive and active infrastructure sharing:** The Government amended the Unified License to allow active infrastructure sharing amongst players resulting in reduced capital infrastructure. Passive infrastructure has been instrumental in expanding the voice telephony market in India. Policies around sharing of active and passive infrastructure would positively impact broadband network deployment
- **RoW rules:** The Government is striving towards defining a uniform policy instituted by the Center and implemented by the states. This policy would aim to ensure timely approvals of RoW permits through a web based platform in a transparent manner. A uniform policy would encourage private participation in network deployment
- BharatNet for facilitating rural broadband: Broadband needs to be made available across geographies without disruption. In order to realize the vision of universal broadband access, the BharatNet project was conceptualized. BharatNet is a dynamic project that not only includes provision of connectivity to the GPs but also futureproofing of networks by deploying ring architecture. It also involves provision of last mile connectivity. Successful implementation of the BharatNet project would result in reducing the digital divide and meeting the objectives of Digital India
- Virtual Network Operators: The Government has decided to issue Unified Licenses for Virtual Network Operators (UL VNO). This would enable emergence of innovative business models which will further accelerate broadband growth

7. Conclusion - Summary of Recommendations

Data networks will define India's future in many ways and will enable India to leapfrog ahead of many countries. Our global competitiveness depends on the wide spread access and speed of broadband proliferation. India will require a fresh look at the pace of development and its regulatory policy environment. Broadband ecosystem players, the Government along with the Regulator, need to work cohesively to revise the National telecom policy.

The policy should be technology agnostic to enable and promote orderly growth, by fostering a robustly competitive environment

A summary of key recommendations is documented below:

01. Set aspirational goals – 600 Mn. broadband subscribers by 2020. **It is critical to define a strategic direction for broadband,** that includes framing the definition of minimum speeds of broadband along with setting capacity and coverage targets, and the ambition to maintain certain minimum levels of availability, reliability and affordability

02. Increase planned budgetary allocation and effective use of USOF:

As a GDP multiplier, Government of India must expand the budgetary allocation for the proliferation of Broadband access by a percentage of GDP. This should reflect in the annual budget of the country. Simultaneously optimal utilization of the USOF is the need of the hour.

Most countries commit a percentage of their GDP to broadband infrastructure growth and India may follow suit.

03. Different approaches can be followed for different regions:

i. Rural broadband
   a) Telecom service providers for facilitating rural broadband: Both Government-led and private-led models could be considered. However, for the private-led model, Government needs to consider incentivizing private players to invest in rural infrastructure
   b) BharatNet: BharatNet strategy has now evolved to create an end to end network with strong service criteria. **'Ring' architecture will be used to strengthen the rollout**. It is recommended to include strengthening the existing network from SHQ to DHQ. Another suggestion is to lay fresh fiber across linear lines especially from DHQ to BHQ, as well as BHQ to FPOI, where fiber life is dated. In order to ensure faster deployment and better accountability of service standards to service providers, the work done by CPSUs can be complemented by outsourcing end to end deployment to pre-qualified private players in an EPC model. They can also be held accountable for the end to end maintenance of the network.

ii. Urban broadband
   a) A market led **healthy competitive environment should be encouraged** to drive growth of urban broadband

b) Refresh building codes: **Consider policies such as mandating buildings to provide broadband infrastructure**

c) **Encourage use of utility corridors**: This would require that specific standards be laid down by the Government in consultation with relevant ministries

d) **New RoW & Tower policy**: Policy aspects include inter alia, a defined RoW and tower policy (pricing, timelines), single window clearances, dig-once policy, awareness and guidelines on deployment standards for fiber roll-out, etc.

iii. Smart cities:

To ensure a self-sustaining model of smart-cities, **various models (e.g. a Government-owned SPV) can be considered. Outsourcing the end-to-end deployment and maintenance of this network will further strengthen the sustainability of the network**

04. Policies and guidelines to facilitate ease, efficiency and sustainability and roll-out of broadband networks

i. **Address regulatory and policy barriers:** The regulatory levies on the Indian telecom sector (in the range of 25-29% of AGR) are significant and therefore a long term sustainable policy ecosystem which is favorable for the orderly growth of the system should be facilitated. The USOF fund maybe increased to further broadband penetration in the country.

ii. **Secure the network:** Policy must be laid down to secure fiber network by adhering to deployment standards and defining guidelines such as 'call before you dig'

05. Spectrum: The Government has introduced policies around spectrum harmonization, spectrum sharing & trading, making it available through a transparent process, which has enabled deployment of various broadband technologies.

Auctions need to be transparent and pricing may be reviewed based on market dynamics. In addition the government should continue to give contiguous blocks of spectrum.

06. Sustainability: It is critical to **deploy networks based on specific standards** - these standards will ensure increased life span of the assets. **GIS mapping for all new fiber must be instituted and a framework must be instituted to secure the network.**

07. Constitute Governance Framework: The Government must consider **instituting an empowered Government-industry joint working group to work on various aspects of the policy** including long to medium term direction, short term tactical fixes and quick wins

Opportune time for new policy after 25 years of reforms

We are, in effect, completing 25 years of telecom sector liberalization. At this milestone in the journey of telecom sector reforms and synergies between the Government and the players, we are presented with an opportune time to review and draft a new telecom policy.

The Government opened up private sector investment in telecom equipment, and invited bids for cellular licenses in the years 1991 and 1992 respectively. Thus we are, in effect, completing 25 years of telecom sector liberalization. At this milestone in telecom sector reforms and synergies between the Government and the players, we are presented with an opportune time to review and draft a new telecom policy. This policy may focus on emergence of Broadband infrastructure and emerging technologies such as Internet of Things (IoT) and Machine-to-Machine (M2M) communication.

India is on the brink of entering a new phase of growth, facilitated by the Government's ambitious and progressive programs. Broadband can stimulate this growth significantly, provided all stakeholders come together to define ambitious yet realistic goals and then work towards achieving them.

8. Glossary of Terms

Abbreviation	Full Form
4G	Fourth Generation Mobile Broadband
5G	Fifth Generation Mobile Broadband
AAI	Airports Authority of India
ADI	Affordability Drivers Index
ADSS	All-Dielectric Self-Supporting (Cable)
APDRP	Accelerated Power Development and Reforms Program
Apps	Applications
AUD	Australian Dollars
AUSPI	Association of Unified Telecom Service Providers of India
BB	Broadband
BBNL	Bharat Broadband Network Limited
BIF	Broadband India Forum
Bn.	Billion
CAGR	Compounded Annual Growth Rate
Cisco VNI	Cisco Visual Networking Index
COAI	Cellular Operators Association of India
CPSU	Central Public Sector Undertaking
CSC	Community Service Centre
CSR	Corporate Social Responsibility
dB	Decibel
DHQ	District Headquarters
DL	Download
DoT	Department of Telecom, Government of India
DSL	Digital Subscriber Line
EHB	Educational Institutions, Healthcare Institutions and Businesses
EHBG	Educational Institutions, Healthcare Institutions, Businesses and Government Establishments
EPC	Engineering, Procurement, Commissioning
FCC	Federal Communications Commission, United States of America
FICCI	The Federation of Indian Chambers of Commerce and Industry
FPoI	Fiber Point of Interconnect
FTTH	Fiber-to-the-Home

Abbreviation	Full Form
FTTx	Fiber-to-the-X (Any Type of Termination)
FY	Financial Year
G2C	Government-to-Citizen
GB	Gigabyte
GBP	British Pound/Great Britain Pound
Gbps	Gigabits per Second
GDP	Gross Domestic Product
GIS	Geographic Information System
GP	Gram Panchayat
GPON	Gigabit Passive Optical Network
GUI	Graphical User Interface
HAM	Hybrid Annuity Model
HH	Household
ICT	Information Communication Technology
IP	Internet Protocol
IP-1	Infrastructure Provider - 1
ISP	Internet Service Provider
IT	Information Technology
ITU	International Telecommunication Union
Kbps	Kilobits per Second
KPI	Key Performance Indicator(s)
LED	Light Emitting Diode
LoS	Line of Sight
LTE	Latest Technology Evolution
MB	Megabyte
Mbps	Megabits per Second
MeitY	Ministry of Electronics and Information Technology
Mn.	Million
MoEF	Ministry of Environment and Forests
Ms	Millisecond
NASSCOM	The National Association of Software and Services Companies
Nbn	National Broadband Network, Australia
NBP	National Broadband Plan
NetCo.	Network Company
NextGen	Next Generation
NFV	Network Functions Virtualization
NHAI	National Highways Authority of India
NOFN	National Optic Fiber Network
NTP	National Telecom Policy
OECD	Organization for Economic Co-operation and Development
OF	Optic Fiber
OFC	Optic Fiber Cable
OpenNet	Consortium of private operators in Singapore
OPGW	Optical Ground Wire

Abbreviation	Full Form
PGCIL	Power Grid Corporation of India Limited
PMO	Prime Minister's Office, Government of India
PMO	Program Management Office
PPP	Public-Private Partnership
PSU	Public Sector Undertaking
RailTel	RailTel Corporation of India Limited
RoW	Right of Way
ServCo.	Service Company
SDN	Software Defined Networks
SGD	Singapore Dollars
SHQ	State Headquarters
SLA	Service Level Agreement
SME	Small & Medium Scale Enterprises
SPV	Special Purpose Vehicle
TCIL	Telecommunications Consultants India Ltd
TRAI	Telecom Regulatory Authority of India
TSDSI	Telecommunications Standards Development Society, India
TSP	Telecom Service Provider
UAV	Unmanned Aerial Vehicles
UBR	Unlicensed Band Radio
UK	United Kingdom
US	United States of America
USD	United States Dollar
USOF	Universal Service Obligation Fund
VSAT	Very Small Aperture Terminal
Wi-Fi	Wireless Fidelity

9. Sources

[i] Open government data platform - data.gov.in. See: https://data.gov.in/catalog/gdp-india-and-major-sectors-economy-share-each-sector-gdp-and-growth-rate-gdp-and-other

[ii]World Bank estimates. See: http://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?locations=IN

[iii]TRAI indicator reports, March 2015 & 2016. See: http://trai.gov.in/Content/PressReleases.aspx

[iv]Primary interviews, Global subs data-GSMA intelligence (March '15)

[v]Ericsson Report. See: https://www.ericsson.com/in/news/160607-india-to-have-810-million-smartphone-subscriptions-by-2021_254740127_c

[vi]Digital Media: Rise of On-demand Content, Deloitte Report, April 2015. See: https://www2.deloitte.com/content/dam/Deloitte/in/Documents/technology-media-telecommunications/in-tmt-rise-of-on-demand-content.pdf

[vii]Cisco VNI Report, 2015. See: http://www.cisco.com/c/dam/en/us/solutions/collateral/service-provider/visual-networking-index-vni/complete-white-paper-c11-481360.pdf; Deloitte analysis

[vii]World Bank estimates. See: http://data.worldbank.org/indicator/SP.RUR.TOTL.ZS?locations=IN

[ix]Impact of Broadband on Economy, ITU Report, April 2012. See: https://www.itu.int/ITU-D/treg/broadband/ITU-BB-Reports Impact-of-Broadband-on-the-Economy.pdf

[x]Connecting America : The National Broadband Plan, March 2010; https://www.ustelecom.org/broadband-industry/broadband-industry-stats/investment

[xi]Broadband China, 2013; http://www.huawei.com/minisite/ubbf2015/ppt/PPT-215-Broadband%20China%20Strategy%20and%20its%20Implementation-Yanbin%20Zhang-0907-V1.pdf

[xii]UK Next Generation Infrastructure Deployment Plan, 2015; Broadband Delivery Plan, 2011; Superfast Broadband Program, 2015

[xiii]NTP 2012. See: http://www.dot.gov.in/sites/default/files/NTP-06.06.2012-final.pdf

[xiv]http://www.sph.com.sg/media_releases/664

[xv]Advancing Australia as a Digital Economy, 2013; National Digital Economy Strategy, 2011; and http://www.nbnco.com.au/corporate-information/media-centre/media-releases/strategic-review.html

[xvi]State of Broadband Report, 2016. See: http://www.itu.int/pub/S-POL-BROADBAND.17-2016

[xvii]State of Broadband Report, 2016. See: http://www.itu.int/pub/S-POL-BROADBAND.17-2016

[xviii]http://www.huawei.com/minisite/ubbf2015/ppt/PPT-215-Broadband%20China%20Strategy%20and%20its%20Implementation-Yanbin%20Zhang-0907-V1.pdf

[xix]COAI Annual Report 2015-16

[xx]Sterlite investor presentation, May 2016

[xxi]Primary interviews, Deloitte analysis

[xxii]TRAI indicator reports, March 2016. See: http://trai.gov.in/Content/PressReleases.aspx

[xxiii]Deloitte Analysis; State of the Broadband Report See: http://www.itu.int/pub/S-POL-BROADBAND.17-2016

[xxiv]State of Broadband Report, 2016. See: http://www.itu.int/pub/S-POL-BROADBAND.17-2016

[xxv]Deloitte Analysis; State of the Broadband Report See: http://www.itu.int/pub/S-POL-BROADBAND.17-2016

[xxvi]TRAI indicator report, March 2016. See: http//trai.gov.in/Content/PressReleases.aspx; Deloitte analysis

[xxvii]Report of Committee on NOFN. See: http://www.dot.gov.in/reports-statistic/2470

[xxviii]Cisco VNI 2015-2020. See: http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.html#Trend_4_Tracking_WiFi_Growth

[xxix]News Article. See: www.livemint.com/Consumer/Uc506lrKsLh4TYllnqPcdO/Future-of-public-WiFi-hot-spots-in-India.html

[xxx]World Bank - Databank

[xxxi]TRAI indicator report, March 2016. See: http//trai.gov.in/Content/PressReleases.aspx; Deloitte analysis

[xxxii]Primary interview, Deloitte analysis

[xxxiii]USOF website. See: http://www.usof.gov.in/usof-cms/usof-fund-status-table.jsp

[xxxiv]ITU Presentation (https://www.itu.int/en/ITU-D/Regional-Presence/ArabStates/Documents/events/2015/SSC/S5-DrDaveFaulkner.pdf)

[xxxv]Source: Deloitte Analysis

[xxxvi]Source: Deloitte Analysis

[xxxvii]Source: Deloitte Analysis

[xxxviii]Source: Deloitte Analysis

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The Department of Telecommunications (DoT) is responsible for formulating developmental policies for the accelerated growth of the telecommunication services, Performance review, Monitoring, International cooperation and Research & Development in the field of Telecommunications. The Department also allocates frequency and manages radio communications in close coordination with the International bodies. It is also responsible for enforcing wireless regulatory measures and monitoring the wireless transmission of all users in the country.

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Acknowledgements

Rajat Banerji, Neeraj Jain, Abhishek, Gunjan Gupta, Shubhra Batra, Anu Peisker, Sahiba Gambhir Agarwal, Rajat Kohli, Apurva Shah

Supporting Associates

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