Fibre-Optic Co-Deployment along the Asian Highways and Trans-Asian Railways for E-Resilience: The Cases of India and Bangladesh

Asia-Pacific Information Superhighway (AP-IS)
Working Paper Series

UNITED NATIONS
ESCAP
Economic and Social Commission for Asia and the Pacific

The Economic and Social Commission for Asia and the Pacific (ESCAP) serves as the United Nations' regional hub promoting cooperation among countries to achieve inclusive and sustainable development. The largest regional intergovernmental platform with 53 member States and 9 associate members, ESCAP has emerged as a strong regional think tank offering countries sound analytical products that shed insight into the evolving economic, social and environmental dynamics of the region. The Commission's strategic focus is to deliver on the 2030 Agenda for Sustainable Development, which it does by reinforcing and deepening regional cooperation and integration to advance connectivity, financial cooperation and market integration. ESCAP's research and analysis coupled with its policy advisory services, capacity building and technical assistance to governments aim to support countries' sustainable and inclusive development ambitions.

The shaded areas of the map indicate ESCAP members and associate members.

Contact:
Information and Communications Technology and Development Section
Information and Communications Technology and Disaster Risk Reduction Division
United Nations Economic and Social Commission for Asia and the Pacific
United Nations Building
Rajadamnern Nok Avenue
Bangkok 10200, Thailand
Email: escap-ids@un.org

Acknowledgements

This working paper was prepared by Professor K M Baharul Islam of the Centre of Excellence in Public Policy and Government at the Indian Institute of Management, Kashipur, India. Substantive comments were provided by Atsuko Okuda, Dongjung Lee and Siope Vakataki 'Ofa of the Information and Communications Technology and Development Section under the general guidance of Tiziana Bonapace, Director, Information and Communications Technology and Disaster Risk Reduction Division of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP). Tarnkamon Chantarawat and Sakollerd Limkriangkrai provided administrative support and other necessary assistance for the issuance of this paper. The working paper also benefited from peer review by Ishtiaque Ahmed of the Transport Division of ESCAP.

October 2018

Cover Photo: Shutterstock

Table of Contents

List of Tables

List of Figures

List of Boxes

Abbreviations and Acronyms

AP-IS	Asia-Pacific Information Superhighway
ASEAN	Association of Southeast Asian Nations
BBNL	Bharat Broadband Network Limited
BDT	Bangladeshi Taka
BOOT	Build-Own-Operate-Transfer
BOT	Build-Operate-Transfer
BSCCL	Bangladesh Submarine Cable Company Limited
BSNL	Bharat Sanchar Nigam Limited
BTCL	Bangladesh Telecommunications Company Limited
BTRC	Bangladesh Telecommunication Regulatory Commission
CAGR	Compound Annual Growth Rate
CDMA	Code-Division Multiple Access
DoT	Department of Telecommunications (India)
ESCAP	Economic and Social Commission for Asia and the Pacific
FOC	Fibre-Optic Cable
FTTH	Fibre to the Home
FTTX	Fibre to the X
GDP	Gross Domestic Product
GP	Gram Panchayats
GSM	Global System for Mobile Communication
ICT	Information and Communications Technology
INR	Indian Rupee
ISP	Internet Service Provider
IT	Information Technology
LTE	Long-Term Evolution
MTNL	Mahanagar Telephone Nigam Limited
NHDP	National Highways Development Project
NOFN	National Optical Fibre Network
NTTN	Nationwide Telecommunication Transmission Network
PGCIL	Power Grid Corporation of India Limited
PMGSY	Pradhan Mantri Gram Sadak Yojana
PPP	Public-Private Partnership
RHD	Roads and Highways Department (Bangladesh)
RoW	Right of Way
SDG	Sustainable Development Goal
TDSAT	Telecom Disputes Settlement and Appellate Tribunal
TEC	Telecommunication Engineering Centre
TRAI	Telecom Regulatory Authority of India
TSP	Telecommunications Service Provider
USD	United States Dollar
USOF	Universal Service Obligation Fund
WPC	Wireless Planning and Coordination Wing

Executive Summary

The development of the information and communications technology (ICT) infrastructure, particularly fibre-optic cables (FOCs), in a cost-efficient manner is a perennial challenge that ICT policy- and decision-makers face across the globe. The high cost associated with the deployment and maintenance of FOCs are often borne by users, which has led to unaffordable Internet and broadband services in many developing countries. In order to achieve the goals and targets set in the 2030 Agenda for Sustainable Development, ensuring inclusive and affordable broadband access is of paramount importance. In response, some measures have been proposed to lower deployment cost; and one of the prominent measures is the co-deployment and co-habitation of FOCs along passive infrastructure, including highways and railways.

Against this background, this working paper has been developed to assess existing and planned co-deployment and co-habitation of FOCs along railways and highways in India and Bangladesh. The paper aims to identify institutional set-ups, policies and regulations that enable or discourage such co-deployment and co-habitation.

India is emerging as a major player in Internet connectivity and is projected to have more than 700 million broadband subscriptions by 2025. Since 2012, India has built a strong ICT infrastructure, focusing on connecting the last mile through a national FOC network (*BharatNet).* Similarly, the development of the ICT infrastructure is a top priority for Bangladesh and a number of initiatives, policies and plans have been adopted in recent years. According to the latest figures given by the Bangladesh Telecommunication Regulatory Commission, Bangladesh has 80.82 million Internet subscribers as of January 2018. Political support through *Digital India* and *Digital Bangladesh* campaigns has played an important role in expanding broadband connectivity in these two countries.

Thus, it is reasonable to look at both countries together to study the current status and the emerging prospects of co-deploying FOCs along highways and railways against the backdrop of the Asia-Pacific Information Superhighway (AP-IS) initiative. According to recent studies of the United Nations Economic and Social Commission for Asia and the Pacific, co-deployment reduces the cost of laying FOCs and opens up revenue-generating opportunities for public utility. In synergizing the construction of roads and the ICT infrastructure, road networks have become an important asset for economic growth and development.

In India, a large portion of the fund for *BharatNet* is spent on excavating trenches for laying the FOC conduits. Considering India's ambitious road infrastructure plans, the country can save substantial funds if the requirement of trenches for laying FOC conduits is incorporated into road design and planning.

An issue that is inextricably linked to the deployment of the ICT infrastructure is the right of way (RoW). It is an easement granted by property owners that gives the right to others for reasonable use of their property. Another issue that often affects FOC deployment is the fees charged by local bodies to grant RoW permissions. Interestingly, Bangladesh Railway has indicated that it has not faced any major challenges deploying its broadband network and

ensuring its resilience from technical, policy, legislative and regulatory perspectives. Bangladesh Railway believes that FOC co-deployment along railway routes as part of the AP-IS initiative will create enormous opportunities for enhancing the availability, affordability, reliability and resilience of the broadband network, especially for landlocked countries in the region.

In the context of the AP-IS initiative, it is important to note that India is proactively pursuing an *Act East Policy.* Thus far, India already practices co-deployment through the RailTel Corporation of India Limited, which has exclusive seamless RoW along its railway tracks passing through 7,000 stations across the country. Similarly, Bangladesh Railway plans to bring its entire network under an integrated telecommunications system by laying FOCs in 44 *upazilas* (subdistricts) in 17 districts to build a safer and more secure train communications system.

The major challenge facing FOC co-deployment in both India and Bangladesh is the charting of a roadmap for cross-sectoral coordination among the plethora of government departments, implementing agencies and telecommunications operators. Creating a conducive environment for such co-deployment is a major coordination exercise among the multiple government authorities, regulators and the private sector.

If *Digital India* and *Digital Bangladesh* are to achieve their vision, fibre-optic co-deployment initiatives will need new governance models, revenue-sharing systems, regulatory mechanisms and legal frameworks that support public-private partnerships and enable government and the private sector to pursue co-deployment and co-habitation.

The findings of this working paper will be shared at various platforms for regional dialogue and regional cooperation in Asia and the Pacific, together with comparative reports conducted in other countries, including Cambodia, China, Japan, Republic of Korea and Myanmar.[4]

[4] ESCAP, "e-Resilience: A Review of National Broadband Policies, Regulations, Strategies and Initiatives of China, Japan and the Republic of Korea", AP-IS Working Paper Series, August 2018. Available at https://www.unescap.org/resources/e-resilience-review-national-broadband-policies-regulations-strategies-and-initiatives; and ESCAP, "A Study on Cost-Benefit Analysis of Fibre-Optic Co-Deployment with the Asian Highway Connectivity", AP-IS Working Paper Series, April 2018. Available at https://www.unescap.org/resources/study-cost-benefit-analysis-fibre-optic-co-deployment-asian-highway-connectivity.

1. Introduction

Broadband Internet is widely acknowledged as a key driver of economic development. It is also recognized as a tool for accelerating the achievement of the Sustainable Development Goals (SDGs). In particular, access to information and communications technology (ICT) is an official indicator for measuring progress towards SDG 4 (quality education), SDG 5 (gender equality), SDG 9 (resilient infrastructure) and SDG 17 (partnerships). Furthermore, ICT has been proven to contribute to poverty reduction, industry productivity, disaster risk reduction, climate change mitigation, efficient agriculture, and better health and education, among other benefits.

Despite these wide-ranging socioeconomic benefits of using ICT, a report of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP)[6] showed evidence of a widening broadband divide in the Asia-Pacific region. While the Republic of Korea has near-universal fixed-broadband coverage, Afghanistan is near-zero. In addition, the digital divide is found even within relatively developed countries, where certain age groups and rural areas are left behind. ESCAP studies[7] conclude that the digital divide in the Asia-Pacific region is in part driven by missing physical infrastructure, inefficient Internet traffic management and limited e-resilience, among other factors. To address these challenges, ESCAP member countries requested the Secretariat to develop the Asia-Pacific Information Superhighway (AP-IS) initiative in Resolution 71/10 adopted at the ESCAP Commission Session in 2015.[9] In 2017, the initiative was launched following the adoption of Resolution 73/6.[11] The AP-IS initiative aims to tackle the digital divide through enhanced broadband infrastructure and affordable broadband Internet for all.

Investment in ICT infrastructure development is costly, and is further complicated by technical entry barriers and political sensitivities, especially when it comes to cross-border connectivity. In light of this challenge, one potential solution to facilitating the timely and affordable development of the ICT infrastructure across borders is to leverage synergies between the concomitant deployment (or co-deployment) of fibre-optic cables (FOCs) with the construction or maintenance of ESCAP's Asian Highway Network and Trans-Asian Railway Network. As a regional transport cooperation initiative that aims to enhance the development of the road infrastructure in Asia, the Asian Highway Network has over 141,000km of roads passing through 32 ESCAP member countries. Similarly, the Trans-Asian Railway Network comprises of 117,500km of railway tracks serving 28 ESCAP member countries.

---

[6] ESCAP, *Artificial Intelligence and Broadband Divide: State of ICT Connectivity in Asia and the Pacific 2017* (Bangkok, 2017). Available at https://www.unescap.org/resources/artificial-intelligence-and-broadband-divide-state-ict-connectivity-asia-and-pacific-2017.

[7] ESCAP, "Building a Resilient Digital Economy: Fostering SMEs in Central Asia", AP-IS Working Paper Series, May 2017. Available at https://www.unescap.org/resources/building-resilient-digital-economy-fostering-smes-central-asia; and ESCAP, "A Pre-Feasibility Study on the Asia-Pacific Information Superhighway in the ASEAN Sub-region", February 2016. Available at https://www.unescap.org/resources/pre-feasibility-study-asia-pacific-information-superhighway-asean-sub-region.

[9] Official Records of the Economic and Social Council, Seventy-First Session, Agenda Items 3 (e) and (f), Resolution Adopted by ESCAP on 2 June 2015 (E/ESCAP/RES/71/10). Available at http://www.un.org/ga/search/view_doc.asp?symbol=E/ESCAP/RES/71/10.

[11] Official Records of the Economic and Social Council, Seventy-Third Session, Agenda Items 3 (e), Resolution Adopted by ESCAP on 23 May 2017 (E/ESCAP/RES/73/6). Available at http://www.un.org/ga/search/view_doc.asp?symbol=E/ESCAP/RES/73/6.

In recognition of the opportunity for leveraging FOC co-deployment with the Asian Highway Network and Trans-Asian Railway Network, ESCAP member countries during the Fourth Session of the Committee on Transport in 2014 recommended that consideration should be given to amending the Intergovernmental Agreement on the Asian Highway Network and the Intergovernmental Agreement on the Trans-Asian Railway Network to include co-habitation. It further recommended that issues related to such amendments be dealt with through future meetings of the working groups on the Asian Highway Network and the Trans-Asian Railway Network. Subsequently, Bangladesh expressed its intention to submit a request for amendments to the working groups on the Asian Highway Network and the Trans-Asian Railway Network during the First Session of the Committee on Information and Communications Technology, Science, Technology and Innovation in 2016.[12] The request was subsequently submitted by Bangladesh to the ESCAP Secretariat for discussion at the next meeting of the ESCAP Working Group on the Asian Highway Network in 2017.

Despite these milestones, the awareness and appreciation of the policy implications on opportunities and challenges of ICT and transport infrastructure co-deployment and co-habitation in the region have been limited. Government officials in the ICT and transport sectors rarely exchange information, lessons learnt and experiences on potential synergies of co-habitation.

Drawing on the above considerations, this paper aims to contribute to the implementation of the *Master Plan for the AP-IS*[13] Initiative 1: Identification, coordination, deployment, expansion and integration of the regional backbone networks at the cross-border intra- and inter-regional levels, in collaboration with member countries and subregional organizations; and Initiative 6: Capacity building. Preliminary results from this paper were presented to the AP-IS Steering Committee Meeting on 1-2 November in Dhaka, Bangladesh,[14] as a basis to discuss the request for amendments with the ESCAP Working Group on the Asian Highway Network at the AP-IS Steering Group Meeting in Bangkok, Thailand, in December 2017.[15]

This paper draws from data collected on the co-deployment and e-resilience of FOCs along the Asian Highway Network and the Trans-Asian Railway Network in India and Bangladesh through a questionnaire survey developed by the ESCAP Secretariat (see Annex 1). It aims to identify challenges and opportunities in the co-deployment and co-habitation of FOCs along highways and railway tracks. Furthermore, it explores the linkage between co-deployment and e-resilience. The findings will be shared at regional forums of AP-IS, as well as at other venues for regional policy dialogue.

[12] ESCAP, "Committee on Information and Communications Technology & Science, Technology and Innovation, First Session". Available at https://www.unescap.org/events/committee-information-and-communications-technology-science-technology-and-innovation-first.
[13] ESCAP, "Master Plan for the Asia-Pacific Information Superhighway, 2019-2022", 16 July 2018. Available at https://www.unescap.org/sites/default/files/ESCAP_CICTSTI_2018_INF1.pdf.
[14] ESCAP, "First Session of the Asia-Pacific Information Superhighway (AP-IS) Steering Committee". Available at https://www.unescap.org/events/first-session-asia-pacific-information-superhighway-ap-steering-committee.
[15] ESCAP, " Joint Session of Asia-Pacific Information Superhighway Steering Group Meeting and Seventh Meeting of the Working Group on the Asian Highway Network". Available at https://www.unescap.org/events/asia-pacific-information-superhighway-steering-group-meeting-12-december-2017-and-joint.

2. Country Contexts in India and Bangladesh

India and Bangladesh are closely linked by shared history, civilization, culture, language and economic relations. Over the years, both countries have made significant progress in improving their respective socioeconomic conditions. On many fronts, they have forged partnerships based on mutual interests and sociocultural ties, and developed multi-dimensional relations through frequent interactions at all government levels. Therefore, it is reasonable to look at the countries together to study the current status and emerging prospects of FOC co-deployment along highways and railways against the backdrop of the AP-IS initiative.

Before that, let's briefly define concepts such as infrastructure sharing, co-deployment and right of way (RoW) that will be frequently used in this paper. The ICT infrastructure includes various facilities such as towers, equipment sheds, cables, ducts and antennas. These facilities that do not include electronic devices are broadly called passive communications infrastructure. Active communications infrastructure, on the other hand, includes facilities where some electronic devices or equipment are used, such as transceivers, transmitters and receivers.[16] In this paper, infrastructure sharing refers to the sharing of passive communications infrastructure, unless stated otherwise. Such sharing is beneficial to operators, consumers, local authorities and citizens as it reduces capital expenditures, end-user cost of services, and procedural delays in seeking multiple permissions from various authorities for constructing these infrastructures. It also minimizes the negative impact on the environment, and opens up opportunities for revenue generation through the renting of these facilities to other entities.

Considering the fact that a large part of the expenditure on the deployment of FOCs goes to civil engineering works,[17] telecommunications service providers (TSPs) are increasingly attracted to the option of using existing dark fibre (unused FOC capacity) and ducts laid by others. Many countries nowadays are making efforts to adopt policies that encourage co-deployment of FOCs during road or railway construction. Co-deployment refers to the strategic installation of FOCs along any utility infrastructure like roads and railways. The deployment of FOCs can be done at the time of construction of the utility infrastructure, or it can be installed later. In this paper, the term co-deployment indicates the existence of FOCs along roads, railway tracks or any other infrastructure.

An issue that is inextricably linked to the deployment of the ICT infrastructure like FOCs is RoW. It is an easement granted by property owners that gives the rights to others for reasonable use of their property. A crucial part of FOC construction work is obtaining this RoW over public or private lands that allows one to excavate trenches and install ducts, poles,

[16] Jayant Raghu Ram, "When Sharing Isn't Always Caring: Understanding Telecom Infrastructure Sharing in the Multilateral Context", 30 April 2017. Available at https://ssrn.com/abstract=2971852.

[17] ESCAP, "e-Resilience: A Review of National Broadband Policies, Regulations, Strategies and Initiatives of China, Japan and the Republic of Korea", AP-IS Working Paper Series, August 2018. Available at https://www.unescap.org/resources/e-resilience-review-national-broadband-policies-regulations-strategies-and-initiatives.

wires, cables or pipes. A licensed telecommunications operator normally includes such RoW in the terms of the licence, but the operator needs to secure the actual "permission" from owners or "authorities" to dig and lay the FOCs by the sides of a road or a railway track. Invariably, the FOCs pass through land that falls under several local jurisdictions such as public works departments, the forest department, and highway and railway authorities. In this paper, RoW refers to the public RoW that is granted to telecommunications operators for delivery of telecommunications services in the "public interest". A RoW is necessary for FOC installation, as well as for its operation, alteration and maintenance. With the opening of the telecommunications sector to market competition, the demand for access to public RoW has become a contested issue. This is because the granting of public RoW usually requires the active participation of public authorities (e.g., municipalities) in permitting the civil works needed in constructing ducts or laying FOCs. Obtaining permissions to use public lands can be time consuming and may hold up the FOC infrastructure project as local authorities may charge high rents or the issuance of RoW permission takes time.

The rest of this section gives a broad overview of the ICT, road and railway infrastructures in India and Bangladesh, as well as their state of broadband connectivity. Section 3 examines some of the major digital initiatives and emerging opportunities in both countries, and in section 4, some key policy and regulatory challenges and issues of co-deployment are highlighted. Section 5 explores public-private partnership (PPP) models that are used in FOC co-deployment, and section 6 discusses the e-resilience of the FOC networks.

2.1 Broadband Connectivity and the Telecommunications Sector in India

India is emerging as a major player in the world of the Internet. It is projected that India's broadband subscriptions will reach more than 700 million by 2025. Interestingly, during the same period, the entire European Union is expected to add only 105 million new broadband subscriptions.[18] India's cyber-economy is estimated to reach INR 10 trillion (USD 155 billion) by 2018, accounting for 5 per cent of its gross domestic product (GDP). The government is creating a conducive environment with regulations, rules, laws and policies that favour the Indian telecommunications sector, which is expected to witness fast growth in the next few years. The Indian government is embarking on emerging technology initiatives such as the Internet of Things, machine-to-machine communications, instant high-definition video transfer and smart cities infrastructures based on the 5G spectrum.[19] India is the world's second largest telecommunications market, with 1.186 billion subscribers as of November 2017.

According to the Telecom Regulatory Authority of India (TRAI), the total number of mobile phone subscribers (GSM, CDMA and LTE) in India was 1,167.44 million as of December 2017, and the mobile teledensity (number of mobile phone connections for every hundred individuals) stood at 90.11 (see Table 1). It is worth noting that in the case of mobile phone subscribers, the private TSPs held 90.45 per cent market share, whereas Bharat Sanchar

[18] David Burt and others, *Cyberspace 2025 - Today's Decisions, Tomorrow's Terrain*: *Navigating the Future of Cybersecurity Policy* (Microsoft, 2014).

[19] India Brand Equity Foundation, "Telecommunications Sector Report – January 2018". Available at https://www.ibef.org.

Nigam Limited (BSNL) and Mahanagar Telephone Nigam Limited (MTNL), the two public sector entities, had a market share of only 9.55 per cent. On the other hand, in the case of fixed-line telephone subscribers (23.23 million at the end of 2017), BSNL and MTNL held 68.03 per cent of the market share.

Table 1: Highlights of the Indian telecommunications sector

Indicators	Mobile	Fixed-line	Total
Total telephone subscribers (million)	**1167.44**	**23.23**	**1190.67**
Net addition in December 2017 (million)	4.97	-0.18	4.79
Monthly growth rate (%)	0.43	-0.76	0.40
Urban telephone subscribers (million)	**668.44**	**19.81**	**688.25**
Net addition in December 2017 (million)	3.50	-0.13	3.36
Monthly growth rate (%)	0.53	-0.67	0.49
Rural telephone subscribers (million)	**499.00**	**3.42**	**502.42**
Net addition in December 2017 (million)	1.47	-0.04	1.42
Monthly growth rate (%)	0.29	-1.29	0.28
Overall teledensity (%)	**90.11**	**1.79**	**91.90**
Urban teledensity (%)	163.44	4.84	168.29
Rural teledensity (%)	56.28	0.39	56.66
Share of urban subscribers (%)	57.26	85.28	57.80
Share of rural subscribers (%)	42.74	14.72	42.20
Broadband subscribers (million)	**345.01**	**17.86**	**362.87**

Source: TRAI.
Notes: Data as of December 2017. Broadband = download speed of ≥ 512 Kbps.

The number of broadband subscribers stood at 362.87 million as of December 2017 (see Table 2). The top five TSPs constituting 93.80 per cent market share of the total broadband subscribers were Reliance Jio Infocom (160.09 million), Bharti Airtel (71.09 million), Vodafone India (52.44 million), Idea Cellular (34.81 million) and BSNL (21.95 million).

Table 2: Broadband subscribers in India by segment

Segment	Broadband subscribers (million)
Wired subscribers	17.86
Mobile devices users (phones and dongles)	344.57
Fixed wireless subscribers (Wi-Fi, Wi-Max, point-to-point radio and VSAT)	0.44
Total	**362.87**

Source: TRAI, "Highlights of Telecom Subscription Data as on 31st December, 2017", Press Release No. 23/2018: Information Note to the Press, 16 February 2018. Available at https://www.trai.gov.in/.
Note: Data as of December 2017.

India adopted the forward-looking National Telecom Policy in 1999 and since then, telecommunications has been one of the fastest-growing sectors in the country. The highly competitive market has led to attractive tariffs that are one of the lowest in the world. The Government of India introduced the Digital India initiative under which different sectors, including health care and retail, have been revolutionized through their connection to the Internet. As a result of the initiative, a large segment of the rural population is now connected to telecommunications services with rural teledensity reaching 56.66 per cent by the end of 2017. Over the years, India has built a strong ICT infrastructure that is focused on connecting the last mile through a national FOC network (BharatNet). Its mission to transform the country into a global telecommunications hub is supported by favourable regulatory reforms and policies that are aimed at unified licensing, full mobile number portability and free roaming.[22]

India's telephone subscriber base increased at a compound annual growth rate (CAGR) of 19.22 per cent, reaching 1,194.58 million during the period 2007-2017. In terms of teledensity, it increased from a mere 17.9 per cent in 2007 to 91.66 per cent by the end of 2017. Revenue generated by the Indian telecommunications sector grew at a CAGR of 7.31 per cent from USD 19.6 billion in 2006 to USD 42.6 billion in 2017. During the first half of the financial year 2017-2018,[23] the gross revenue of the telecommunications sector in India reached USD 20.4 billion.[24] As per the projections in the Union Budget for 2018-2019, it is expected that there will be a 58 per cent increase in telecommunications sector revenue to reach INR 48,661.42 crore (USD 7.52 billion) during the period.[25] Similarly, broadband subscription in the country witnessed a CAGR of 17.48 per cent during 2007-2017.

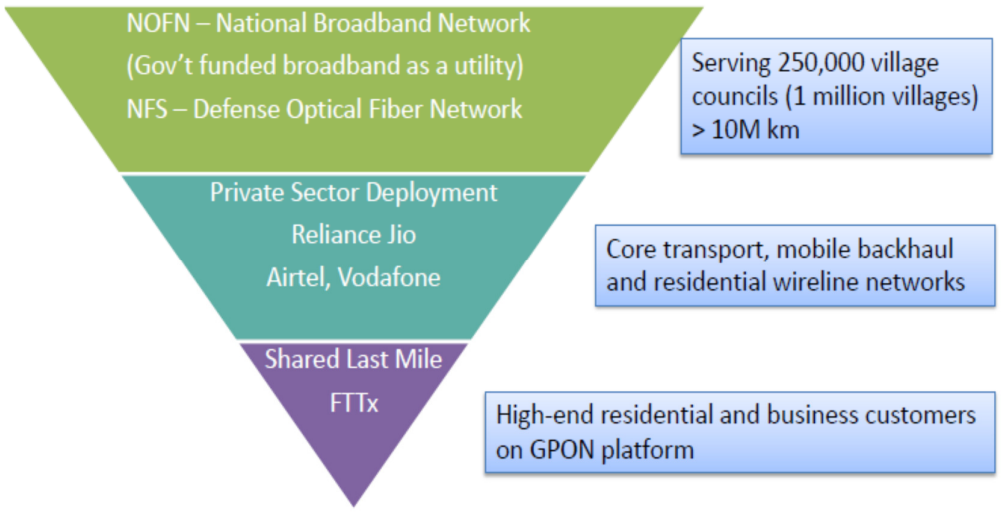
2.2 Fibre-Optic Co-Deployment along Roads and Railways in India

Although most of the roads and railway tracks in India have FOCs running alongside, these have been deployed by public and private sector TSPs after the construction of the roads and railway tracks. Besides the huge cost of laying FOCs, there are a number of issues that TSPs encounter while laying the FOCs post-construction of roads that range from planning networks to obtaining multiple RoW permissions for such deployment. Of late, some new road construction projects in states like Chhattisgarh have included ducts installation at the time of road construction, and are now available to TSPs on rent.[26] Moreover, various states of India have adopted models of PPP and associated policies that are increasingly encouraging the co-deployment of FOCs at the time of road construction.

[22] Government of India, "National Telecom Policy 2012". Available at http://www.dot.gov.in/sites/default/files/NTP-06.06.2012-final.pdf. Among other things, the policy aims to provide a single licence framework, un-bundle spectrum from licences and liberalize spectrum.
[23] In India, the government's financial year runs from 1 April to 31 March.
[24] TRAI. Available at https://www.trai.gov.in/.
[25] India Brand Equity Foundation, "Telecommunications Sector Report – January 2018". Available at https://www.ibef.org.
[26] Naya Raipur Development Authority, "Telecom infrastructure available for private developers in Naya Raipur". Available at http://www.nayaraipur.gov.in/pdf/telecom_infrastructure.pdf.

The ICT infrastructure networks along roads have helped India increase its broadband Internet subscriptions in recent years especially in remote areas. A recent national study reveals that a 10 per cent increase in Internet subscribers has resulted in a 2.4 per cent growth in the state's GDP per capita.[27] With the launch of the ambitious National Optical Fibre Network (NOFN) Project, now called BharatNet, India's Department of Telecommunications (DoT) is committed to deploying high-speed FOC-based telecommunications networks throughout the country in order to provide broadband connectivity to 250,000 *gram panchayats* (GP).[28] These FOC networks are being deployed along the country's robust road and railway networks. In some hilly terrains, FOCs are installed overhead using power transmission poles. In the construction of roads and the ICT infrastructure, road networks have become an important asset for economic growth and development. Moreover, with the expanding ICT infrastructure, central and state governments in India are increasingly using ICT in all aspects of governance, and recognizing the enormous potential of using ICT to deliver services to citizens.[29]

Figure 1: Fibre-optic connectivity drivers in India



Source: Sterlite Limited.

[27] Rajat Kathuria and others, *Quantifying the Value of an Open Internet for India* (Indian Council for Research on International Economic Relations, 2016). Available at http://icrier.org/pdf/open_Internet.pdf. The estimation method is based on the growth multiplier for the Internet using an adaption of Prof. Robert Barro's endogenous growth model. It consists of a panel of socioeconomic variables such as per capita gross state domestic product, gross capital formation, total number of persons engaged in labour, etc. for 19 states in India.

[28] A *gram panchayat* (village council) in India is the grass-roots level of the *panchayati raj* (local governance system) at the village or small-town level, and has a *sarpanch* (president of the village council) as its elected head. There are about 250,000 *gram panchayats* in India. The *gram panchayat* is divided into wards and each ward is represented by a ward member, referred to as a *panch* or *panchayat member*, who is directly elected by the villagers. The term of the elected representatives is five years.

[29] Ashis Sanyal, "How the national highways can drive the telecom revolution", *Governance Now*, 30 May 2014. Available at http://www.governancenow.com/news/regular-story/how-national-highways-can-drive-telecom-revolution.

India has a massive road network of 3.3 million kilometres. Highways, which constitute about only 1.7 per cent of this road network, carry about 40 per cent of the total road traffic. To correct this skewed situation, the government is enhancing the traffic-worthiness of state highways and district roads. To promote economic inclusion by way of increasing access to economic and social services and thereby generate increased agricultural incomes and employment opportunities, the Pradhan Mantri Gram Sadak Yojana (PMGSY) or Prime Minister's Rural Roads Scheme is a nationwide plan to provide good all-weather road connectivity to unconnected areas. Launched in 2000, PMGSY intends to cover 178,184 settlements with a population of 500 in plain areas and 250 in hilly areas. As of February 2018, 130,947 settlements are connected under PMGSY, and another 14,620 settlements are connected under various state governments' initiatives. Together, 82 per cent of the total settlements in India are connected to good roads.[30]

In the context of the AP-IS initiative, it is important to note that India is proactively pursuing an Act East Policy[31] that focuses on the multi-layered cooperation between India and the Association of Southeast Asian Nations (ASEAN)[32] based on three pillars: commerce, culture and connectivity. India envisages a region of integrated connectivity through a network of road, railway and maritime links. The present government renewed its focus on north-eastern states to develop them as the gateway to ASEAN. The major road development programmes in the north-eastern states (see Figure 2) is expected to stimulate closer ties with ASEAN countries and enhance connectivity in this region.[33] Giving special attention to infrastructure development such as road, rail and telecommunications networks in North-East India, the government has announced highway projects worth about INR 1.45 trillion (USD 22.32 billion) in the next two to three years (2018-2020). Moreover, the government has taken up many road improvement projects under the Special Accelerated Road Development Programme for North-East for better connectivity in the region.[34]

[30] Press Information Bureau, Government of India, "Background information on major initiatives & announcements for rural development sector in the general budget 2018-19", 1 February 2018.

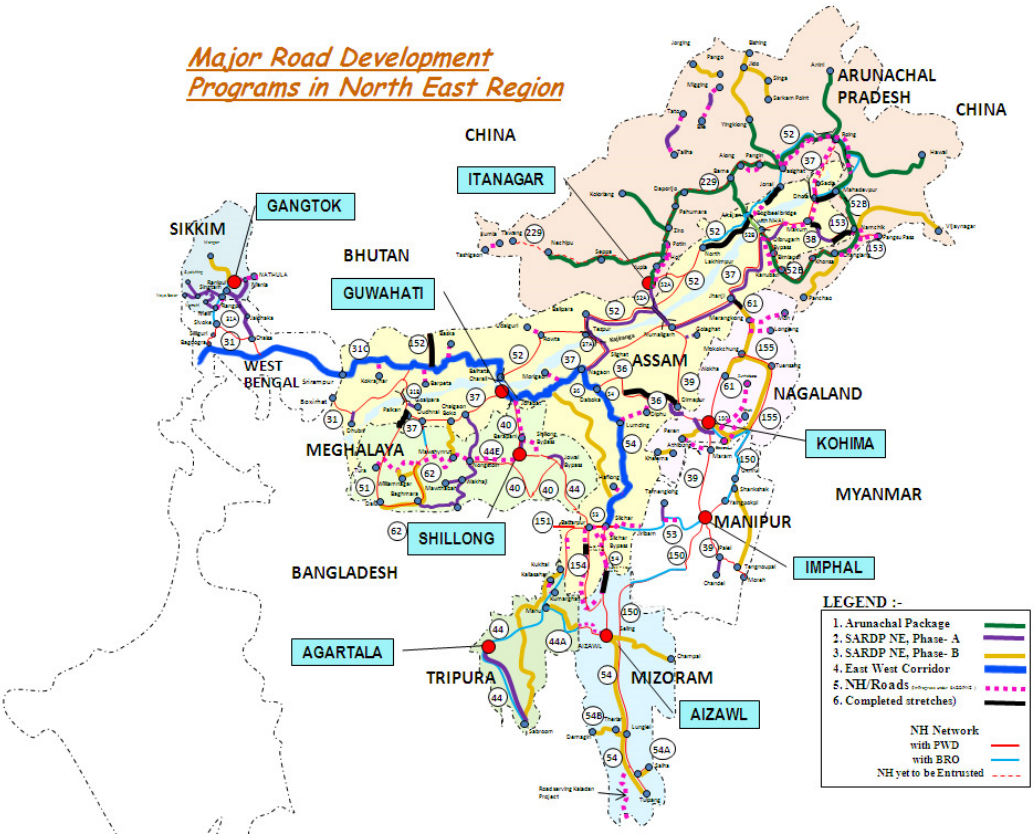
[31] Earlier known as Look East Policy, the policy aims to develop extensive economic and strategic relations between India and South-East Asian nations.

[32] ASEAN is a regional intergovernmental organization comprised of ten South-East Asian countries that promotes intergovernmental cooperation and regional integration amongst its members and other Asian countries. The members are: Brunei, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand and Viet Nam.

[33] Manish Chand, "Act East: India's ASEAN Journey", Ministry of External Affairs, Government of India, 10 November 2014. Available at https://www.mea.gov.in/.

[34] Press Trust of India, "Statement made by Nitin Gadkari, Minister of Road Transport and Highways, India", 25 October 2017.

Figure 2: Road network in North-East India



Source: Ministry of Development of North Eastern Region.

Like the road networks, Indian Railways has an extensive network, making it the fourth largest railway network in the world by size, with 121,407km of tracks and over 67,368km of routes as of 31 March 2017.[35] Initially, Indian Railways used telecommunications services from DoT and later the state-owned telecommunications company, BSNL. However, to increase efficiency and administrative control, Indian Railways started building its own ICT infrastructure from the early 1970s based on overhead telephone lines, quad cables and microwave signalling. In 1983, the Railway Reforms Committee recommended the introduction of FOCs in its dedicated network. In tandem with the National Telecom Policy 1999 that liberalized the telecommunications sector, the Government of India formed a telecommunications corporation, RailTel Corporation of India Limited, to provide broadband and virtual private network services. Besides creating a nationwide broadband network, RailTel has also been focusing on modernizing train control operation and railway safety systems.[36]

[35] Indian Railways, *Indian Railways Statistical Publications 2016-17: Statistical Summary*. (New Delhi, Ministry of Railway, 2017). Available at http://www.indianrailways.gov.in/.

[36] Rail News, "RailTel celebrates its Annual Day", 18 October 2013. Available at http://www.railnews.in/.

RailTel has exclusive seamless RoW along its railway tracks passing through 7,000 stations across the country. Using this RoW, RailTel has so far laid 47,536 route kilometres of FOCs, out of which 44,496 route kilometres are lit FOCs,[37] as of 31 March 2017. Works on another 6,700km are in various stages of execution.[38] RailTel is creating points of presence at every railway station and it has a distribution layer network in over 600 cities. RailTel is also one of the three implementing partners of BharatNet and is laying FOCs in the north-eastern states of Mizoram, Tripura, Meghalaya, Arunachal Pradesh, Manipur and Nagaland. RailTel has signed a memorandum of understanding with Bharat Broadband Network Limited (BBNL)[39] to work in 11 states covering 8,678 *gram panchayats*.

The nationwide FOC network deployed by RailTel, as shown in Figure 3, is not only meeting the Indian Railways' own operations and communications needs, but also creating a source of additional revenue. In fact, it has become a strong competitor of BSNL in providing broadband services, particularly through "RailWire", its fibre-to-the-home (FTTH) broadband service. With its FOC network spread across the country, points of presence in all railway stations and partnerships with local cable television operators, RailTel is able to deliver broadband connection at a very competitive price. BSNL is apprehensive of the fact that with RailTel's FOC network extending to the remotest villages of the country, BSNL's broadband subscribers (using asymmetric digital subscriber line) may gradually move over to RailTel's FTTH broadband Internet service.[41] RailTel is an example of how synergies between telecommunications and railway infrastructures, and commercial use of the surplus capacity of its FOC network, can generate additional revenue and at the same time build a national ICT infrastructure.

TSPs are also using RailTel's FOC network as it helps TSPs avoid the associated costs of laying FOCs and the issues related to obtaining RoW permissions in remote areas with multiple jurisdictions of local authorities. The case of RailTel demonstrates that the co-deployment of FOCs along railway tracks can help boost broadband services and foster business partnerships in a competitive market. Similar synergic partnerships can be established within the region if FOC networks across borders can join hands to share infrastructure and resources like dark fibres and ducts. It will go a long way to foster broadband expansion and boost economic activities for all stakeholders. There are, however, a number of operational and regulatory

[37] Lit FOC refers to the FOC that has been connected to a port on a piece of telecommunications equipment. Dark or unlit FOC refers to unused fibre-optic capacity that is potentially available for use in the ICT infrastructure. It is a common practice for an owner of dark fibre to lease the dark FOCs to another authorized/licensed entity to light up (use) such fibre and provide electronic communications services over such fibre network. Source: Dingley Marshall, "What is the difference between dark and lit fibre?" 16 May 2011. Available at https://www.dingleymarshall.co.za/what-is-the-difference-between-dark-and-lit-fibre/.

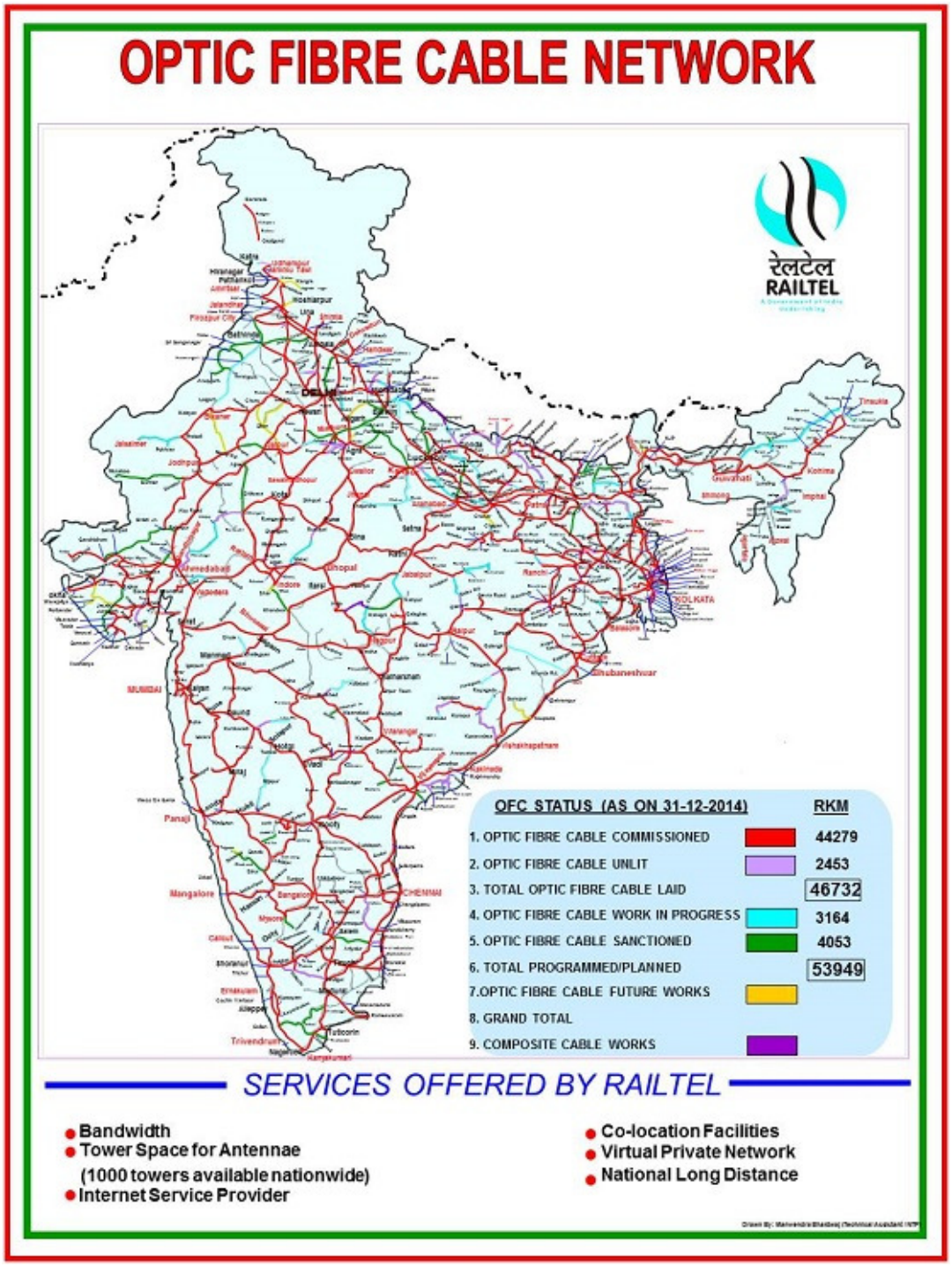
[38] RailTel, "Annual Report of RailTel for the year 2016-2017 laid on the table of Indian Parliament (Lok Sabha)", 20 December 2017.

[39] BBNL is a special purpose vehicle set up by the Government of India under the Ministry of Communications and Information Technology, DoT, for the establishment, management and operation of the NOFN. BBNL was incorporated on 25 February 2012 as a public sector undertaking/company, and the company was granted a national long distance operating licence by DoT in 2013.

[41] V.G. Sabu and others, "A Comparative Study on Retail Business Processes of RailTel and BSNL in the Provisioning of FTTH Based Broadband Internet Services", conducted by BSNL Telecom Division, Nedumangad, Kerala, 2016.

issues that need to be worked out within the countries and within international cooperation frameworks for such a networked infrastructure to function seamlessly. These issues will be discussed in the later part of this paper.

Figure 3: Fibre-optic network of RailTel India



Source: RailTel.
Note: As of 31 December 2014.

2.3 Broadband Connectivity and the Telecommunications Sector in Bangladesh

Bangladesh, one of the most densely populated countries of the world, has witnessed a rapid increase in mobile broadband expansion over the past five years with an increasing number of mobile phone subscribers. However, fixed-line subscriptions are slowly decreasing and the mobile broadband market is still at an early stage of development.[42] The development of the ICT infrastructure, therefore, is a top priority for the Government of Bangladesh and a number of initiatives, policies and plans have been adopted in recent years. According to the latest figures given by the Bangladesh Telecommunication Regulatory Commission (BTRC),[43] Bangladesh has 80.82 million Internet subscribers as of January 2018, the majority of which are mobile Internet users (see Table 3). Compared with many other developing countries the Internet penetration rate is quite impressive.

Table 3: Internet subscribers in Bangladesh

Category	Subscribers (million)
Mobile Internet	75.396
WiMAX	0.088
ISP + PSTN	5.345
Total	80.829

Source: BTRC, "Internet Subscribers in Bangladesh", January 2018. Available at http://www.btrc.gov.bd/content/internet-subscribers-bangladesh-january-2018.
Note: Data as of January 2018.

The telecommunications sector in Bangladesh has experienced significant growth over the last five years. This growth has mainly been driven by mobile phones and increasing investment in the sector. 4G Internet alone has attracted an investment of BDT 226 billion (USD 27.13 billion).[45] In 2017, the number of mobile phone subscribers increased by 20.87 per cent, and has resulted in connecting more people to the Internet. Mobile phone operators registered 18.7 million new users and the total active mobile connection in Bangladesh stood at 144.5 million by the end of 2017.[46]

[42] BuddeComm, “Bangladesh: Telecoms, Mobile and Broadband – Statistics and Analyses”, 11 September 2017. Available at https://www.budde.com.au/.
[43] BTRC is an independent commission established under the Bangladesh Telecommunication Act, 2001. It is responsible for regulating all matters related to telecommunications (wire, cellular, satellite and cable) in Bangladesh.
[45] The Daily Star, 20 June 2017.
[46] The Daily Star, “Operators witness jump in SIM, internet connections”, 30 January 2018. Available at https://www.thedailystar.net/business/telecom/operators-witness-jump-sim-internet-connections-1527142.

Table 4: Mobile subscribers in Bangladesh

Operators	Active Subscribers (in millions)
Grameen Phone Limited	65.866
Robi Axiata Limited	44.225
Banglalink Digital Communications Limited	32.356
Teletalk Bangladesh Limited	4.553
Total	**147.000**

Source: BTRC.

Notes: Data as of January 2018. Excludes data from Citycell. "Active subscriber" means number of subscribers who have any activity (voice, data, SMS, etc.) at least once in the preceding 90 days.

During the same period (2017), telecommunications operators added 13.9 million new Internet connections, which was a 14.79 per cent increase from the previous year. With 20 million people using 3G services during 2017, the total number of active 3G connections in Bangladesh stood at 60.4 million at the end of 2017. Moreover, the total number of active mobile phone subscription reached 147 million at the end of January 2018 (see Table 4).

Bangladesh's telecommunications regulator, BTRC, attributed this growth to: "the telecommunications operators as they are expanding networks and offering affordable services," although the sector continues to face challenges in improving the quality of services.[49] The BTRC is expecting the situation to improve once technology neutrality[50] is applied, which will allow operators to use their spectrum efficiently, and offer faster and better data services to customers. The BTRC has already started offering mobile operators technology neutrality, allowing them to offer services through any technology – 2G/3G/4G/LTE – by using any of the frequencies they have.[52]

Bangladesh has substantially expanded its basic telecommunications facilities, but it has a long way to go in terms of offering digital services and increasing its Internet usage. In terms of contribution to the GDP and compared to other sectors such as manufacturing, agriculture and services, Bangladesh's telecommunications sector is still at a nascent stage.[53]

[49] According to Mr. Shahjahan Mahmood, Chairman of the BTRC. The Daily Star, "Operators witness jump in SIM, internet connections", 30 January 2018. Available at https://www.thedailystar.net/business/telecom/operators-witness-jump-sim-internet-connections-1527142.

[50] Technology neutrality means that different technologies offering essentially similar services are regulated in similar manners. However, technologies offering similar services do not necessarily have similar features in all aspects, and identical regulations may, therefore, result in the advantage of one technology over another in the market. Technology neutral regulation can, consequently, include slightly differing regulations for different technology solutions in the same market segments. infoDev and the International Telecommunications Union, "ICT Regulation Toolkit". Available at http://www.ictregulationtoolkit.org/.

[52] The Daily Star, "BTRC to earn $100m in tech neutrality fees", 2 February 2018. Available at https://www.thedailystar.net/business/btrc-earn-100m-tech-neutrality-fees-1528801.

[53] Hal Khata Team, "An Overview on Digital Services of Bangladesh Telecom Industry", 24 February 2018. Available at http://hal-khata.com/2018/02/24/digital-services-of-bangladesh-telecom-industry/.

2.4 Fibre-Optic Co-Deployment along Roads and Railways in Bangladesh

In Bangladesh, the deployment of FOCs has been undertaken by both government organizations and private companies during and after the construction of roads and railways. Details of their routes and lengths have not yet been summarized by the Roads and Highways Department (RHD) as FOC deployment has been carried out by different parties. It is estimated that the FOCs deployed so far almost cover the length of the national highways in the country (3,800km). FOCs are also installed along roads built by the city corporation, the *pouroshova* (municipality) and the Local Government Engineering Department.

The RHD does not have any provision or plan for FOC co-deployment and it does not provide any ducts or trenches for FOCs along the roads and highways. Mostly, FOCs have not been deployed at the time of road construction. But RHD later permitted several government organizations, such as the ICT Division and the Bangladesh Telecommunications Company Limited (BTCL), as well as some private companies (e.g., Grameenphone, Banglalink, Summit and Fibre Bangladesh), to install FOCs along highways after their construction (see Figure 4).

The RHD officials are aware of the issues associated with the deployment of FOCs after the construction of roads. They complained about frequent deviations of the telecommunications operators from the permitted locations, parameters and damages done to the roads while deploying FOCs. The RHD indicated during this study that it is planning to set permanent utility ducts in major road networks so that they will remain uninterrupted during any development or road maintenance work.

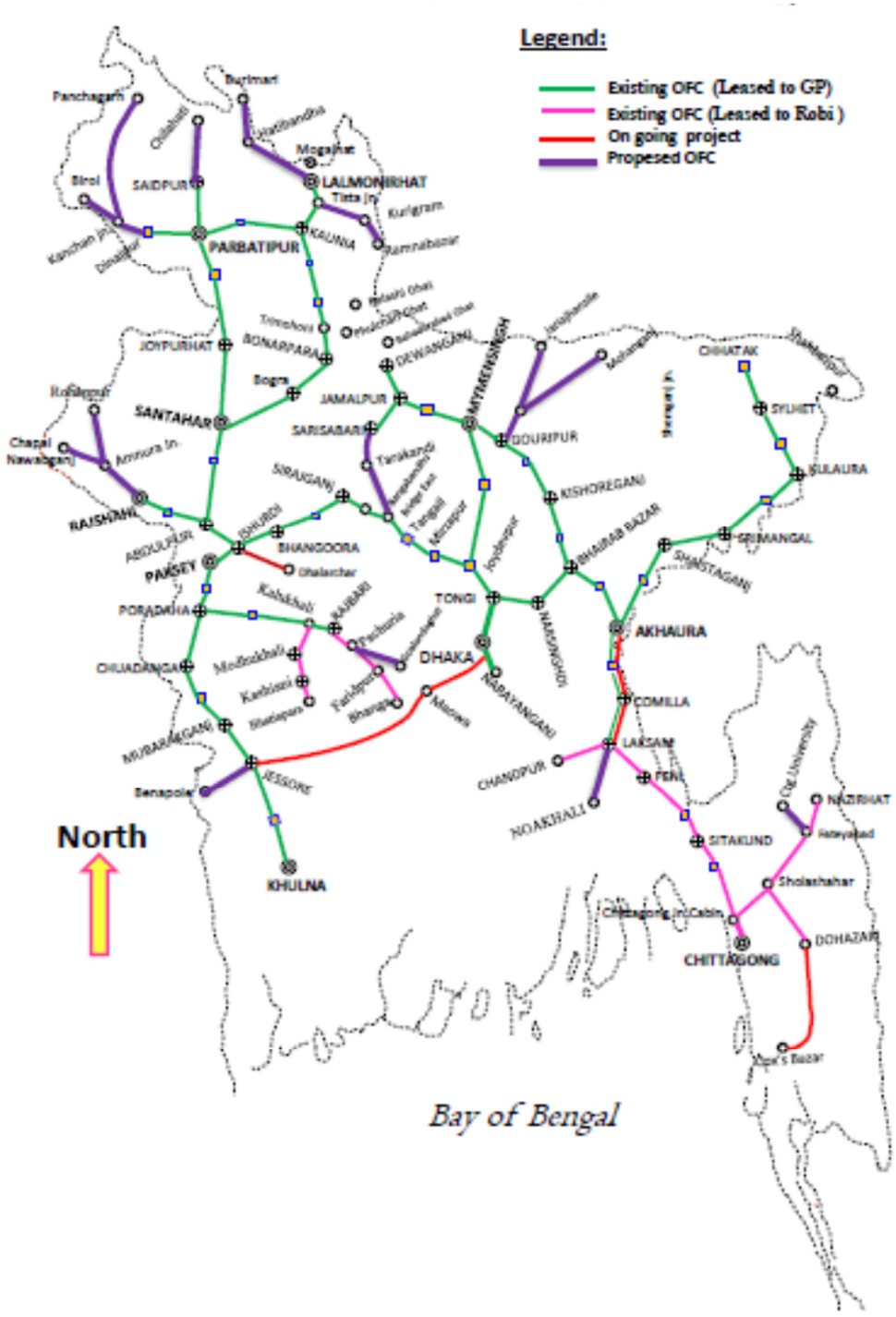
Figure 4: Fibre-optic network of BTCL

Source: BTCL.

In the case of railways, Bangladesh Railway had first launched an FOC-based integrated telecommunications system back in 1992 with a Norwegian grant under which over 1,600km of FOCs had been installed. Subsequently, Bangladesh Railway, in association with Grameenphone, deployed another 439km of FOCs that the private cell phone operator is now operating commercially. Out of the total 2,877km of railway route, Bangladesh Railway has

about 2,300km co-deployed with FOCs, part of which have been leased out to Grameenphone Limited and Robi Axiata Limited. In addition, FOCs are being laid along 380km of new railway tracks under different projects.

Figure 5: Status of fibre-optic co-deployment along railway routes in Bangladesh



Source: Bangladesh Railway.

The Bangladesh Railway has submitted a proposal to the Planning Commission for laying FOCs along 575km of secondary railway routes. Bangladesh Railway will implement the proposed project from January 2018 to June 2020 with an estimated cost of BDT 781.30 million (approximately USD 10 million), which will be fully funded from the national exchequer. It is expected that within the next two or three years, FOCs will be co-deployed along all the railway tracks in Bangladesh making it a robust telecommunications network. A route map showing the status of FOC co-deployment on existing and planned lines is shown in Figure 5.

Bangladesh Railway plans to bring its entire network under an integrated telecommunications system by laying FOCs in 44 *upazilas* (subdistricts)[54] under 17 districts to build a safer and more secure train communications system.[55] Overall, Bangladesh has an impressive layout of FOCs. According to BTRC, there are currently 54,228km of FOCs, of which the Nationwide Telecommunication Transmission Network (NTTN) licensees and operators have a major share (see Table 5).

Table 5: Fibre-optic cables laid by telecommunications operators in Bangladesh

Licence holder / operator	FOC coverage (km)
NTTN	
Summit Communication	20,670
Fibre@Home	15,468
Bangladesh Telecommunications Company Limited	4,935
Power Grid Company of Bangladesh Limited	4,402
Bangladesh Railway	2,105
Mobile phone operators	
Banglalink	3,000
Grameenphone	2,500
Other operators	1,157

Source: The Independent.

[54] *Upazila* (subdistrict), formerly called *thana* (police station area), is a geographical region in Bangladesh used for administrative or other purposes. It functions as a subunit of a district.

[55] The Independent, "Railway to bring its entire network under integrated telecom system", 17 September 2017. Available at http://www.theindependentbd.com/home/printnews/114461 10-12-2017.

3. Emerging Opportunities

3.1 India

The Indian government has been focused on accelerating the development of the road sector and information superhighways to connect remote areas and rural communities across the country.

In 2011, the Government of India approved the NOFN Project to propel a broadband revolution in the rural and remote areas of India. NOFN was conceived as an information superhighway to create a nationwide "middle-mile" broadband infrastructure up to the village level. The project, later renamed as BharatNet, aimed to connect all 250,000 *gram panchayats* in the country covering nearly 625,000 villages by utilizing the existing FOC networks and extending it to unserved villages. The project budget of USD 4 billion was from the Universal Service Obligation Fund (USOF), funded through a universal service levy of 5 per cent of the adjusted gross revenue of TSPs.[56]

The BBNL was incorporated in 2012 under the Companies Act of 1956 to implement and coordinate the project. The BBNL was subsequently awarded a national long distance operating licence by India's DoT that gave it a wholesale bandwidth licence. The actual on-site execution of the project and the laying of the FOC network was outsourced to three major public sector undertakings: BSNL, RailTel and the Power Grid Corporation of India Limited (PGCIL). These entities, in turn, had the authority to delegate cable laying tasks to private Internet service providers (ISPs).

In order to connect every village in the country with broadband services, the project aimed to utilize existing FOC networks of the three public sector undertakings assigned, and wherever necessary, lay additional FOCs to connect the *gram panchayats*. The project intended to use their dark fibre networks to deliver sufficient bandwidth to the *gram panchayats*, and subsequently, provide non-discriminatory network access to TSPs, ISPs, cable TV operators and content providers to launch various services at the grass-roots level. The target was to provide 600 million broadband connections by the year 2020 with a minimum of 2 Mbps download speed, and provide higher speeds of at least 100 Mbps on demand.[58]

However, a few years after its launch, the NOFN Project was falling far behind its original plans and schedules in terms of connecting the *gram panchayats* and laying the FOCs. A committee was formed in January 2015 to review the project in light of the vision of Digital India. The committee recommended that the project be renamed as BharatNet to "reflect the national aspiration" and a new vision was put forward as follows:

[56] Osama Manzar, Ritu Srivastava and Rajat Kumar, *National Optic Fibre Network Status Study: A Review of the Pilot Blocks* (New Delhi, Digital Empowerment Foundation, 2015). Available at http://www.defindia.org/files/2015/01/Internet-Access.pdf.

[58] BBNL, "Report of the Committee on National Optical Fibre Network", 31 March 2015. Available at http://www.bbnl.nic.in/admnis/admin/showimg.aspx?ID=683.

> *BharatNet shall be a project of national importance to establish, by 2017, a highly scalable network infrastructure accessible on a non-discriminatory basis, to provide on-demand, affordable broadband connectivity of 2 Mbps to 20 Mbps for all households and on-demand capacity to all institutions, to realize the vision of Digital India, in partnership with States and the private sector*.[59]

The new BharatNet Project continues to be funded by the USOF. The objectives are to improve telecommunications services in rural and remote areas of the country, and facilitate the delivery of e-governance, e-health, e-education, e-banking and other services. The project is a centre-state collaborative project, with the states contributing free RoW for establishing the FOC network. The three-phase implementation of BharatNet is as follows:

> **Phase 1** – Provide 100,000 *gram panchayats* with broadband connectivity by laying underground FOCs by March 2017.
>
> **Phase 2** – Provide connectivity to all 250,500 *gram panchayats* using an optimal mix of underground fibre, fibre over power lines, radio and satellite media. In addition, deploy aerial FOCs over electricity poles, as well as Wi-Fi hotspots in *gram panchayats*.
>
> **Phase 3** – From 2018 to 2023, deploy state-of-the-art, future-proof networks, including fibre between districts and blocks with ring topology to provide redundancy.[60]

The FOC construction work completed so far under BharatNet is very encouraging (see Table 6). The idea is that once all the *gram panchayats* are connected to the FOC network, last-mile connectivity to all villages will be provided by the commercial telecommunications operators, by expanding the current national network of 38,000 Wi-Fi hotspots to 700,000 Wi-Fi hotspots to cover all 625,000 villages in India. Telecommunications companies like Bharti Airtel, Reliance Jio Infocomm, Vodafone India and Idea Cellular have already expressed interest in providing last-mile connectivity on BharatNet's FOC infrastructure.[61] The government has projected a 10 per cent increase in Internet usage in the country by the end of the second phase, leading to a 3.3 per cent increase in GDP.[62]

[59] Ibid.
[60] BBNL, "National Optical Fibre Network (NOFN)", 26 June 2015. Available at http://www.bbnl.nic.in/index1.aspx?lsid=249&lev=2&lid=21&langid=1.
[61] The Hindu Businessline, "Only 'Made in India' equipment for BharatNet: Govt", 12 November 2017. Available at https://www.thehindubusinessline.com/info-tech/only-made-in-india-equipment-for-bharatnet-govt/article9954895.ece.
[62] According to Aruna Sundararajan, Secretary, DoT, Government of India. The Hindu Businessline, "Only 'Made in India' equipment for BharatNet: Govt", 12 November 2017. Available at https://www.thehindubusinessline.com/info-tech/only-made-in-india-equipment-for-bharatnet-govt/article9954895.ece.

Table 6: Status of fibre-optic deployment under BharatNet (Phase 1)

State		Incremental cable to be laid in Phase 1		FOC laid		FOC laid (%)	
Unit		km	GPs	km	GPs	km	GPs
BSNL (16 States and 1UT)		185,742	84,366	203,956	88,881	101	102
1.	Assam	2,739	1,013	4,162	1,348	152	133
2.	Bihar	12,971	5,202	13,007	4,754	100	91
3.	Chhattisgarh	6,016	2,110	9,154	3,210	131	150
4.	Haryana	10,518	6,090	11,005	5,803	105	95
5.	Jammu and Kashmir	1,068	624	459	211	36	32
6.	Karnataka	11,642	5,599	12,914	6,062	102	107
7.	Kerala	693	977	830	1,129	120	116
8.	Madhya Pradesh	31,353	10,516	33,731	11,770	99	111
9.	Maharashtra	28,674	12,055	26,697	12,545	88	98
10.	Punjab	8,270	6,128	10,692	7,136	111	110
11.	Rajasthan	20,027	6,967	21,845	7,143	100	101
12.	Uttar Pradesh (E)	26,835	14,474	34,256	16,532	109	108
13.	Uttar Pradesh (W)	14,470	8,040	17,027	7,959	106	97
14.	Uttarakhand	3,358	1,767	2,895	1,463	78	83
15.	West Bengal	7,023	2,658	5,263	1,804	69	67
16.	Andaman and Nicobar Islands	66	69	0	0	0	0
17.	Chandigarh	19	12	19	12	100	100
RAILTEL (7 States and 1 UT)		19,999	8,714	16,844	7,306	72	74
1.	Arunachal	1,130	256	958	364	56	82
2.	Nagaland	2,544	743	1,634	506	58	62
3.	Manipur	70	24	380	178	321	508
4.	Mizoram	814	163	497	91	52	45
5.	Tripura	1,961	1,021	1,672	816	81	79
6.	Meghalaya	1,897	638	539	201	28	30
7.	Gujarat	11,494	5,771	11,072	5,052	82	77
8.	Puducherry	89	98	92	98	103	100
PGCIL (5 States)		17,113	7,196	19,422	7,549	107	102
1.	Andhra Pradesh	N/A	N/A	766	283	N/A	N/A
2.	Telangana	4,696	2,097	4,488	2,038	95	97
3.	Odisha	8,443	3,388	8,629	3,163	94	92
4.	Jharkhand	3,221	1,428	5,010	1,894	145	124
5.	Himachal Pradesh	753	283	529	171	64	54
28 States and 2 UTs		**222,854**	**100,276**	**240,222**	**103,736**	**98**	**100**

Source: BBNL, "BharatNet (Phase-I) – Status of OFC Laid as on 12.11.2017". Available at http://bbnl.nic.in/index1.aspx?lsid=577&lev=2&lid=471&langid=1.

Notes: As of 12 November 2017. GP = *gram panchayat* (village council). UT = union territory.

For the roll out of the FOC network and telecommunications services through Wi-Fi hotspots to the remotest corners of the country, the government announced subsidy support of INR 36,000 million (USD 550 million) towards attracting TSPs to cover commercially non-viable villages.[64] Furthermore, BharatNet offered bulk broadband bandwidth at 75 per cent discounted rates to commercial telecommunications operators so that they can provide rural wireless broadband services to rural customers at a lower price. Commercial operators like Bharti Airtel has already set up 4G base tower stations in Madhya Pradesh and Rajasthan and is providing high-speed 4G mobile broadband services to people through BharatNet.[65] See Table 7 for the status of BharatNet as of February 2018.

Table 7: Status of BharatNet

Description of work	Status
FOC pipe laid	264,528 km (1,16,565 GPs)
FOC laid	265,296 km (1,12,677 GPs)
Tenders finalized	3,291 blocks / 1,22,790 GPs
Work started	3,279 blocks / 1,21,403 GPs
Current weekly performance of FOC laying	1,263 km
Current weekly performance of FOC pipe laying	826 km
FOC delivered on site	330,196 km
Service-ready GPs	103,279 GPs

Source: BBNL.
Notes: Status as of 25 February 2018. Does not include data from Andhra Pradesh. GP = *gram panchayat* (village council)

During the second phase of BharatNet, launched in November 2017, the government aims to lay one million kilometres of additional FOCs, and the central government signed agreements with seven states: Maharashtra, Gujarat, Chhattisgarh, Andhra Pradesh, Telangana, Tamil Nadu and Jharkhand. These states will roll out the project with partial funding support from the central government.[67]

India's federal budget of 2018-2019 allocated INR 19,000 crore (USD 291.63 million) for the development of roads in rural areas under PMGSY, which is a 12.42 per cent increase from last year's fund allocation.[68] Under the National Highways Development Project (NHDP), the National Highways Network and other ongoing projects, India has about 5.48 million

[64] Indo-Asian News Service, "Govt to launch second phase of BharatNet", 13 November 2017. Available at https://www.thenewsminute.com/article/govt-launch-second-phase-bharatnet-connect-15-lakh-panchayats-internet-71530.
[65] Mansi Taneja, "Bharat turns new telco battleground", *DNA India*, 13 November 2017. Available at https://www.dnaindia.com/business/report-bharat-turns-new-telco-battleground-2559788.
[67] The Economic Times, "Government rolls out BharatNet Phase 2, aims 100% connectivity by 2020", 14 November 2017. Available at https://economictimes.indiatimes.com/tech/internet/government-rolls-out-bharatnet-phase-2-aims-100-connectivity-by-2020/articleshow/61632756.cms.
[68] Money Control, "Budget 2018: Rural roads see an allocation of Rs. 19,000 crore under PMGSY", 1 February 2018. Available at https://www.moneycontrol.com/news/business/economy/budget-2018-rural-roads-see-an-allocation-of-rs-19000-crore-under-pmgsy-2490503.html.

kilometres of road networks, which is the second largest in the world in terms of length.[69] The NHDP was reviewed to adopt a macro-approach while planning expansion of the national highways network, and a new programme called "Bharatmala Pariyojana" has been initiated by the central government as a new umbrella programme.

Bharatmala Pariyojana focuses primarily on bridging critical infrastructure gaps through interventions like the development of economic corridors, inter-corridors, feeder routes, national corridor efficiency improvement, border and international connectivity roads, coastal and port connectivity roads, and green-field expressways. A total of around 24,800km of roads are being considered in the first phase of Bharatmala Pariyojana. The objective of the programme is optimal resource allocation for a holistic highway development/improvement initiative.[70] According to India's Finance Minister, investments of over INR 50 lakh crore (USD 786.02 billion) are required to: "increase the growth of GDP, connect and integrate the nation with a network of roads, airports, railways, ports and inland waterways, and provide good quality services".[71] India's budgetary allocation for infrastructure is set at INR 5.97 lakh crore (USD 93.85 billion) for 2018-2019, and around 35,000km of road construction has been approved for the first phase of Bharatmala Pariyojana at an estimated cost of INR 5.35 lakh crore (USD 84.10 billion).[72]

Similarly, the telecommunications sector in India received a higher budgetary allocation for 2018-2019 with INR 10,000 crore (USD 15.32 million) earmarked for enhancing the ICT infrastructure in the country, including the laying of 400,000km of FOCs by March 2019.[73]

From the experience of implementing BharatNet, a large portion of the fund has been spent on excavating trenches for laying the FOC conduits. Considering the ambitious road infrastructure plans described above, India can save substantial funds in FOC deployment if the requirement of trenches for laying FOC conduits is incorporated into road design and planning. However, this would require active coordination between concerned ministries, departments and implementing agencies of telecommunications, rural development, roads and transport.

[69] Press Information Bureau, "Bharatmala Pariyojana - Phase-I". Available at http://pibphoto.nic.in/documents/rlink/2017/oct/p2017102504.pdf.
[70] Ibid.
[71] Gaurav Vivek Bhatnagar, "Budget 2018: 'All-Time High' Allocation for Rail and Road Infrastructure", *The Wire*, 1 February 2018. Available at https://thewire.in/economy/budget-2018-time-high-allocation-rail-road-infrastructure.
[72] India Brand Equity Foundation, "Union Budget of India (2018-19)", February 2018. Available at https://www.ibef.org/economy/union-budget-2018-19.
[73] Press Trust of India, "Budget 2018: Telecom sector to create 4 lakh new jobs in 5 years, says Manoj Sinha", *The Financial Express*, 1 February 2018. Available at https://www.financialexpress.com/budget/budget-2018-telecom-sector-to-create-4-lakh-new-jobs-in-5-years-says-manoj-sinha/1045247/.

3.2 Bangladesh

The Government of Bangladesh's Digital Bangladesh initiative is an integral part of its Vision 2021 that promises a prosperous and equitable middle-income Bangladesh. Since January 2009, under the leadership of Prime Minister Sheikh Hasina, this new vision places ICT as the central driving force of its economy. The four priorities of Digital Bangladesh are:

1. Developing human resources with 21st century skills;
2. Providing nationwide Internet connectivity and ensuring that the benefits of Digital Bangladesh reach the marginalized and disadvantaged;
3. Creating a digitized government offering ICT-enabled services; and
4. Promoting the productivity and competitiveness of businesses through the use of digital technology, including the establishment of a high-tech park for businesses.[74]

In its Seventh Five-Year Plan 2016-2020, the Government of Bangladesh highlights the need to leverage ICT as a tool for the economic development of the country. In line with the priorities of Digital Bangladesh, the government has set the target of ICT export at USD 5 billion and aims to increase the number of information technology (IT) professionals to 2 million by 2021. The government recognizes that it is not possible to attract investment and achieve the ambitious target of ICT export without a robust ICT infrastructure. Bangladesh has therefore undertaken a number of ICT infrastructure projects for faster connectivity to encourage the development of the ICT industry. There are four pillars identified for the development of the ICT sector:

1. Infrastructure and connectivity
2. ICT industry development
3. Human resources development
4. e-Governance

Under the ICT infrastructure and connectivity pillar, the government has launched two ambitious projects: Bangla Govnet and Infosarker. These projects involve the deployment of FOCs up to the upazila level, the establishment of connectivity among 18,415 government offices (58 ministries/divisions, 227 departments, 3,520 district-level offices and 14,610 upazila-level offices), and the installation of a video conferencing system in 800 government offices and educational institutions.[76] Two major FOC deployment projects that have recently been completed in Bangladesh are:

1. The Internet Information Network Expansion Project – a partnership between the Government of Bangladesh and the Korean government that laid 1,450km of FOCs.
2. The Optical Fibre Cable Development Project – a Government of Bangladesh initiative that laid 8,000km of FOCs in 1,000 *union parishads*.[77]

[74] BuddeComm, "Bangladesh: Telecoms, Mobile and Broadband – Statistics and Analyses", 6 January 2016. Available at https://www.budde.com.au/.

[76] Shyam Sunder Sikder, "ICT infrastructures: Present and future", *The Independent*, 27 January 2017. Available at http://www.theindependentbd.com/printversion/details/78115.

[77] *Union parishad* is the smallest rural administrative and local government unit in Bangladesh. Each union is made up of nine wards. Usually one village is designated as a ward. There are 4,554 unions in Bangladesh. A

Another two projects are in the pipeline – Infosarker-3 and Establishing Digital Connectivity – that will provide broadband connectivity to all *union parishads*. The Infosarker-3 Project has already been approved by the Executive Committee for National Economic Council, and the Establishing Digital Connectivity Project is awaiting approval. Moreover, Bangladesh has unveiled a plan to provide broadband connectivity to villages and set up an information centre in each village. To date, about 5,300 digital centres have been established in the rural areas and they are now providing over a hundred e-services to rural citizens.

The BTRC is currently reviewing Grameenphone's exclusive use of Bangladesh Railway's FOC network as part of the effort to maximize the use of the FOC infrastructure available to Bangladesh Railway. In 1997, Grameenphone signed an agreement with the Railway Division after winning an international bid to use, maintain and run the business operation of Bangladesh Railway's FOCs. In line with the Digital Bangladesh initiative, the government has now started a move to withdraw the exclusivity agreement between Grameenphone and Bangladesh Railway, and open the FOCs to other operators as well. If the exclusivity of use by Grameenphone is removed, BTRC believes that more than 2,100km of Bangladesh Railway's FOCs will be available to other interested parties, and Bangladesh Railway will be able to supervise and lease or sublease the dark fibre to any other entity.[78]

union council, comprised of a chairman and twelve members, is primarily responsible for agricultural, industrial and community development within the union.

[78] The Independent, "Railway to bring its entire network under integrated telecom system", 17 September 2017. Available at http://www.theindependentbd.com/home/printnews/114461 10-12-2017.

4. Challenges and Issues of Fibre-Optic Co-Deployment

One of the key challenges in FOC deployment is obtaining RoW to deploy cables after a road has been constructed. Telecommunications operators often find their work held up by authorities at various levels, including small towns where municipal bodies can cause delays in granting RoW permissions for FOC deployment work.

In 2016, India's DoT developed a new set of rules – the Indian Telegraph Right of Way Rules – that mandated the telecommunications licensees to seek permission from "appropriate authority" for laying underground cables. The definition of "appropriate authority" includes a large number of bodies as follows:

> *Central Government, respective State Governments, local authority or such authority, body, company or institution incorporated or established by the Central Government or the State Government, in respect of property, under, over, along, across, in or upon which underground or over-ground telegraph infrastructure, is to be established or maintained, vested in, or under, the control or management of such appropriate authority.*[90]

The Right of Way Rules of 2016 are well appreciated by the telecommunications operators as they help expedite the installation of FOCs and building of towers, and fast-track the spread of connectivity across the country.[91] These rules provide for the issuance of RoW approvals in a time-bound manner, and include mechanisms for disputes settlement, as well as support for better coordination between companies and government authorities.

Another challenge that often affects FOC deployment in India is the arbitrary fees charged by local bodies to grant RoW permissions. In some cases, the charges have been as high as INR 70 million per kilometre for laying underground cables.[92] The Right of Way Rules of 2016 prohibit local authorities from imposing any fees and charges other than the expense that they would incur as a consequence of the proposed work as follows:

> *RoW application under the rules shall be accompanied with such fee to meet administrative expenses for examination of the application and the proposed work as the appropriate authority may, by general order, deem fit and such fee to meet administrative expenses shall not exceed one thousand rupees per kilometre.*[93]

The Cellular Operators Association of India anticipated that these new rules would help them improve their quality of service, and expand cell site coverage as well as fibre implementation to support broadband services.[94]

---

[90] Clause 2(b) of the Indian Telegraph Right of Way Rules, 2016, notified by the Ministry of Communications, DoT, on 15 November 2016 in exercise of the powers conferred by subsection (1) and clause (e) of subsection (2) of section 7 read with sections 10, 12 and 15 of the Indian Telegraph Act, 1885 (13 of 1885).

[91] P. Balaji, Chairman, National Council on Telecommunication and Convergence, Associated Chambers of Commerce and Industry of India, in *The Indian Express*, 20 November 2016.

[92] Ibid.

[93] Indian Telegraph Right of Way Rules, 2016.

[94] Rajan Matthews, Director General, Cellular Operators Association of India, in *CXO Today*, 20 November 2016.

Nevertheless, FOC deployment would be simpler for TSPs if, at the time of road construction, underground trenches are also excavated or FOCs are co-deployed. This appears to be a more strategic way forward. Moreover, providing trenches to the TSPs to lay FOCs may create an opportunity for revenue generation, and the additional funds could go towards road maintenance.

Alternatively, free of cost use of the trenches may be compensated by the TSPs by providing free telecommunications services to road authorities. This kind of co-deployment is practised in many advanced countries like the United States of America and the Republic of Korea, and it leads to a creation of what is popularly called, "smart infrastructure". The model of TSPs offering free bandwidth to the Public Works Department and the Transport Department in exchange for facilitating co-deployment is evident in some states in the United States of America and Jamaica. In India's state of Jammu and Kashmir, in exchange for RoW, the TSPs are: "required to provide to the state government a minimum bandwidth of 16 Mbps at state headquarters, 8Mbps at district headquarters (one in each district) and 2 Mbps at each tehsil/subdivision/block free of cost".[96]

Creating a conducive environment for such co-deployment and smart infrastructure will, however, require effective coordination among multiple government authorities, regulators and the private sector. It will also need appropriate legislation to empower a single-window authority to ensure such co-deployment in all future road construction. In the United States of America, for example, a presidential executive order of 14 June 2012 on "Accelerating Broadband Infrastructure Deployment" involved eleven federal and state government agencies. As part of the order, the "dig-once requirements" were adopted to address the concerns of all stakeholders in building such smart infrastructures. Similarly, the Republic of Korea adopted the National Land Planning and Utilization Act, which provides for the installation and management of "utility tunnels" that have necessary facilities for the TSPs.

Other challenges to FOC co-deployment identified by Indian stakeholders include, high cost of operations to install FOCs in remote areas, damage to FOCs and equipment due to unplanned digging on the roads by various parties without prior communication with the concerned departments (contrary to agreed guidelines), and limited coordinated regulatory mechanism across line departments. In addition, Indian's governmental departments expressed the need for more clarity on the cost-effectiveness of FOC co-deployment, the revenue/business models and the regulatory mechanisms to resolve cross-border issues.

While Indian regulator, TRAI, is recommending PPP models for optimal use of co-deployed FOC networks, the Ministry of Road Transport and Highways has publicly invited other parties to utilize its infrastructure to generate revenue. According to Nitin Gadkari, the Minister of Road Transport and Highways, Government of India:

[96] Information Technology Department, Government of Jammu-Kashmir, *Right of Way (RoW) Policy* (2012). Available at http://www.jkit.nic.in/docs/rowpolicy.pdf.

India's 200,000 kilometres of highways can be used for laying optic fibre and oil and gas pipes, which will help the road ministry earn additional revenues. The Ministry of Road Transport and Highways, Government of India has offered the use of this entire stretch for laying optic fibre and oil and gas pipes.[97]

In the case of Bangladesh, the concerns of RHD on FOC co-deployment are related to the development of appropriate designs for road crossing, bridge and culvert crossing, intersection crossing, maintenance facilities and safety features. The RHD has also raised some policy concerns related to accommodating the cost of construction and maintenance, its budget allocations, revenue collection and regulations regarding the use of ducts, and assigning of responsibility for the preservation of ducts that can be used by multiple organizations.

The Government of Bangladesh's Department of Telecommunication echoed similar challenges, including the lack of policies on the sharing of co-deployed FOCs among stakeholders, as well as regulatory issues and coordination mechanisms that will be needed for seamless maintenance and operation of these networks within the country and beyond the borders.

Interestingly, Bangladesh Railway has indicated that it has not faced any major challenges deploying its broadband network and ensuring its resilience from technical, policy, legislative and regulatory perspectives. Bangladesh Railway believes that FOC co-deployment along railway routes as part of the AP-IS will create enormous opportunities for enhancing the availability, affordability, reliability and resilience of the broadband network, especially for landlocked countries in the region. There may have been some challenges in cross-border interconnections but Bangladesh Railway believes that these can be resolved if the countries involved work collaboratively.

The major challenge facing FOC co-deployment in both India and Bangladesh is the charting of a roadmap for cross-sectoral coordination among the plethora of government departments, implementing agencies and telecommunications operators. There needs to be a comprehensive domestic policy backed by law and a framework for international cooperation encompassing all the infrastructure sectors to facilitate the coordinated development of roads, ICT and other utilities. Various infrastructure entities, including roads, highways, railways, telecommunications, water, gas and electricity, must come together instead of guarding their turfs through a maze of overlapping rules, regulatory requirements and legislation.

In India, a committee headed by the Telecommunications Secretary is trying to coordinate BBNL's business development and bandwidth demand aggregation for the BharatNet Project in cooperation with other line ministries working in rural development, local governance, human resources development, health, and women and child development, to promote the utilization of the FOC network. This kind of coordination may be the way forward to mitigate various issues around FOC co-deployment in both countries.

[97] Indo Asian News Service, "Highways to be used for laying optical fibre, oil and gas pipelines: Gadkari", 14 July 2017. Speech delivered by Nitin Gadkari, Minister of Road Transport and Highways, Government of India at INFOCOM 2017. Available at http://www.pib.nic.in/.

Considering the encouraging responses and initiatives from government departments, officials and private players in both countries, the market potentials, increasing demands across key customer segments, and promising technological innovations, these challenges are not insurmountable and weigh far less in comparison with the potential benefits of FOC co-deployment.

The establishment of cross-border links faces additional challenges such as high upfront costs, RoW permissions and difficulties in replacing old networks with next-generation technologies. However, technology innovations, learnings from best practices around the world, and the harmonization of policies and regulations will certainly help countries and their telecommunications sectors resolve many of these issues.

4.1 Policy and Regulatory Issues

4.1.1 India

India's Ministry of Road Transport and Highways issued a set of revised guidelines in 2013 for granting RoW permissions to telecommunications service licensees and infrastructure providers seeking to deploy FOCs and ducts on national highway land.[98] These guidelines were first issued in September 2000, and they were subsequently revised in March 2006 and September 2010, allowing private telecommunications licensees to lay FOCs on national highway land for mobile and basic telephone services. The 2013 guidelines came in the wake of increasing demands for FOC deployment on national highway land. The primary aim of the latest guidelines is to prevent damages to the completed highway projects, and reduce restoration-related disputes in cases of PPP projects. These guidelines are expected to provide clarity with respect to the government's policies on allowing private parties to deploy FOCs along the highways.[99]

The 2013 guidelines specify that in cases of PPP projects, compensation for financial losses due to laying or shifting of cables or cable ducts will have to be borne by the telecommunications licensee through mutual agreement with the concessionaire. The ministry, highway authority or the implementing authority for the project are therefore not liable to the concessionaire for such loss. In cases of shifting or altering laid FOCs necessitated by the widening of highways and construction of bridges and flyovers, the guidelines mandate the telecommunications licensee to carry out the additional alteration work at its own cost at a later date but within a specified period communicated by the respective agency. More importantly, the 2013 guidelines push forward the co-deployment policy in order to avoid

[98] Ministry of Road Transport and Highways, Government of India, "Guidelines for granting right of way permissions to telecom service licensees/infrastructure providers for laying of telecom cables/ducts on NH land", 6 August 2013. Available at https://dit.tripura.gov.in/sites/default/files/Guidelines%20of%20RoW-2013%2017102013.pdf.

[99] Project Monitor, "Fresh guidelines issued for laying of telecom cables on national highway land", 22 August 2013. Available at http://www.projectsmonitor.com/daily-wire/fresh-guidelines-issued-for-laying-of-telecom-cables-on-national-highway-land/.

repeated excavations on the same route, and encourage the laying of FOCs in available ducts along the national highway, subject to the fulfilment of technical requirements.

In routes where such ducts are not available, the first party to deploy the FOCs will be allowed to voluntarily lay extra ducts/conduits with extra capacity for meeting future needs. In such cases, the deploying party may be allowed to commercialize the use of such ducts/conduits later through mutual agreements with the state governments and utility agencies. If the central or state agencies lay ducts/conduits at the time of road construction, they can levy charges for the use of the facility by private parties. At the same time, the guidelines reiterate that any licensee or registered infrastructure provider of the Ministry of Communications will be eligible for RoW permission. However, such permission will be limited by the scope of service given in the licence. The present policy is to provide a 2m wide utility corridor on either side of the extreme edge of the RoW, and where required, the RoW of at least 45m is to be made available that will include provision for FOC ducts. The RoW facility is to be provided at no cost to the licensees of DoT, but a "performance bank guarantee" is required as a security against the improper restoration of ground, compensation for damages and disruption of services.

4.1.2 Bangladesh

The BTRC is empowered under the Bangladesh Telecommunication Act 2001 to issue necessary guidelines for the licensees and service providers relating to various aspect of the ICT infrastructure in the country. BTRC has adopted an infrastructure sharing approach in order to minimize the cost of network deployment and protect the environment by reducing the proliferation of telecommunications installations like mobile towers. In 2008, BTRC issued its Guidelines for Infrastructure Sharing[100] designed to streamline network sharing practices among telecommunications operators. The guidelines cover passive infrastructure and transmission backhaul, and require operators to lease, rent or swap infrastructure on a non-discriminatory basis among themselves. Network sharing has been quite common in the mobile telecommunications industry in Bangladesh from the very beginning, but in 2011, BTRC revised the guidelines. The revised guidelines prescribe transmission backhaul sharing only via the NTTN licensee protocol, which restricts infrastructure sharing among mobile network operators, as NTTN licences are issued only to non-mobile operators.[101]

It is a well-established fact that infrastructure sharing is mutually beneficial not only among telecommunications operators, but also across other sectors like energy and transport as it brings down the cost of telecommunications services. There is no specific cross-sectoral infrastructure sharing policy in Bangladesh. However, the case of Bangladesh Railway's FOC sharing with Grameenphone is illustrative of the potential benefits of such sharing.

Licensed telecommunications operators in Bangladesh are given the RoW under the Bangladesh Telecommunication Act 2001 to: "install any apparatus, thing or facility on, above

[100] BTRC, "Guidelines for Infrastructure Sharing", 8 September 2008. Available at http://www.btrc.gov.bd/guideline/infrastructure_sharing_guidelines.pdf.
[101] Ferdous Mottakin, "Mobile network infrastructure sharing in Bangladesh", 18 September 2016. Available at https://www.linkedin.com/pulse/mobile-network-infrastructure-sharing-bangladesh-ferdous-mottakin/.

or over any land for the purpose of establishing a telecommunications system or for providing telecommunications service". However, this RoW is subject to the granting of permission from concerned authorities. The Government of Bangladesh's RHD has road-cutting guidelines that govern the issuance of such permission. In fact, telecommunications operators are not given any preferential consideration by RHD; rather, such permissions are issued as per the road-cutting guidelines.

There are a number of implementing agencies involved in the co-deployment of FOCs along highways and roads in Bangladesh. According to RHD, the Department of ICT, BTCL and Bangladesh Submarine Cable Company Limited (BSCCL) are the major actors in FOC co-deployment in the country. Bangladesh Railway, under the Ministry of Railways, is also involved in FOC co-deployment along its railway tracks. In fact, Bangladesh Railway was granted a NTTN licence from BTRC in 2014. As an NTTN licensee, Bangladesh Railway is entitled to lay FOCs along railway routes for its own use, as well as for revenue generation.

4.2 Coordination Structures for Fibre-Optic Co-Deployment

It is clear that the telecommunications sectors in India and Bangladesh are entering into the next phase of growth, which is heavily dependent on reliable high-speed connectivity provided by their respective nationwide FOC networks along highways and railways. Government and private sector investments in FOC networks are being driven by the growing demand for broadband services, the proliferation of next-generation broadband technologies like LTE,[102] and increasing co-deployments in rural areas for last-mile connectivity (FTTX).[103] Besides telecommunications, other sectors such as oil and gas, are expected to benefit significantly as the latter sectors need reliable high-speed connectivity for their operations and services.

Telecommunications operators' investments in FOC deployment are driven by the need to increase revenue from the data segment, as voice offers less room for growth and spectrum has become expensive. Having acquired spectrum in the 2G, 3G and 4G service bands, telecommunications operators are deploying FOCs on all network fronts – access, core (long distance) and last mile for this purpose. FTTH deployment is also increasing with both public and private operators rolling out these services. While the uptake is currently limited, it is likely to pick up with growth in high-bandwidth content in the market.[104] Meanwhile, government departments (on roads, highways, railways and transport) in both countries have started examining various FOC network-sharing models as it will help them optimally utilize

[102] LTE or Long-Term Evolution, commonly marketed as 4G LTE, is a standard for wireless communications of high-speed data for mobile phones and data terminals. It is based on GSM/EDGE and UMTS/HSPA network technologies, increasing the capacity and speed using a different radio interface together with core network improvements.

[103] Fibre to the X (FTTX) is a generic term for any broadband network architecture using optical fibre to provide all or part of the local loop used for last mile telecommunications. FTTX is a generalization for several configurations of fibre deployment, arranged into two groups: FTTP/FTTH/FTTB (fibre laid all the way to the premises/home/building) and FTTC/N (fibre laid to the cabinet/node, with copper wires completing the connection).

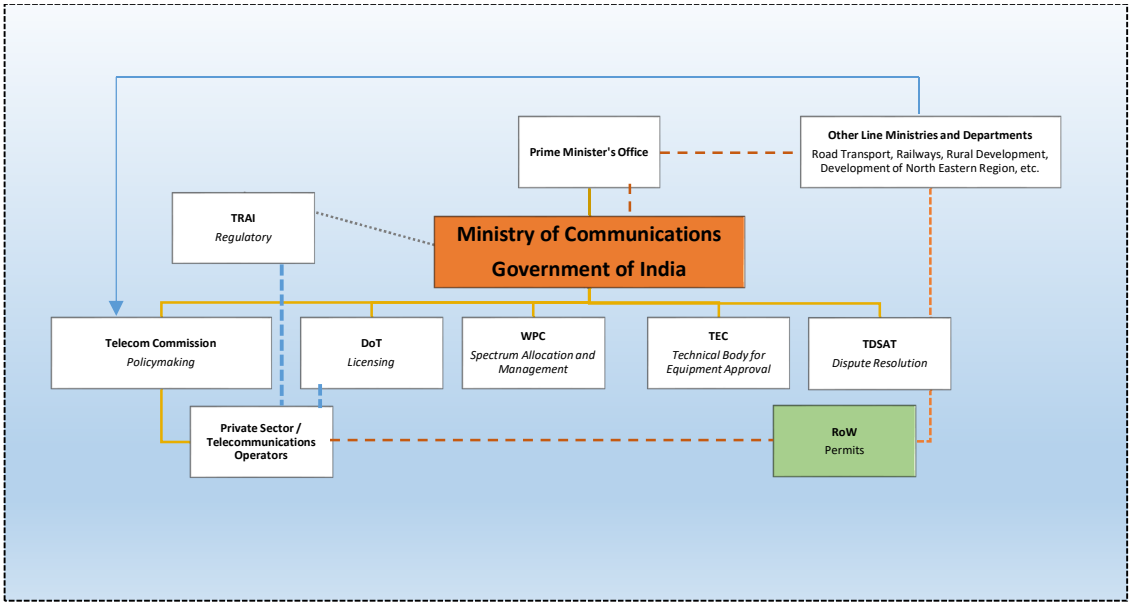
[104] India Infrastructure, *Report of the 3rd Annual Conference on OFC Networks in India* (New Delhi, 2014).

their existing co-deployed FOC data networks and make future expansions more cost-effective.

Based on extensive discussions with officials of concerned ministries, departments, public utilities, regulatory bodies and private sector organizations during this study, a coordination structure has emerged to support FOC co-deployment in India (see Figure 6) and Bangladesh (see Figure 7).

4.2.1 India

Figure 6: Coordination structure for fibre-optic co-deployment in India



Source: Author based on available information and responses received for this study.

In India, the Telecom Commission is an inter-ministerial high-level government body headed by DoT's Secretary. The Telecom Commission is delegated to deal with policy formulation, licensing and coordination matters relating to all aspects of the telecommunications sector in the country, and also addresses international cooperation in the area of telecommunications. Furthermore, the Telecom Commission facilitates standardization, research and development, as well promote private investment in the sector.

The DoT acts as the executive arm of the central government, and is responsible for licensing and regulatory matters. It takes the lead in promoting international cooperation relating to telecommunications, and interacting with organizations such as the International Telecommunication Union and the International Telecommunications Satellite Organization.

To ensure a level playing field for all the telecommunications operators, TRAI, an independent regulator, provides a fair and transparent policy environment, and facilitates competition

among various telecommunications players. TRAI also has the authority to decide tariffs for telecommunications services. TRAI interacts with DoT in policy matters through its recommendations on various critical issues.

The Telecom Disputes Settlement and Appellate Tribunal (TDSAT) acts as a dispute resolution platform for the operators, licensees, DoT, service providers and customers. The Wireless Planning and Coordination Wing (WPC) is responsible for spectrum management, including licensing of wireless stations. The Telecommunication Engineering Centre (TEC) is a technical body representing the interest of DoT, and prepares specifications and common standards for telecommunications network equipment, services and interoperability.

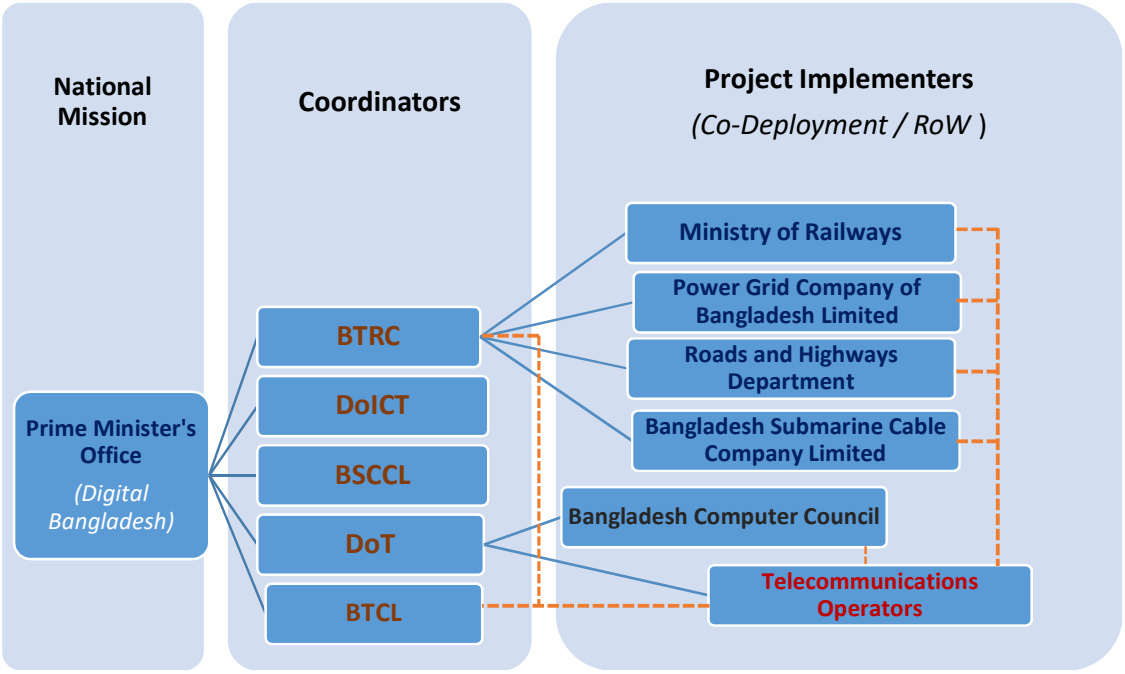
It is within this structure that all telecommunications activities, including FOC co-deployment are rolled out. Once a licence is issued to the telecommunications operator, it proceeds to interact with other departments and ministries for RoW permits and enter into partnerships to implement telecommunications projects. For example, the BharatNet Project implementers have been working closely with the Ministry of Road Transport and Highways on the granting of RoW permits for FOC deployment. Above all, the Prime Minister's Office provides policy directions in line with the Digital India initiative, and facilitates coordination among line ministries.[105]

4.2.2 Bangladesh

In Bangladesh, the regulator, BTRC, plays a central role in issuing licences, monitoring compliances and tariffs, and coordinating major FOC deployment activities among telecommunications operators and service providers. It is an independent commission that is responsible for regulating all matters related to telecommunications (wire, cellular, satellite and cable). A few other government and private actors were identified during the study based on the responses received from various ministries involved in FOC co-deployment within the country. However, in the absence of any official authorizations or delegation of power, they form a tentative part of the coordination structure that takes a lead role in FOC co-deployment initiatives in Bangladesh.

[105] Nivedita Mookerji, "The most powerful PMO in India's history", *The Business Standard,* 10 October 2017.

Figure 7: Coordination structure for fibre-optic co-deployment in Bangladesh



Source: Author based on available information and responses received for this study.

The Digital Bangladesh initiative spearheaded by the Prime Minister of Bangladesh is the prime mover of FOC deployment in the country. The five major coordinators of the nationwide FOC network are: BTRC, Department of ICT, BSCCL, Department of Telecommunication and BTCL. Placed in the next stage are the various project implementers, line ministries and public utilities that are key players in deploying FOCs, such as Bangladesh Railway of the Ministry of Railways, Power Grid Company of Bangladesh Limited and Bangladesh Computer Council. The RHD facilitates RoW permissions.

Other major actors that play an important role in FOC deployment are the government and private sector telecommunications operators. They include: BTCL, NovoCom Limited, One Asia AHLJV, BD Link Communication Limited, Mango Teleservices Limited, Summit Communication Limited and Fibre@Home Limited that are licensed by BTRC and are at various stages of implementing different FOC expansion projects.

5. Public-Private Partnerships

5.1 India

Due partly to a perceived fear that infrastructure sharing would harm the competitive advantage of telecommunications operators by impacting their market share in an aggressive business environment, PPP models are yet to gain prominence in the co-deployment of FOCs in both India and Bangladesh.

TRAI, however, is of the opinion that infrastructure sharing would not damage the sector's competitive landscape; rather, it would contribute to the success of infrastructure projects. TRAI is piloting a Common Duct Policy in the state of Jharkhand. Once successful, it is envisaged that the policy will be replicated in other parts of the country. This policy includes a clear denial to any operator to excavate a road for the next twenty years, and only allows TSPs to lay fibre or infrastructure through this common duct system (see Box 1).[106]

[106] Muntazir Abbas, "Infrastructure sharing won't dilute competition: RS Sharma", *The Economic Times*, 25 April 2017. Available at https://telecom.economictimes.indiatimes.com/news/infrastructure-sharing-wont-dilute-competition-rs-sharma/58358110.

Box 1: Common Duct Pilot Project in India

The Telecom Regulatory Authority of India (TRAI) is experimenting with duct sharing in the Deoghar District of Jharkhand. In this pilot initiative, the ICT infrastructure is shared among telecommunications service providers, and the owner of the infrastructure (the local government) can earn revenue from the infrastructure.

As part of this initiative, TRAI has developed a Common Duct Policy, which seeks to provide a time and cost effective model for telecommunications companies to lay fibre-optic cables in cities. Based on this policy, a common duct system will be built using the public-private partnership structure. The ducts are then made available to any telecommunications service providers, for a fee paid as rent to the local government.

Based on this policy, all major roads leading to marketplaces, offices, educational and health institutes will be ducted. The local government will then be able to lease out micro-ducts to telecommunications service providers for their cables. The owner of the duct infrastructure (the local government) will be responsible for its maintenance.

This initiative will not only save costs and bring revenue to the local government, it will also ensure that roads will not be dug repeatedly, which will be a big relief for the people. Furthermore, telecommunications service provider will not need to secure right of way permission from the Ministry of Road and Highways, thus saving significant time.

TRAI has partnered with the Jharkhand government in this initiative, and based on its success, the model will be replicated in other parts of the country.

Source: The Sunday Guardian, 8 April 2017.

The difficulties that individual operators face in obtaining RoW permissions from multiple authorities are making the common duct approach highlighted in Box 1 an attractive alternative and a win-win solution to the problem.

Early in 2016, TRAI recommended the application of PPP models for the roll out of the BharatNet Project, which was delayed due to various operational challenges.[107] According to TRAI, the preferred options for FOC deployment would be the Build-Operate-Transfer (BOT) and the Build-Own-Operate-Transfer (BOOT) models. In BOT, the private sector (concessionaire) deploys the FOCs and returns it to the government. In BOOT, the private entities deploy the FOCs and other network infrastructure, own it for an extended time period through a lease, and operate the network during the period of contract. In return, they would be entitled to earn revenues from dark fibre and/or bandwidth (see Annex 3). TRAI proposed a contract period of 25 years, which could be further extended in blocks of 10, 20 or 30 years.[109]

[107] Yuthika Bhargava, "TRAI for PPP model for Bharat Net Project", *The Hindu*, 2 February 2016. Available at https://www.thehindu.com/business/trai-for-ppp-model-for-bharat-net-project/article8179848.ece.
[109] Ibid.

TRAI also recommended that private sector entities be selected through reverse bidding, and funding should be made available to cover the loss incurred due to higher operating expenses and lower commercial proceeds in remote areas.[111]

In addition, TRAI suggested the following considerations when applying PPP models for FOC deployment:

- The central and state governments should become the anchor clients of the BharatNet Project to purchase minimum bandwidth of 100 Mbps at market rate.
- To ensure that the concessionaire does not discriminate between different service providers when granting access to FOCs, arm's length relationship between concessionaire and service providers should be maintained by reserving 50 per cent of the FOCs for telecommunications and cable service providers.
- The government should become a minority partner of the concessionaire with a 26 per cent stake as it will lower the cost of obtaining finances for the project, as well as solve the risks associated with windfall profits.

India recognizes that to achieve the vision of Digital India, high-speed connectivity is essential as digital disparities among people and places can widen inequalities between the rich and the poor. According to industry reports, India is projected to have 526 million Internet users and over 1.5 billion connected devices by the end of 2018. This not only brings the nation closer to achieving the goals of Digital India, it also opens up huge opportunities for the private sector to collaborate with the government in offering more technology-based services to the end users.[112]

Through mutually beneficial partnerships, private sector players can bring in latest technologies and expertise, leveraging their experience in global operations. Professional project management, timely execution of projects and the scaling up of best practices, together with strong domain knowledge and financing capacities, are some of the reasons that the private sector is an important stakeholder in achieving the Digital India vision.

Over the years, governments have increasingly accepted the fact that PPPs bring in crucial value addition to digital service delivery initiatives. The fact that India has, at present, 46 ICT infrastructure development projects under PPP mode in 33 cities drives this point home.[113] In fact, according to the PPP Cell of the Department of Economic Affairs, there is a total of 1,534 infrastructure projects being implemented by the government based on the PPP model, at a total project cost of INR 134.91 trillion (USD 1,780 billion), as of 31 December 2017.[114]

Based on an estimate by Gartner, the Indian government's IT infrastructure spending that includes servers, storage and enterprise networking equipment, amounted to USD 2.2 billion

[111] Ibid.
[112] Puneet Gupta, "Public private partnerships for a Digital India", *The Financial Express*, 22 June 2015. Available at https://www.financialexpress.com/economy/public-private-partnerships-for-a-digital-india/88242/.
[113] Ibid.
[114] Department of Economic Affairs, Government of India, "Database of Infrastructure Projects in India". Available at https://www.pppinindia.gov.in/infrastructureindia/home.

in 2017.[115] This estimate includes spending by the government sector (including state governments and government agencies) on internal IT services (including personnel), hardware, software, external IT services and telecommunications.[116] Another report estimated that IT spending on Indian banking and securities firms grew by 11.7 per cent to reach USD 9.1 billion in 2017, driven by investments in the digital payments infrastructure.[117] Against such a growth projection, the PPP model could play a crucial role where the private sector could join hands with the government to set up the robust technology infrastructure required to support the roll out of various digital services in a geographically diverse country that poses serious challenges in covering the last mile.

A number of conducive policies to support PPP models have been put in place in India. The Ministry of Finance, for example, has enhanced financial support for projects in the infrastructure sector through the Viability Gap Funding Scheme. Under two flagship programmes in India – the Smart Cities Mission (for 100 smart cities) and the Atal Mission for Rejuvenation and Urban Transformation (for 500 cities) – it is expected that private sector participation will play a crucial role in these projects through partnerships with central and state governments, as well as local authorities. These two programmes have enormous potential to become a model for showcasing the efficacy of PPP in India. An industry report states the following:

> *Clearly we are at an inflection point, and the Digital India opportunity can help us leapfrog into the 21st century in terms of business and technology. One factor that will determine the success of this initiative will be private participation. Going by the intent and initial signs that have been demonstrated, that is not far from realization*.[118]

Another PPP entry point is the National e-Governance Plan of India that aims to provide affordable public services to all Indians, including those in remote villages. Under this plan, the government is making significant investments in the online delivery of services related to land management, taxes, driving licences and passports. Private sector involvement in the National e-Governance Plan includes developing infrastructure, delivering services in the form of mission mode projects and raising awareness. Partnerships with industry are also deemed crucial in the implementation of projects. The Banking and Insurance Central Mission Mode Projects, for instance, are implemented through industry partnerships. While core

[115] The Hindustan Times, "India's IT infrastructure spend to reach $2.2 bn in 2017, Gartner says", 4 May 2017. Available at https://www.hindustantimes.com/business-news/india-s-it-infrastructure-spend-to-reach-2-2-bn-in-2017-gartner-says/story-B23vHLInOpSAnpjOsBCPIN.html.
[116] Gartner, "Forecast: Enterprise IT Spending by Vertical Industry Market, Worldwide, 2012-2018, 3Q14 Update", 2014. Available at https://www.gartner.com/doc/2868719/forecast-enterprise-it-spending-vertical.
[117] The Economic Times, "IT spend by banks, security firms to cross $9 bn: Gartner", 13 November 2017. Available at https://economictimes.indiatimes.com/tech/ites/it-spend-by-banks-security-firms-to-cross-9-bn-gartner/articleshow/61626123.cms.
[118] Puneet Gupta, "Public private partnerships for a Digital India", *The Financial Express*, 22 June 2015. Available at https://www.financialexpress.com/economy/public-private-partnerships-for-a-digital-india/88242/.

application development takes place at the central level, application customization and roll out is carried out by the state governments through BOT and BOOT models.[119]

The Broadband India Forum has provided some suggestions on ways to make the BOOT model more attractive. For example, a long-term lease (at least 25-30 years instead of the proposed 10 years) should be permitted. The government should provide funding support (e.g., through the Viability Gap Funding Scheme) to make it commercially viable for the operator. Turnkey contracting in PPP mode should be considered whereby the FOC deployment project milestones are linked to payment and clearance of deployment. This could encourage parties to deliver in a timely manner and meet all pre-specified criteria within a budget. The Broadband India Forum further commented that: "very few companies can actually pay for the network due to perceived risks for such projects", but many interested parties will bid for the FOC deployment projects if the burden of ownership is removed.[121]

State-run BSNL in India has been negotiating with private telecommunications operators, such as Bharti Airtel and Reliance Jio Infocomm, on the sharing of its dark or unused FOCs in an attempt to double its revenue from network sharing to about INR 3,000 crore (USD 472.47 million) in 2017-2018. BSNL's collaboration strategy, initiated in 2015, generated about INR 1,500 crore (USD 236.26 million) in additional revenue in 2016-2017 through active and passive ICT infrastructure sharing with others, which included INR 1,000 crore (USD 157.49 million) from tower sharing alone. BSNL has the largest FOC-based network spread over nearly 700,000km throughout the country, and has offered its mobile infrastructure, FOCs, intra-circle roaming and bandwidth to private sector players. According to BSNL chairman, Anupam Shrivastava:

> *Time is ripe. Service providers are focusing on sharing infrastructure within themselves due to financial stress and are coming forward. BSNL will continue to play a role in resource sharing.*[125]

BSNL is strategically focusing on "coopetition"[126] to monetize its unused or underutilized resources and stay competitive in the present scenario. The major challenge that affects private players in FOC co-deployment is a perceived lack of suitable market in the rural areas, because: "merely laying down infrastructure without having an operator might not ultimately result in citizens in these *gram panchayats* receiving Internet connectivity".[127] Another example of cooperation in India is illustrated in Box 2.

---

[119] Ministry of Electronics and Information Technology, Government of India, "National e-Governance Plan". Available at http://meity.gov.in/divisions/national-e-governance-plan.

[121] Broadband India Forum, "Point-by-point response to questions relating to the TRAI Consultation Paper on Implementation Model for BharatNet", 16 December 2015.

[125] Muntazir Abbas, "BSNL in talks with Bharti Airtel, Reliance Jio for sharing dark fibre", *The Economic Times*, 10 August 2017. Available at https://telecom.economictimes.indiatimes.com/news/bsnl-in-talks-with-bharti-airtel-reliance-jio-for-sharing-dark-fibre-eyes-to-double-network-sharing-revenue/59991336.

[126] Coopetition (sometimes spelled "coopertition") is a neologism coined to describe cooperative competition. Coopetition is the act of cooperation between competing companies; businesses that engage in both competition and cooperation are said to be in coopetition.

[127] Pranav Mukul, "BharatNet project: Ground work ready, connectivity not so much", *The Indian Express*, 14 December 2016. Available at https://indianexpress.com/article/india/bharatnet-project-ground-work-ready-connectivity-not-so-much-4425953/.

Box 2: Railtel Partners with Cable TV Operators to Improve Rural Connectivity

In the state of Tamil Nadu, RailTel Corporation of India is partnering with local cable TV operators to cover the last mile for broadband connectivity in rural India. Through a revenue-sharing business model with the cable TV operators, RailTel will connect its fibre-optic network to cable TV cables to deliver high-speed Internet to homes. Under the arrangement, local operators will bear the cost of laying the last mile cables between RailTel's nearest point of presence and the end-user households. The cable TV operator will also provide the modem switch that separates TV signals from data traffic.

RailTel is eyeing other southern markets such as Karnataka, Andhra Pradesh and Kerala, where it has over 10,000km of fibre-optic cables. Its current product, RailWire, delivers Internet speeds ranging from 256 kbps to 10 Mbps to about 2,500 subscribers in 16 of the 32 districts in the state. Current tariffs are competitive and RailTel has already extended the service to other states like Kerala.

Source: Ryan Huang, ZDNet, 25 November 2013.

5.2 Bangladesh

A recent GSM Association report entitled, *Bangladesh: Driving mobile-enabled digital transformation*, stressed that by working closely with the government, the private sector can "unlock digital transformation for millions of Bangladeshis, as well as drive social and economic growth for the country".[128] The report identifies seven areas in which collaboration could accelerate impact, including closing digital access and gender gaps, increasing digital literacy, improving health outcomes and financial inclusion. It specifically talks about how the industry can provide applications and services that are vital to a digital society, beyond basic connectivity to include the following objectives:

- Providing affordable access to basic voice and data services to enable access to e-learning and online teaching networks, in order to increase digital literacy;

- Empowering women, making them more connected, safer, and able to access information, services and life-enhancing opportunities (such as health, financial services and employment opportunities);

- Improving health standards by enabling access to formal and informal health-related information via voice, SMS and apps, as well as facilitate access to a broader suite of digital health services, including remote patient monitoring, telemedicine, digital booking systems and drug stock management;

[128] GSM Association, *Bangladesh: Driving mobile-enabled digital transformation* (London, 2017). Available at https://www.gsmaintelligence.com/research/?file=e2f5981f5184fb3f389aa6c9d826f6c5&download.

- Improving agricultural productivity by providing access to nutritional information and effective agricultural practices, as well as connecting remote communities to digital agricultural marketplaces to increase price transparency and reduce volatility; and

- Expanding access to financial services through mobile money, by providing the unbanked with the financial services they need to manage cash flows and save.[129]

PPP is still a largely unexplored area in Bangladesh, according to the Road Transport and Highways Department. Bangladesh Railway has its own experience in FOC co-deployment, but it has expressed the view that in future, for extension of existing activities, PPP models may be considered. The Road Transport and Highways Department has worked with Grameenphone (Telenor Bangladesh), BTCL, Bangla Link, Teletalk, Airtel and Robi, and the Ministry of Railways has earlier involved Grameenphone in laying and replacing FOCs along the railway route.

Despite some major challenges that Bangladesh faces, including population growth, poverty, inequality, natural disasters and climate change, the country has made significant progress over the past few years, and appears to be on the right track towards reaching the goals set out in its Vision 2021. While the PPP model is a viable solution in rolling out the ICT infrastructure and services, it has not been easy working out an ideal win-win solution that suits both government and industry players. This is because factors such as technical feasibility, basic physical infrastructure and standardization, old laws and policies make the partnership-building process challenging.

Nevertheless, in both countries, a cross-section of stakeholders has emphasized the importance of collaboration and partnership between governments and the private sector in delivering digital services and bridging the digital divide. Considering the huge area and diverse population that governments need to serve, PPP models may be the key to the success of the country's digitization initiatives. Private sector participation can fill gaps and offer services, applications and technologies using the basic ICT infrastructure created by the governments. At the same time, the private sector is given the opportunity to access a huge customer base that comes with the nationwide networks created by the governments.

New economic models, policies and frameworks are being put in place in both countries to create an enabling environment for PPPs. With the conducive environments, new models of PPPs are expected to bring together the government, industry and citizens on a mutually beneficial agenda where each of them will leverage the combined resources of the nations in terms of ICT infrastructure, expertise and technologies. For the success of Digital India and Digital Bangladesh, new governance models, revenue-sharing systems, regulatory mechanisms and legal frameworks will need to be developed to support PPPs and enable government and the industry to replicate and scale up pilot PPP initiatives in the region.[130]

[129] Ibid.

[130] In conversation with Shri N. Sivasailam, Additional Secretary, DoT, Government of India.

At the same time, there is a need to take adequate precautions to minimize the risk of PPP failures by learning from past unsuccessful PPP ventures. Other precautions include: conducting realistic and comprehensive feasibility studies, limiting aggressive bidding, minimizing protracted disputes, providing conflict resolution mechanisms, and avoiding ambiguous risk allocation and ambiguous tariff adjustment guidelines.[131] According to a Deloitte report, the BOOT model runs the risk of monopoly during the implementation of the project by way of vertical integration between telecommunications company, equipment provider and a managed services provider. It is suggested that in the BOOT model, the demand generation for these services be built in.[132]

[131] Pranav Mukul, "BharatNet project: Ground work ready, connectivity not so much", *The Indian Express*, 14 December 2016. Available at https://indianexpress.com/article/india/bharatnet-project-ground-work-ready-connectivity-not-so-much-4425953/.

[132] Deloitte, *Broadband Infrastructure for Transforming India* (2016). Available at https://www2.deloitte.com/content/dam/Deloitte/in/Documents/technology-media-telecommunications/in-tmt-broadband-infrastructure-for-transforming-india-noexp.pdf.

6. Resilience of Fibre-Optic Networks

The resilience of the FOC network is the ability of the system to both absorb shock as well as recover rapidly from a disruption so that it can return to its original service delivery levels or close to it. In the aftermath of natural disasters or man-made disruptions (e.g., accidental damage to FOCs caused by excavation or drilling), infrastructure resilience is a major concern. In other words, "resilience" is the FOC infrastructure's ability to continue to function normally in spite of some subsystem and component failures. To attain such resilience, it requires a balanced approach utilizing design, elimination of single-failure points, redundancy equipment and regular maintenance. In the post-installation phase, it is important to put in place a consistent maintenance schedule to keep FOC equipment at optimum operating levels.

Network redundancy contributes to its resilience. Redundancy is a link backup service against the failure of a primary link/unit in the FOC network, and is insurance against a primary unit failure. While a single link or port failure can cause downtime leading to loss of connectivity, a redundant link backup service guarantees minimal impact on the users when there are unexpected broadband outages.

However, designing a resilient network is more than just adding redundancy.[133] Depending on the end users' needs, a minimum level of redundancy is required to create a resilient FOC network. As the FOC network is increasingly becoming the critical infrastructure for voice and video communications that are crucial for government, public and private users, a redundant system will invariably need multiple channels to provide alternate paths for communications in case of a particular link failure. Besides redundancy, a resilient network needs to be able to adapt to link failures and resume normal operations when the failure has been resolved.

Stakeholders in India and Bangladesh have indicated that there is sufficient resilience in their FOC networks. RailTel in India provides dedicated and uncompressed Internet leased line services to enterprise sector and various academic institutes. It has high uptime assurance with industry-standard service level agreements, and redundancy in network connectivity. It ensures that system resilience is built as part of its network solution. In addition, RailTel is linked to international gateways in Mumbai and Chennai for assuring traffic routing at Trans-Atlantic and Trans-Pacific paths.[134] The RailWire platform that is used to extend connectivity to remote villages in Kerala has high resiliency and redundancy features to provide high uptime and network quality parameters in line with industry practices.[135]

BSNL signed an agreement with PGCIL in 2014 (effective for a period of 10 years), to improve connectivity in the north-eastern region, including Sikkim. The agreement envisaged provisioning of bandwidth on FOCs laid over the high tension electric transmission network of PGCIL. As many as 34 links comprising of multiple 10 Gbps capacity telecommunications

[133] Terry Slattery, "Network Redundancy or Resilience?" *No Jitter*, 25 March 2013. Available at https://www.nojitter.com/post/240151667/network-redundancy-or-resilience.
[134] G. Chinthan, "Railwire Leased Line Providers in Chennai", 11 February 2017. Available at http://www.spotonlive.in/2017/02/leased-line-providers-in-chennai.html.
[135] Aegis Knowledge Trust, "RailTel Corporation of India – Digital India winner 2015", 12 February 2016. Available at http://bellaward.com/railtel-corporation-of-india-digital-india-winner-2015/.

circuits were commissioned to provide redundancy to the existing underground FOC network of BSNL.[136] BSNL is adopting passive optical network technology that is emerging as the next generation of broadband access technology. Passive optical network enables high bandwidth and high reliability with fibre redundancy up to the customer premises.[137]

It is interesting to note that India and Bangladesh have both experienced no major cables and communications disruption due to natural disasters in the past five years, despite their high susceptibility to natural hazards.[138] Bangladesh's Department of Telecommunication has put in place FOC disruption mitigation mechanism by deploying redundant FOC systems. The private player, Fibre@Home Limited, has completed its fourth-year roll-out obligation by extending its FOC network across the country. Fibre@Home cites protection path and redundancy as their "most competitive advantage" as it has created its transmission network with ring topology[139] to offer better redundancy and failover options even if any portion of its FOC backbone is damaged.[140]

With regards to mechanisms and measures to reduce any disruptions and enhance the resilience of FOC systems, the Government of Bangladesh's RHD is planning to set permanent utility ducts in major road networks so that they will remain uninterrupted during any development or maintenance of roads. Similarly, Bangladesh Railway has laid all FOCs under the ground at a depth of more than one metre from the surface using high-density polyethylene ducts. As for most bridges, the FOCs are laid under the river bed by horizontal direct drilling. There are handholes after every 500m for maintenance activities. Due to these measures, the FOCs are reported to be almost free from any natural disruption and inference, which has enhanced the resilience of the FOC system.[141]

[136] BSNL, "News Update", 3 June 2014. Available at http://www.bsnl.co.in.
[137] BSNL, "EPON & GPON", 16 March 2011. Available at http://bsnlexam.ucoz.com/.
[138] Responses received from Indian and Bangladeshi officials/stakeholders to the questionnaire survey circulated during this study.
[139] A ring network is a network topology in which each node connects to exactly two other nodes, forming a single continuous pathway for signals through each node – a ring. Data travels from node to node, with each node along the way handling every packet.
[140] Fibre@Home Limited, "Connecting our future with light: Company profile". Available at https://basis.org.bd/profile/74550bc15fe461dce5034147ab450693.pdf.
[141] Responses received from Bangladesh Railway to the questionnaire survey circulated during this study.

Annex 1

Questionnaire Developed by the ESCAP Secretariat for the Study

Q1: Has co-deployment of fibre-optic cables been done along the Highway/Railway? (Skip to Q2 if the co-deployment has not been done)
If it has been done, please provide details of route, length of the route (in km), and the total amount for the co-deployment
……
……

Q2: Are there any plans for the co-deployment of fibre-optic cables along the Highway/Railway?
If it is planned, please provide details of route, length of the route (in km), and the total budget for the co-deployment
……
……

Q3: Is there any policy/regulation/legislation governing the co-deployment?
……
……

Q4: Which ministry/government office/national institute is involved in the co-deployment?
……
……

Q5: Is it implemented/planned to be implemented under public-private partnerships?
……
……

Q6: Which telecom operator/private company is involved in the co-deployment?
……
……

Q7: Are you aware of any cables and communications disrupted by natural disasters in the past five years?
……
……

Q8: What are the mechanisms and measures you are implementing or planning to implement to reduce such disruptions and enhance resilience of fibre-optic cable systems?
……
……

Q9: In your opinion, what are the technological, policy, legislative, legal and regulatory challenges and opportunities in promoting co-deployment and resilience of broadband networks?
……
……

Q10: If there is cross-border (between countries) co-deployment, please specify details below:

1) Who is the main coordinator (please specify name of the coordinating ministry/authority)
   ……
   ……

2) What is the coordination structure (Names of ministries/authorities/telecom operators/local authorities who are involved in the co-deployment; Where possible, specify the coordination organograms/coordination mechanism/communications layer
   ……
   ……

3) If there is an agreement among all parties, specify the agreement and its process (how it came to such agreement)
   ……
   ……

4) Relevant details on right-of-way or open access (if applicable)
   ……
   ……

5) Relevant details on cost saving or revenue sharing for cross-border co-deployment
   ……
   ……

Q11: Other relevant details
……
……

Annex 2

List of Stakeholders Consulted

(Ministries, Departments, Public Utilities and Private Sector Companies)[142]

INDIA

Shri N Sivasailam, IAS
Special Secretary to the Government of India
Department of Telecommunications
Ministry of Communications
Sanchar Bhawan, New Delhi 110001

Shri Amit Kumar Ghosh, IAS
Joint Secretary to the Government of India
Ministry of Road Transport and Highways
Transport Bhawan, New Delhi 110001

Shri A D James
Deputy Secretary to the Government of India
Ministry of Road Transport and Highways
Transport Bhawan, New Delhi 110001

Shri Anshul Gupta
Executive Director, Telecom Development
Railway Board
Ministry of Railways
Government of India &
Director (Network Planning and Marketing)
RailTel Corporation of India Limited
Rail Bhawan, New Delhi 110001

Shri Sanjai Kumar
Group General Manager (Projects)
RailTel Corporation of India Limited
(A Government of India Undertaking)
CO: 143, Institutional Area, Sector-44
Gurugram 122003 National Capital Region

Shri Osama Manzar
Founder
Digital Empowerment Foundation
New Delhi 110016

[142] Besides the government officials and organization representatives listed, ten major telecommunications service providers (seven in India and three in Bangladesh) were informally consulted using this study's standard questionnaire survey as a guide.

Sri Danish Aziz
Devproquo ICT4D
New Delhi 1100013

Adv Sarwar Raza
Managing Partner
Telecom Laws and Regulations
Legislegal, New Delhi 110065

Shri Kamal K Mukherjee
Acumen eGovernment and ICT4D Research
Gurugram, National Capital Region, India

Er Sarbesh Kumar
Bharat Sanchar Nigam Limited
Kashipur 244713 Uttarakhand India

Er Shishir Srivastava
Uttarakhand Power Corporation Limited
Dehradun 248001, Uttarakhand

BANGLADESH

Ms Maliha Nargis
Additional Director General (Joint Secretary)
Department of Information and Communication Technology
Government of Bangladesh
Agargaon, Dhaka 1207

Colonel Md Mustafa Kamal
Director General, Engineering and Operations Division
Bangladesh Telecommunication Regulatory Commission
IEB Bhaban, Ramna, Dhaka 1000

Mr Md Rafiqul Islam
Joint Secretary
Ministry of Railways
Government of Bangladesh
Abdul Gani Road
Railbhaban, Dhaka 1000

Mr Iqbal Mahmud
Joint Secretary
Posts and Telecommunications Division
Government of Bangladesh
New Motijheel, Dhaka

Mr Abu Ayuhal Md. Moyashir
Additional Director General (Technical)
Department of Telecommunication
Government of Bangladesh
Tejgaon Industrial Area, Dhaka 1208

Mr Nasir Uddin Ahmed
Chief Signal and Telecommunication Engineer (Telecom)
Bangladesh Railway
Government of Bangladesh
Abdul Gani Road
Railbhaban, Dhaka 1000

Mr Mohammod Abul Hashem
Deputy Director (Planning and Development)
Department of Information and Communication Technology
Government of Bangladesh
Agargaon, Dhaka 1207

Mr Mohammad Bulbul Hossain
Executive Engineer (CC)
Roads and Highways Department
Government of Bangladesh
Sarak Bhaban, Tejgaon, Dhaka 1208

Annex 3

PPP Model for BharatNet Project

The Telecom Regulatory Authority of India (TRAI) issued a consultation paper on the implementation model of BharatNet in November 2015. In the consultation paper, TRAI's build-own-operate-transfer (BOOT) model was suggested as an alternative and stakeholders were asked to provide their comment. After considering the comments from stakeholders, TRAI made the following recommendations:

- ✓ Develop a public-private partnership that aligns private incentives with long-term service delivery in the vein of the build-own-operate-transfer/build-operate-transfer models.
- ✓ Broaden the work of the private sector company or concessionaire to include deployment and implementation of fibre-optic cables, as well as network operation for the duration of the concession period.
- ✓ Extend the concession period to 25 years, which can then be further extended in blocks of 10, 20 or 30 years.
- ✓ Select concessionaires through a reverse-bidding process to determine minimum viability gap funding (VGF) sought for the concession. The area of implementation may be analogous with the licensed service areas of the state/union territory. The use of the reverse-bid process to determine the lowest VGF sought can ensure the amount of support from public funds.
- ✓ Ensure that the concessionaires provide access to all service providers in a non-discriminatory and transparent manner. Such competition is essential given that all manner of the content will be delivered on the network.
- ✓ Ensure that central and state governments become minority partners of the concessionaire with 26 per cent stake, as it can lower the perceived risks and cost of obtaining private finances for the project. In addition, this can help the government check monopolistic behaviour on the part of the concessionaire.

Source: The Communications Today, February 2016.