Report of the Committee on National Optical Fibre Network (NOFN)

Dated March 31, 2015

Foreword

The Digital Era has opened up exciting possibilities for India. We have long been bedevilled by various divides: between rich and poor, city and village, literate and illiterate, besides larger socio-cultural ones. Much has been written about the digital divide: a new societal schism between those who possess digital devices and have the capability of using them and, on the other hand, those who do not. In fact, one can use the technology to serve as a digital bridge, an enabler that not only obviates any digital divide, but helps to reduce many of the other disparities in society.

Digital India is an exciting, visionary and audacious program to do just that. Through various specific projects linked to financial inclusion, e-governance and citizen services, it can truly transform India. With almost a billion mobile phones assuring unprecedented reach, the telecommunication revolution and Aadhar provide the means to implement many of these services. However, underlying this has to be the network – the very foundation – which provides the required connectivity. It is this basic infrastructure that the National Optical Fibre Network (NOFN) aims to provide.

Traditionally, railways and highways have carried goods and been facilitators of economic activity. Today, i-ways are the new highways. Information ways that help move ideas, information, services, economic transactions and social interactions, have become the carriers and catalysts of development. Broadband connectivity can carry vital content – education, health services, market intelligence, agricultural information, etc. – that can transform communities.

Imagine, for example, a young student in a remote village being able to hear, see and interact with the best teacher; the learning enhanced by animation, slow-motion or real-life video footage. Think of super-specialists studying, online, a villager's health parameters and providing advice to the patient located in a remote corner of the country. Or a farmer getting up-to-date information on crop prices and weather, and agricultural advice in real time. Visualise skills training being provided in-situ to youth anywhere in the country, or of rural craftspeople being able to sell their creations to customers anywhere in the globe through their website and e-commerce platforms. Imagine reaching institutions and individuals in every Gram Panchayat in the country (and, by extension, every village and villager) with high-speed connectivity.

These dreams, and much more, can become reality with the aid of a nation-wide broadband network. BharatNet – the newer, updated and upgraded version of NOFN – will provide this base. We must create a network that can be used - and that is used - by each and every citizen, in every part of the country. BharatNet is an infrastructure to unite Bharat and India together.

The objective of achieving 175 million broadband connections by the year 2017 and 600 million by the year 2020 at a minimum of 2 Mbps download speed and making available higher speeds of at least 100 Mbps on demand is dependent on the success of the National Optical Fibre Network (NOFN). The original project report on NOFN prepared by Telecommunications Consultants India Limited (TCIL) in 2011 estimated a uniform broadband speed of 100 Mbps across all Gram Panchayats in the country. However, the growing demand for data and the proliferation of video – for both, utility and entertainment purposes – as also the booming digital economy point to the need for higher broadband capacities in the country. The increasing dependence on digital networks and the ambitious vision of Digital India necessitates reliable, secure and fast connectivity across the length and breadth of the country.

It is these considerations of the enhanced role and needs of a nation-wide broadband network that have prompted the committee to re-examine the original architecture, capacity, reliability and design of NOFN and to evolve this into the proposed BharatNet. This will be a robust, future-orientated network, with built-in possibilities of capacity enhancement. Importantly, the report also discusses and makes recommendations on the migration path from NOFN (and its present status/commitments) to the

revised architecture. The crucial task of planning and managing the project so that it delivers within time and cost targets is also addressed in detail.

Over the last few years, the NOFN project has fallen far behind its planned schedule. The committee has analysed the causes in some detail, and interacted with those concerned to try and understand the reasons for the delays. Based on this, the report makes specific recommendations regarding alternative models of implementation, taking into account the diversity of the country, the varying contexts, and the differing capabilities of various States in this field. It has also kept in mind the need to tap the expertise of the private sector.

The overall planning of such a complex and large project is not an easy task. Taking note of the experience and difficulties encountered so far, the report has made specific recommendations regarding the organisation structure and management of the project, and the roles of various entities. The report also integrates disparate efforts for connectivity across Departments of Government – National Information Infrastructure, Government User Network, improvements in State Wide Area Networks, for example - who have each tried to fill in a piece of the jigsaw without the larger puzzle being visualised. The totality of the exercise contemplated can be conceivably designed to operate in the mission mode. These considerations have prompted the committee to suggest a high-level mechanism for promoting a joint Centre-State thrust for this project, in keeping with the spirit of cooperative federalism. BharatNet has been conceived uniting the tremendous capacities of the Centre, the State and the private sector collaborating to deliver the dream of Digital India.

At the operational level, it has recognized the need for greater flexibility and autonomy for BBNL and the requirement of considerably enhancing its human resource base. It has also noted that quick decision-making is critical for efficient implementation of the project. To this end, it recommends the creation of an Empowered Project Group. If the committee were to be asked as to the single most important factor for the success of BharatNet, we would have no hesitation in pointing to the importance of leadership, in Government that understands the need to provide flexibility and autonomy to BBNL, and in BBNL, leadership that appreciates the need to keep the trust that the Government and the people of India ask from it.

Digital India is the visionary plan for the future; BharatNet is the vehicle for attainment of this vision. As we went about our task, our realization grew that NOFN, in its present form, cannot work. To this extent, the appointment of this committee to review NOFN has been timely. The report of the Committee is now before the Government. What is now required in the interest of this visionary project, are fast decisions to fundamentally alter the direction of NOFN. We cannot afford to lose any more time or proceed in phases. All resources and energies would have to be mobilized so that all Gram Panchayats are reached in the shortest possible time. Only then would Digital India, and through it the countryside prosper. As we conclude our task, the Committee hopes that the Government gives due consideration to what we have tried to put together.

J.Satyanarayana

Kiran Karnik

S.Sadagopan

A.K Bhargava

Som Mittal

Tapan Ray

Aruna Sundararajan

Rajat Moona

V.Umashankar

Acknowledgement

The Committee to review the National Optical Fibre Network (NOFN) in the context of Digital India was constituted on January 14, 2015. The last two months have been a journey in three dimensions – a walk into the past and a dream of the future and both coalescing into the deliberations of the present. Many have assisted us in this journey and the Committee has been benefited by the experiences shared by its fellow travellers.

Many thanks goes out to those whose thoughtful advise, hard work into putting together and analysing data, writing papers and sharing ideas made the journey for the Committee that much simpler. They include Ashish Sharma, Neel Ratan, Naveen Xavier, Vishal Sharma, R.S Mani, Neelaksh Sharma, Vishal Puri, K.Lalitesh. The Committee expresses its gratitude to them for all their selfless efforts in dedication of a national cause.

Many thanks also go out to P.K Agarwal of BBNL and his team Tejpal, Rajni Taneja, M.K. Chauhan; A.N Rai, R.K Singh, Ranjan Ghosh, R.R Yadava and other officers of BSNL, Dr Sethuraman and Vivek Singh of ISRO, officers of Central Government Ministries and State Governments, RailTel, Power Grid, C-DoT and others - who helped out with their thoughts, data and ideas for the Committee to mull over. Many thanks also to officers of telecom service providers, multi-system operators, satellite operators, internet service providers, engineering construction companies, equipment manufacturers, COAI, AUSPI, ISPAI, R.K Mishra, N.Chidambaram and many others who participated enthusiastically in the consultations, many at short notices, and gave their views to the Committee. The voluminous record of consultations demonstrates the keen interest that many showed for transforming the project of today into the vision of tomorrow.

Last but most certainly amongst all else, the Committee expresses its thanks to Deepak Sharma and Jitendra Garg of BBNL who were seconded to the Committee and helped it in many ways that made its functioning smoother. Without them, the Committee may not have been able to complete the journey that started two months ago in the time that it did.

Digital India is the dream that many in India share. The report outlines a path to realising this dream. It may not be the only path, but that we in our wisdom thought best to recommend. We complete our task but the journey is still on.

Dated: March 31, 2015.

Contents

Summary of Recommendations

CHAPTER - 1

Beyond NOFN to Digital India: A case for BharatNet

1) The Committee recommends that the project may be renamed as BharatNet to reflect the national aspiration through the vision articulated below:
"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 realise the vision of Digital India, in partnership with States and the private sector." **(para 1.19)**

CHAPTER 2

Estimating Bandwidth and Sizing Infrastructure for BharatNet

2) The Committee has recommended
   (i) the objectives of the sizing exercise **(para 2.05)**
   (ii) the principles to be adopted for bandwidth estimation **(para 2.07 to 2.13)**
   (iii) the guidelines for sizing of ducts, fibre and electronics **(para 2.15 to 2.16)**
3) The Committee recommends that degrees of freedom be given to the States adopting the State-led Implementation model described in Chapter 4 in the following areas:
   (i) to determine the minimum aspired per capita bandwidth for households and businesses
   (ii) to include urban areas and business users in the coverage and
   (iii) to design the demand estimation matrix suited to their State.
   However, the funding commitment of the Central Government may be limited to the base network design that is suggested across all States. **(para 2.17)**
4) The Committee recommends that the key guiding principles for alternative media options other than optical fibre are low bandwidth requirements based on Household (HH) density (500 or less HH) at GP level and high fibre laying Block to GP distance of over 7.5 km. Certain States and regions where difficult terrain inhibits both fibre and radio for connectivity would need to be covered through satellite media. **(para 2.20)**
5) The Committee recommends that in areas where HH density is less than 150 HHs and where the distance of the GP from the Block HQs is over 10 kms, satellite media be used to provide broadband at the GP level. **(para 2.22)**
6) The Committee recommends estimates that around 20,000 GPs would need to be connected over Radio and around 3000 GPs over Satellite media. In the remaining 57,000 GPs out of the 34%, the Committee has assumed that bandwidth capacity may be provided through optical fibre media in linear architecture. In GPs linked on linear topology and located along border areas, redundant provisioning may be considered using radio or satellite media for strategic purposes. **(para 2.23)**
7) The Committee recommends that provision of horizontal connectivity at the DHQ, BHQ and GP level which involves laying of optical fibre should be considered as an inherent component of BharatNet. The Committee recommends the number of horizontal connectivity as 25 at each DHQ, 10 at each BHQ and 3 at each GP (including at GP termination point) for Government institutions under BharatNet. **(para 2.25 to 2.27)**

CHAPTER 3

Architecture, Planning and Technology Choice

8) The Committee identified certain guiding principles before proceeding to make choices on architecture and technology. The Committee recommends that these guiding principles should inform the exercise of choice on architecture and technology on examination of possible alternatives. **(para 3.06)**

9) The Committee recommends that DHQs to BHQs connectivity should also be factored in the project architecture, though it would mean higher project investment outlay, in order to ensure that the investment would be gainfully utilised in kick-starting a broadband eco-system in rural areas and not be limited to Government services provisioning alone. The Committee also recommends that ring architecture for the DHQ to BHQ connectivity layer is an absolute must as this layer aggregates traffic across Blocks. **(para 3.12)**

10) The Committee recommends that fresh optical fibre cable be laid from BHQ to GPs for acceptable quality and greater reliability for which the average length per GP has been estimated at 4 km. **(para 3.16 & 3.17)**

11) The Committee considered the possibilities of middle mile connectivity using radio spectrum instead of optical fibre. The Committee recommends that both licensed and unlicensed band radios may be considered depending upon the surveys, ground realities of terrain and line of sight (LOS) requirements while deploying same. **(para 3.20)**

12) The Committee estimates that in about 20,000 GPs (8% of all GPs), the reach to these GPs would be through radio spectrum. The capital investment for reaching 15,000 GPs through licensed band radio spectrum (assuming single hops) is Rs 3000 crore. On the other hand, if unlicensed band radio spectrum is used for connectivity, the capital cost would be Rs 200 crore. The Committee understands that microwave spectrum is allocated administratively and regulatory compliances have to be completed before BBNL is able to provide services using licensed band radio spectrum. **(para 3.21)**

13) The Committee recommends that in areas where the distance of the GP from the Block HQs is over 10 kms, satellite media may be used to provide broadband at the GP level Indian Space Research Organisation (ISRO) indicates that availability of satellites may limit the availability of satellite media for high speed broadband. The Committee has estimated the total cost for connecting 3000 GPs with satellite media would be Rs 162 crore. Additionally, the recurring expenditure in terms of satellite transponder (space bandwidth charges) would need to be paid. The Committee recommends that Department of Telecommunications and Department of Space would need to jointly work out a mechanism so that these charges are moderated. The other operations and maintenance charges also needs to be considered. **(para 3.26)**

14) The Committee accepts the findings of the single district survey results to postulate that the ring topology to 66% of GPs may be attempted for which it is assuming an additional cost of 25% of the capital investment estimated for BHQ to GP connectivity on linear topology as per the GIS-based survey conducted by BBNL. Therefore, the Committee recommends that GPs for which fibre has been laid in Phase-I may be re-planned from the view-point of ring topology and additional fibre, if required, may be laid for achieving fibre rings. **(para 3.27)**

15) The Committee refrains from making any recommendations on last mile connectivity except in respect of Government services. **(para 3.28)**

16) The Committee recommends that where overhead fibre cable is to be laid preferably on electricity

poles, suitable arrangements for right-of-way over electricity poles will have to be arranged between the Department of Telecommunications and BBNL with State Governments and State Electricity Utilities. **(para 3.30)**

17) The Committee recommends that the institutions that need to be connected through optical fibre at the three levels must be specifically identified and limited to those institutions where speed and reliability are of essence. If other Government institutions desire to connect to the PoP at the District, Block or G.P through optical fibre, they may be permitted by BBNL on payment of capital cost for laying fibre. The cost estimates for horizontal connectivity are given in Table 3.4. **(para 3.31)**

18) The Committee's recommendations on fibre parameters are in Table 3.5. **(para 3.33)**

19) The Committee recommends that IP/MPLS as the technology of choice for DHQ-BHQ layer which would assist in creating a services oriented network. The comparative technology options are indicated in Table 3.7. **(para 3.44)**

20) The Committee recommends the service oriented homogeneous technology option of IP/MPLS at the BHQ to GP layer where fiber ring topology is adopted with GPON for GPs where linear fibre topology is preferred. The comparative technology options are indicated in Table 3.8. **(para 3.50)**

21) The Committee recommends that BBNL shall facilitate the provision of free right-of-way available to it for the project under the terms of the tri-partite Memorandum of Understanding (MoU) signed with the Central and State Governments for inter-linking with PoPs to be established at DHQ, BHQ and GP by considering it as an integral part of the project though it shall be paid for and laid by the private service provider. **(para 3.51)**

22) The Committee recommends that District-level Tier-2 Data Centres of 5-10 racks, co-located with the PoP of the network be provided, which will function as an integrated PoP interconnecting to different users of the network including NII. The Committee has estimated the cost of the Data Centres as Rs 1407 crores. **(para 3.55)**

23) The Committee recommends that Wi-Fi infrastructure alone may be provided by BBNL/State SPV through public investment and the Wi-Fi services delivery could through any licensed TSP/ISP (called the "Community Wi-Fi services provider"). At least one hour of free Wi-Fi usage per day for each resident of the GP should be provided by the identified Community Wi-Fi services Provider for which wholesale bandwidth may be made available by BBNL/State SPV. The Wi-Fi service provider can build a business model around advertising revenues (similar to F.M radio) while permitting a base level of public Internet access to all residents of the G.P irrespective of economic status. The Committee, however, strongly recommends that BBNL should in no case become the Wi-Fi services provider to prevent issues of conflict of interest as the owner of infrastructure and provider of services. The Committee has estimated the cost for the Wi-Fi infrastructure at each GP to be Rs 895 crore. **(para 3.57 and 3.60)**

24) The Committee is conscious that the suggested technology consumes more power than GPON and therefore, appropriate arrangements for power supply and back-up would need to be made at the three levels of the network. For the DHQ electronics, the Committee has assumed that grid electricity supply would be available and power back-up can be provided through that provisioned for the District-level Data Centre as shared infrastructure. Therefore, no additional costing for power supply back up for the DHQ electronics is provided. For the BHQ electronics, the Committee has also assumed the availability of grid electricity supply. However, cost for power back up for BHQs has been estimated at Rs 869 crore. **(para 3.61)**

25) For power supply at GPs, the Committee is conscious of the unreliable electricity availability in rural areas across large swathes of the country. The Committee noted the thrust being given to solar power and improvements in solar energy technology to falling prices. The Committee notes that power availability at GPs will be an important determinant in ensuring SLAs, especially in the context of the suggested technology choice and that the responsibility for maintenance of SLAs rests upon the Implementation Partner. Therefore, the Committee recommends that no single solution be suggested for power provisioning at the GP level and the solution be left to the Implementation Partner i.e. the private sector or Implementing CPSU as the case may be, with the specification that at least 8 hours of secondary power back up to go along with the primary power supply be suggested by the bidder. The cost of the solution may be built into the annuity submitted by the bidders. **(para 3.62)**

CHAPTER 4

Implementation Strategy

26) The Committee has identified certain fundamental guiding principles to be followed before designing a comprehensive model for project implementation, operations, utilisation and maintenance in the long-term. **(para 4.10)**

27) The Committee has suggested a multiple model approach that spreads risks and builds on available capacities. The Committee has recommended three models – the State Government-led model, the CPSU-led model and Private sector-led model. The three Implementation models and their key principles are encapsulated in Table 4.1. **(para 4.11)**

28) The Committee has evaluated the three Implementation Models with respect to challenges witnessed in Phase-I of NOFN in Table 4.2. **(para 4.13)**

29) The Committee has recommended a detailed activity chart for the Private sector-led and CPSU-led Implementation Models in Table 4.3. **(para 4.14)**

30) The Committee has detailed the package based mechanism for the Private sector-led Implementation Model, its advantages and risks. **(para 4.15 to 4.17)**

31) The Committee has detailed the CPSU-led Implementation Model, its advantages and risks. **(para 4.18 to 4.21)**

32) The Committee has suggested that the State Government shall create or assign a State SPV for carrying out all project activities. While designing and customizing its network, the State SPV may adopt more advanced and more scalable technology architecture than adopted by BBNL, subject to the condition that the State Network so designed shall interoperate with the National network seamlessly and provide visibility at the national level. The Committee has detailed the parameters of the State Government-led Implementation Model along with differentiated roles and responsibilities of BBNL and the State SPV in Table 4.4. **(para 4.22 to 4.24)**

33) The Committee recommends that irrespective of the implementation model adopted, the responsibility of funding should be with the Central Government to ensure equality of treatment of all States. The investment costs including incentives and disincentives for timely or delayed completion would be the same as for the CPSU model. At the same time, the State SPV should be eligible to receive viability gap funding for operations and management (O&M) after adjustment of revenues derived from fibre auctions and bandwidth provisioning on the costs for O&M discovered through a transparent mechanism. The State SPV would be free to induct any private

entity through equity participation provided the combined holding of State Government and the Central Government/BBNL is not less than 50%. **(para 4.26)**

34) The Committee recommends that horizontal connectivity through OFC to Government institutions at the DHQ, BHQ and GP level shall also be provided and provisioned by the Implementation Partner/State SPV. The operations and maintenance shall also be undertaken by the Implementation Partner with well-defined, pre-determined SLAs different from that for the District to Block and Block to GP layers. Besides the identified institutions, the Committee recommends that any additional Government institution could be connected to be network on payment of capital cost for extending the optical fibre connectivity to the institution. **(para 4.29)**

35) BBNL assured the Committee that while the present design of the OSS essentially interfaces with GPON equipment, the design could be modified to include any other technology, the Committee, therefore, recommends that while the OSS to be deployed may have to be developed and tested for the new technology and architecture proposed, C-DoT could continue to work with BBNL for design and development of the OSS. If necessary, a new agreement with revised costs would have to be put in place. **(para 4.30)**

36) The Committee strongly recommends that the OSS should be comprehensively tested and evaluated through a third-party process before it is inducted into operations. **(para 4.31)**

37) The Committee recommends that BBNL may rework the Business Support Systems (BSS) based on the broadband utilisation models suggested by it in Chapter 6. The reoriented BSS would have to support business management of dark fibre linked to the fibre management module as well as the BSS for bandwidth provisioning. BBNL may also have to design and develop a module for auction of fibre to support the utilization Models suggested by the Committee. Therefore, the Committee recommends that BBNL may revisit the tender for the BSS and also develop a module for fibre auctions. **(para 4.32)**

38) The Committee recommends that no change is required in the present NOC being built by BBNL at Delhi and Bengaluru in the light of the new structure proposed. **(para 4.33)**

39) The Committee recommends that in case of the State-led model, the State SPV would have the primary responsibility for network management, whereas in the private sector-led and the CPSU-led models, the primary responsibility will devolve on BBNL to be enforced through the concerned Implementation Partner. Therefore, the NOC design would have to factor in the need for integration across the different models. Table 4.5 encapsulates the requirements in respect of the three suggested implementation models. **(para 4.34)**

40) The Committee recommends that to expedite RoW approvals, BBNL may make a lump sum payment upfront to NHAI, Railways, and the Oil Companies against which adjustments could be made for each approval and the balance adjusted/reimbursed/paid annually between BBNL and these agencies. This would obviate the need for case-to-case payments. Thereby, the local officers of these agencies on whom grant of RoW approvals is delegated will only look at the technical aspects while granting approval. **(para 4.37)**

41) As in the case of the State Governments, the Committee recommends that bi-partite agreements may be signed between NHAI, Oil Companies, Indian Railways on one side and BBNL on the other side duly overseen by the concerned administrative Ministries to work out a common procedure for RoW approvals and, if possible, grant free RoW permission. **(para 4.38)**

42) The Committee recommends that a similar agreement on RoW could be arrived at between Ministry of Environment & Forests and Department of Telecommunications for expeditious forest clearances. **(para 4.38)**

43) The Committee recommends the appointment of empowered Nodal Officers in these agencies to come to the aid of BBNL for expeditious RoW approvals may assist project implementation. **(para 4.38)**

44) The Committee recommends that the planning stage consisting of desk-top survey, physical validation of survey, preparation of cost estimates and finalization of bill of material with quantities, must be approached with great diligence and certainty so as to lend confidence to the subsequent stages of tendering, award of project and actual implementation. **(para 4.39)**

45) Considering the immense pressure on timely execution and the importance of the planning process, the Committee strongly recommends that the capacities of the private sector in GIS must also be leveraged so that both timeliness and accuracy are both kept in the cross-hairs of project planning. The Committee feels that the base maps prepared by GIS-NIC on 1:10,000 scale can be adopted while the planning tool developed by C-DoT could be improved upon by involving the private sector with global experience and industry bodies in the GIS-sector in GIS-based planning. **(para 4.40)**

46) Considering the need for speedy by robust, accurate and timely planning, the Committee recommends that the planning process should be completed in 3-4 months for all States for the tendering process to commence immediately thereafter. **(para 4.40)**

47) For early identification and restoration of faults, the Committee recommends collecting and maintaining positional intelligence through sensor-based geo-tagging of optical fibre assets. The additional costs due to geo-tagging will be more offset by substantially reduced direct repair and maintenance costs and the indirect costs due to service disruptions. **(para 4.42)**

48) The Committee recommends that the Central Government, through legislative or executive instruments as may be appropriate, lay down a mechanism for severe punishment for causing damage, willfully or otherwise, to optical fibre assets. **(para 4.42)**

49) The Committee recommends that obtaining prior clearance of BBNL or State SPV for any digging activity in the vicinity of buried optical fibre assets should be made mandatory as in the case of oil and gas pipelines. **(para 4.42)**

50) The Committee recommends that a team with experience in project management using I.T tools be constituted to design and develop a project management tool to be put in place within three months in parallel to the planning process so that the tool is available for project management before the award of work to the successful bidders. **(para 4.43)**

CHAPTER 5

Project Cost and Timelines: BharatNet and NOFN+

51) The Committee has estimated the total cost of the project at Rs 72,778 crore, details of which are given in Table 5.1. **(para 5.01)**

52) The Committee has suggested pilot projects to assess if BSNL's duct infrastructure could be used to lower project costs. If the pilot succeeds then the cost of pulling fibre through existing duct infrastructure between Block and GP would reduce project cost by Rs 6900 crore even if only 50% of the existing infrastructure is usable. Given the substantial savings than exist, the results of the pilot projects may be looked into closely before the strategy for the project is finalized. If the pilots reveal the possibility of adopting this strategy, then BSNL may be incentivized in offering their duct infrastructure by giving 4 fibres in the 24 core optical fibre cable being laid along with

responsibility for maintenance of the fibre as the payment in kind for lease of the duct, offering a win-win to Government, BBNL and BSNL. **(para 5.02)**

53) The Committee has demonstrated that that even in terms of cost comparison over 10 years, the restructured network, BharatNet, scores over NOFN+. Details are available in Table 5.2. **(para 5.04 and 5.06)**

54) The Committee has calculated that the implementation of the project can result in expected benefits in FY 2018-19, the first year of commissioning, of Rs 66,465 crores. (para 5.07)

55) The Committee has re-worked the timelines for implementation, the details of which is indicated in Table 5.4 which indicated that the project could be commissioned by December 2017. **(para 5.10)**

56) The Committee strongly recommends that the duration and processes for initial decision-making may be expedited to the maximum so that sufficient time is available for re-planning the network architecture, the competitive processes for award of contracts and project implementation on the ground. **(para 5.11)**

CHAPTER 6

Rural Broadband through BharatNet

57) The Committee has recommended the guiding principles to be considered for designing the business and utilization models **(para 6.08)**

58) The Committee recommends that the determination of demand for bandwidth and pricing for the same is best left to market forces while keeping a ceiling on retail tariff to ensure affordability since using full cost recovery as the basis for bandwidth tariff may inhibit the growth of broadband in many areas and underprice investment in other areas. **(para 6.12)**

59) The Committee was of the opinion that this enables adoption of a mixed business approach to make available both dark fibre and bandwidth from every District to every GP. **(para 6.14)**

60) The Committee recommends that not less than 50% pairs of dark fibre at GP be set aside for allocation to telecom service providers, multi-system operators, local cable operators, Internet service providers and other service providers through forward-cum-reverse auction process the mechanism for which is detailed in paragraph 6.17. 4 pairs of dark fibre shall be provisioned for bandwidth by the CPSU, State Government SPV or Implementation Partner in the three implementation models. Of this, of at least some pairs may be dedicated for Government services usage. Thereby, the model ensures availability of bandwidth and dark fibre while using the full potential of the infrastructure created through Government investment. Balance fibre(s) shall be retained as spare for maintenance purpose. **(para 6.15)**

61) The Committee recommends that forward-cum-reverse auction process would be equally applicable in all three models as mentioned in the chapter 4. In the State Government-led model, freedom may be provided to the State SPV to decide the number of pairs of dark fibres to be put to auction subject to the condition that a minimum of 50% of the fibre pairs at Block-GP level is put to auction. The State SPV may also have the freedom to decide the number of pairs that could be used for Government services. The Committee recommends that fibre auctions could be conducted for the District as a unit. The process for auction has been detailed in **para 6.17.**

62) The Committee recommends that bandwidth shall be dedicated for Government services, including education, health and other services. Other available bandwidth shall be available at wholesale

rates for any retail services provider by laying the necessary infrastructure. BBNL shall ensure that the wholesale prices are calibrated appropriately so that it does not distort the retail market and uses these prices to bring stability to services pricing. The CPSU, State SPV or Implementation Partner shall be incentivised if bandwidth utilisation exceeds 50% of the bandwidth provisioning. In so far as the balance fibre in the DHQ-BHQ layer is concerned, the same may be available in case of diversion of traffic, splicing for architecture purposes and maintenance. **(para 6.18)**

63) The Committee recommends that service provisioning for public health, school education and Government-sponsored multi-skilling institutions be provided free to the Government user institution, considering the immense societal benefits and the pressing public interest in providing better education and health facilities. The tariff for connectivity Government services provisioning will be fixed by BBNL with the approval of the Central Government in case of the CPSU-led and Private-sector led model and by the State SPV with the approval of the State Government in case of the State-led model. **(para 6.20)**

64) The Committee recommends that the Department of Electronics & I.T may re-work its proposal for the National Information Infrastructure upwards of the District layer and subsume the State Wide Area Network (SWAN) and the National Knowledge Network (NKN) below the District layer with the restructured BharatNet. **(para 6.20)**

65) The Committee recommends that State Government may either establish a State Digital Services Corporation or convert one of the existing State PSUs into a Digital Services Corporation by expanding their mandate so as to ensure that focussed attention on creating the right content, inducting information technology platforms in Government departments and digitisation of Government records/services is given to truly create transformative change through "minimum government, maximum governance" **(para 6.21)**

66) The Committee recommends that BBNL or State SPV, as the case may be, provide wholesale bandwidth to retail service providers as a market balancing mechanism and ensure alternative supply channel for the broadband bandwidth market. The Committee also recommends that the tariff for wholesale bandwidth provisioning be fixed by BBNL, in case of the CPSU-led and Private-sector led model, and by the State SPV in case of the State-led model. The tariff so fixed shall be in accordance with and comply with the applicable regulations of the Telecom Regulatory Authority of India (TRAI). **(para 6.23)**

CHAPTER 7

Migration from NOFNto BharatNet

67) The Committee recommends that Survey and re-planning the entire network based on the architecture and technology suggested in Chapter 3 is going to be the first step towards migration to the new framework. **(para 7.02)**

68) The Committee recommends that the OFC that has already been procured could be utilized in the new implementation structure by CPSUs in the first instance, and the balance offered to the successful bidder in the private-sector led model at the purchase rate. **(para 7.04)**

69) The Committee recommends that no further extensions be permitted and BBNL should not place any further purchase orders beyond the supplies of OFC received within the extended delivery period. **(para 7.05)**

70) The Committee recommends that the supply of GPON that is likely to be made could be utilized for horizontal connectivity at District and Block level to Government institutions or in the approximately 24% GPs proposed to be connected in linear topology. Here too, the Committee recommends that BBNL should not permit further extension in the already extended delivery period of the contract which has already overshot the original supply period. **(para 7.07)**

71) The strategy for migrating project implementation to the new methodology would depend on the model proposed by the Committee. The Committee recommends that:-

(i) For States suggested to be operated on the State-led model, the work being undertaken by the CPSUs has already been stopped or should be stopped immediately after the State makes a submission for adopting the model.

(ii) For States recommended for implementation through CPSUs, the work may be continued for the time being by the CPSUs. The revised planning exercise may incorporate the work already undertaken by the CPSUs in Phase-I. Additional CPSUs may be inducted for project execution.

(iii) For States recommended to be taken up for implementation through the private sector, the duct being procured by the implementing CPSUs in these States may be reassigned to the States proposed for implementation through CPSUs under the new methodology. The balance ducts, if supplied, may be offered to the successful bidder at the purchase rate. No work orders for trenching and laying may be awarded in these States after March 31, 2015. The implementation of trenching and laying of ducts and pulling of OFC in the blocks for which work orders have been issued by March 31, 2015 may be completed by August 31, 2015. By this time, the Committee hopes that the tendering process for the private-sector led model would have commenced. The work already done may be integrated into the planning process and included as pre-existing fibre in the tender documents to be prepared for inviting bids.

The Committee recommends that the interim orders on the above lines could be considered till the planning process for a new network is completed. **(para 7.11)**

72) The Committee is of the opinion that its recommendations in this Chapter enable the migration to the new implementation methodology and architecture without loss of investment and additional costs. **(para 7.12)**

CHAPTER 8

Empowered Structure and Empowering BBNL

73) The Committee recommends that BBNL must possess the requisite managerial and technical capacities and must be duly empowered financial, operationally and administratively for efficient management. **(para 8.01)**

74) The structural challenges faced by BBNL currently in project execution has been detailed by the Committee in **para 8.04.**

75) The Committee, on reviewing BBNL's organisational structure, identified fundamental factors for restructuring it into an effective and performance oriented entity. **(para 8.05)**

76) The Committee is of the view that if BharatNet is to be executed on time, at performance levels above global benchmarks, its governance must be boldly restructured – both external and within BBNL. In the Committee's view, this is the single most urgent, important factor that would

determine BharatNet's implementation success. To successfully deliver BharatNet, the Committee recommends a governance structure that operationalises three strategic administrative principles. **(para 8.06 & 8.07)**

77) The Committee recommends that in order to transform BBNL into a Board-led Company and professionalise decision-making at the Board-level by taking the following steps:

(i) Separate the posts of Chairperson and Managing Director and appoint a globally-renowned and eminent Indian with proven expertise in project management, preferably from industry, as non-executive Chairperson of the Board. The Committee suggests that the Chairperson may be selected by the Prime Minister along with the Finance Minister and the Minister of Communications & I.T through a search process.

(ii) Appoint an experienced executive from Government as Managing Director and Chief Executive Officer of BBNL for a defined term of 5 years. The Managing Director would have a highly accomplished, objectively credible track record of managing and delivering projects in the telecommunications, infrastructure or information technology sectors. At the time of appointment, quarterly project milestones would be negotiated with the Managing Director-select and these milestones would comprise part of the order of appointment. The Managing Director would be eligible to receive a consolidated pay and would face incentives and disincentives in emoluments in case of early or delayed achievement of quarterly milestones. The performance of the Managing Director shall be reviewed annually in terms of achievement of the quarterly milestones by a Empowered Project Group as detailed in paragraph to determine the incentives and disincentives.

(iii) Expand and professionalise the Board, to include both wider representation from key Government agencies and from industry, finance, telecommunication, consultancy and project management expertise. At least 50% of the Board of Directors shall be drawn from outside Government. The Committee has suggested the composition of the Board of Directors.

(iv) The Committee observes that a Search-cum-Selection Committee has been constituted under the chairmanship of Chairman, Public Enterprises Selection Board (PESB) for selecting a person as CMD BBNL on deputation basis for a period of 5 years, the post being open only to officers in Government substantively holding the post of Joint Secretary or equivalent be reviewed urgently in the light of the recommendations above.

(v) Professionalise BBNL's human resources and talent pool to world-class standards, in an organisation run according to best management practices. As an indicative measure, the Committee recommends that at least a significant proportion of all senior management positions should be drawn from amongst those who have previously not worked in Government.

(vi) Design for accountability so that BBNL's professional staff would operate in an organisational framework with clearly defined, coherently allocated responsibilities and powers.

(vii) Develop a two-tier operational framework, with centralised planning; distributed execution at State/Regional level. **(para 8.08)**

78) The Committee suggests that BBNL should develop strong legal expertise to manage disputes that are likely to arise in interpretation of contract clauses. The Committee recommends that a credible third party dispute resolution and arbitration mechanism should be put in place for expeditious resolution of disputes. **(para 8.09)**

79) The Committee recommends that USOF should be permitted to borrow from the financial market to smoothen short-term capital flows. The interest cost on this account shall be legitimately accepted as an element of project expenses by Government. **(para 8.10)**

80) The Committee recommends a new approach for de-layering decision-making:

(i) Establish an Empowered Project Group headed by the Union Minister of Communications & I.T and including the Secretaries of the Departments of Telecommunications, Electronics & I.T, Economic Affairs, Industrial Policy & Promotion, Rural Development and Power, Vice-Chairman of the Niti Aayog and Chairman BBNL. The Empowered Project Group will have Additional Secretary, Telecom, as its Secretary. This Group may be empowered by the Union Cabinet to take decisions on matters referred to it by BBNL which is beyond the purview of BBNL to decide. The Empowered Project Group can also invest BBNL with the authority to decide on matters in future that fall within the penumbra of jurisdictional uncertainty. Matters which the Empowered Project Group feels requires the consideration of the Union Cabinet shall be placed before the Cabinet along with its recommendation. The Empowered Project Group shall monitor project implementation, the flow of funds from Government for the project and the overall performance of BBNL. The Empowered Project Group shall directly report to the Prime Minister on progress in achievement of milestones and anticipated areas of shortfall. The Empowered Project Group shall substitute the Telecom Commission in so far as matters concerning BharatNet are concerned. Thereby, BBNL can directly refer, with the approval of its Board of Directors, matters to the Empowered Project Group through the Additional Secretary, Telecom-cum-Secretary.

(ii) Establish a Council for BharatNet which shall be chaired by the Union Minister of Communications & I.T and include Ministers of I.T of all States, Union Ministers of prominent user Central Ministries, Vice Chairman of the Niti Aayog with Secretary, Department of Telecommunications as the Secretary to the Council. The Council shall meet once every six months for inter-agency co-ordination in project implementation and assess readiness for network utilisation.

(iii) Establish a Committee at the State Level to be chaired by the Chief Secretary of the State and including user Departments of the State Government with the CEO or a functional Director of BBNL as Member to support and troubleshoot BharatNet implementation, to formulate institutional mechanisms that exploit BharatNet capabilities and to integrate BharatNet with existing State networks. **(para 8.12)**

Chapter - 1

Beyond NOFN towards Digital India: A Case for BharatNet

Introduction

0.01 National Optical Fibre Network (NOFN) is an ambitious initiative to trigger a broadband revolution in rural areas. NOFN was envisaged as an information super-highway through the creation of a robust middle-mile infrastructure for reaching broadband connectivity to Gram Panchayats.

1.02 The concept note for NOFN was first considered by the Telecom Commission on June 16, 2011. The Government approved the proposal for NOFN on October 25, 2011. The implementation strategy for creating NOFN, institutional mechanism for implementing NOFN and funding modalities for its establishment and maintenance were detailed. The network was supposed to be commissioned in 2 years at a cost tentatively estimated at Rs 20,000 crore. Over three and a half years have elapsed since but the network has reached only around 5000 GPs. Costs of implementation have gone up significantly. Obviously, NOFN in all its dimensions needs to be reassessed and course corrections made. In the meanwhile, Digital India was conceived by weaving various strands of communications and information technology for digital empowerment of citizens and delivering better governance. The vision of Digital India is based on the timely commissioning of a redesigned version of NOFN. It is in this context that this Committee has come to being, invested with the responsibility of assessing the existing architecture and implementation strategy and re-drawing the architecture and reconstructing the implementation philosophy learning from the lessons of the past three years working on NOFN.

NOFN: A History

1.03 NOFN was conceived as a project for connecting Block Headquarters (BHQs) to GPs by using existing fibre of Central Public Sector Undertakings (CPSUs) – Bharat Sanchar Nigam Limited (BSNL), RailTel Corporation Limited (RailTel) and Power Grid Corporation of India Limited (PGCIL) and laying incremental fibre to bridge the connectivity gap up to the GPs. The incremental OFC so laid was to be owned by the Government and the ownership of the existing fibre was to be continued to be vested with the current owners.

1.04 Keeping in mind the involvement of large number of agencies and organizations of Central and State Governments "as well as the private sector" in creation, implementation and usage of NOFN as a national asset, an Executing Agency (EA) was proposed to be created to undertake the work of establishment, management and operation of the NOFN through a transparent bidding process.

1.05 To resolve the right-of-way for laying of fibre, tripartite MoUs were proposed to be signed between the Central Government, State Government and E.A envisaging that no right-of-way charges including reinstatement charges will be levied by the State Government, their local bodies, companies or agencies on the grounds that the information highway proposed to be created was primarily for the benefit of the local communities, Panchayats and State Governments. This support was to be considered as the contribution of the State Government towards the project for ensuring time bound implementation. Right-of way agreements were signed with all States and Union Territories in 2013 except the State of Tamil Nadu.

1.06 The institutional mechanism for implementation was divided in the following three stages. In the first stage, a High-Level Committee (HLC) was constituted to decide the scope of work, execution strategy, funding requirement and time-frame for creation of NOFN and projected traffic demand while committing to provide OFC connectivity to GPs. Project implementation team comprising of members from BSNL, RailTel, PowerGrid, NIC and C-DOT was to look after various preparatory activities such as Geographical Information System (GIS) mapping, finalization of network design, formulation of bid package and issues related to establishment of a special purpose vehicle (SPV) for NOFN which would work under the supervision and guidance of HLC. At the second

stage, the SPV would be incorporated to be fully owned by the Central Government with equity participation from Government and interested CPSUs (BSNL, RailTel, PowerGrid, GAILTel etc). The management of NOFN was to be transferred to this SPV and it was to take over all functions and responsibilities of the EA also. The HLC was to provide the necessary guidance on all issues related to expeditious establishment and operationalization of the SPV and after formation the functions of the HLC were to be performed by the Board of Directors of the SPV. In the third stage, private sector companies were also to be inducted into the SPV by equity expansion based on need and necessity and in absence of such need, the progress could be stopped at the earlier stage. Bharat Broadband Network Limited (BBNL) was incorporated on February 25, 2012 as a Special Purpose Vehicle for the establishment, management and operations of NOFN. The HLC was constituted in April 2011 and dissolved in August 2014.

1.07 In so far as the funding arrangements were concerned, net cost for establishing and maintaining NOFN was to be funded by the Universal Service Obligation Fund (USOF) based upon bids received by the EA. As the precise estimate was difficult to chalk out at that time, an indicative requirement of funds was approved. The EA was to prepare the estimates of the funds required for the project under supervision of USOF and the funds were to be allocated based on actual bid amount and after necessary approval by the competent authority. The likely CAPEX on NOFN was estimated at Rs 20,000 crore based on certain assumptions contained in a Detailed Project Report (DPR) prepared by TCIL. The administrative expense of the EA was to form part of OPEX of the project. The absolute amount of the expense was subject to approval. USOF was to fund entire CAPEX and OPEX net of revenue streams for a period of five years. Suitable incentives were to be provided to EA for maximizing revenues. The funds were to be allocated by the Ministry of Finance to USOF within the amounts accrued/accruing to the USOF and no additional liability on the state exchequer outside of USOF was envisaged. For the purpose of accountability, the expenditure on the incremental infrastructure so created and the resultant revenue was to be clearly demarcated and kept separate from any other revenue or expenditure to be earned or incurred by the EA. The user charges for the incremental infrastructure were to be determined within the overall limit fixed by the regulator.

1.08 Before embarking on nation-wide implementation, it was thought prudent to carry out pilot projects at different geographical locations. The 8th HLC meeting on March 16, 2012 decided that pilot trials be carried out in 3 Blocks. BBNL embarked upon pilot projects in three blocks covering 59 GPs in three different states - Arain in Ajmer District of Rajasthan, Parvada in Vishakhapatnam District of Andhra Pradesh and Panisagar in North Tripura District of Tripura. The pilot projects were completed on October 15, 2012 and the Department of Electronics & I.T (DeITY) enabled the delivery of G2C services through a counter funding program in these GPs. The High-Level Committee decided that BSNL, RailTel and PGCIL may be entrusted with the physical implementation on behalf of BBNL. Accordingly, the work was split State-wise between BSNL, RailTel and PGCIL in the ratio of 70:15:15. The HLC also decided to adopt the incremental fibre approach by leveraging the existing fibre of BSNL and the other PSUs for reducing cost of the project. However, the use of existing fibre of PGCIL and RailTel was found to be infeasible and led to the dependence on BSNL fibre alone for connectivity. The procurement of optical fibre cable and electronic equipment was to be done by BBNL by aggregating volumes to obtain lower prices.

1.09 On the technology adopted for the project, the Technical Advisory Committee (TAC) constituted by the HLC had recommended in March 2012 that the technology choice depends on striking a balance between NOFN objectives and ground realities. The lack of availability of power supply in rural areas in general, availability of space in GPs, lack of skilled manpower to maintain advanced technology equipment in GPs and sustainability were identified as factors

influencing technology choice. Two scenarios were indicated. One scenario described was poor power availability with less fibre and closely spaced GPs for which passive electronics i.e Passive Optical Network (PON) was recommended. The other scenario spoke of good power availability, fibre availability and GPs located at distances for which hybrid or active technology was recommended. The TAC recommended that pilot projects may be taken up to settle the technology choice. The HLC in a meeting on May 31, 2012 decided on Gigabit Passive Optical Network (GPON) as the technology choice considering the architecture and ground conditions of power availability etc.

1.10 In the early stages itself, implementation bottlenecks were seen. The Telecom Commission took cognisance of it and in a meeting on July 2, 2013, the Commission advised that decisions on tenders for various components should be taken by M/s BBNL in accordance with provisions of General Financial Rules (GFR) and within the limits of the approval of the Union Cabinet for implementation of NOFN. The Commission also advised that the applicable schedules of rates including State Schedule of Rates (SoR), CPWD or implementing CPSU schedule may be considered for each unit for which tender had been issued. In a subsequent meeting on October 10, 2013, the Commission further advised that for the purpose of trenching and laying of optical fibre cable, the SoR followed by BSNL at the level at which it issues tenders or corresponding State SoR as on a reference date, be taken as applicable SoR by BBNL. The Commission also decided that considering the scale of the project, the implementation be carried out in a phased manner with 100,000 GPs taken in the first phase. The target was further reduced to 50,000 GPs in July 2014 to be completed by March 2015.

1.11 Considering the slow pace of the project, a revised strategy for direct implementation by BBNL in 50,000 GPs as Phase-II was conceived. The Telecom Commission in a meeting on June 13, 2014, expressed its opinion that selection of a project management consultant with proven capabilities of handling large projects in a transparent manner is critical for successful implementation. The Commission directed USOF and BBNL to design an appropriate, rational and transparent mechanism for selecting a Project Management Consultant (PMC). Stating that timely implementation of NOFN was critical to roll out of Digital India, the Commission reiterated its opinion that selection of project management consultant with proven capabilities of handling large projects in a transparent manner was critical for successful implementation. The Commission also expressed a view that robust involvement of States in project monitoring and implementation must be built into the project. In a meeting on January 7, 2014, the Telecom Commission approved 'in-principle' a proposal by the Government of Andhra Pradesh stating that the proposal of State Government could form one of the possible modes expeditiously reaching broadband connectivity to GPs. The approval was subject to regulatory compliances and alignment with USOF mandate on such funding besides the commitment by the State Government to adhere to the principles and outcomes of NOFN.

1.12 The pilot projects and subsequent interactions with service providers brought across the point that there was no compelling business case for broadband provision in rural areas. To ensure utilization of NOFN infrastructure and to catalyse the development of broadband services delivery, Government User Network (GUN) was conceived as an extension over NOFN. GUN envisages that the connectivity would be aggregated at district level from where it can be connected to the National Knowledge Network and the public Internet. GUN enables broadband connectivity from District to GP by entering the network at the demand point and exiting anywhere - Block or GP through a single window, provide community wi-fi services at GP and link three government rural institutions in the GP such as schools, post offices etc. The detailed project report on GUN was considered by the Telecom Commission in its meeting on June 13, 2014, at a capital cost of Rs 4942 crore to be funded by USOF and annual operational expenses of Rs 2472 crore to be provided by the Ministry of Rural Development. The project is yet to receive approval of the competent authority for implementation.

Challenges and Issues in NOFN

1.13 The data on physical progress of NOFN since January 2013 shows that the progress has been tardy and targets have fallen behind by a substantial margin. The Committee held discussions with the implementing CPSUs and BBNL to understand the challenges and problems faced by them in implementation. These issues can be grouped into three aspects - issues in technology & architecture of NOFN, issues in implementation strategy and issues in broadband service delivery using NOFN.

1.14 The issues in the design of NOFN and technology choice identified by the Committee through the consultations process are as under:

(i) The existing design is based on linear topology from Block to GP which may not be able to provide the reliability acceptable to service providers and users of bandwidth.

(ii) NOFN is based on fibre connectivity to all GPs irrespective of geographic conditions, population density, length of incremental fibre laid etc. Laying of fibre to some GPs may be extremely expensive and it may be possible to provide broadband reach through other technological means.

(iii) 24 fibre optical cable under NOFN is connected to a single fibre of BSNL at the Point of Interconnect (PoI). Thereby, 23 fibre strands would remain unutilized. Further, a single cut of the fibre between Block and PoI would disconnect services to number of GPs.

(iv) The health of BSNL fibre from Block to the Point of Interconnect (PoI) with NOFN fibre is uncertain. Thereby, the attenuation loss may hinder reliable service provision.

(v) NOFN was envisaged as an incremental network to the existing backhaul fibre, and only minimal incremental fibre was required to be laid. However, during implementation it has been observed that the backhaul fibre infrastructure may be degraded or missing in parts resulting in patchy quality of service.

(vi) Delays have been reported by some implementing CPSUs due to traceability of existing fibre and then ascertaining its availability and quality.

(vii) Too many points of interconnections at block level are a hindrance for effective utilization of the network.

(viii) The framework for integration of NOFN with other Government networks like NIC/NKN/SWAN etc for effecting service delivery has not been provided.

(ix) Non-involvement of States, an important collaborator in the project, in the planning and implementation of NOFN has led to a distancing of the State from ownership of the project and resulted in slow progress besides the risk of the infrastructure not being utilised. Strong involvement and robust participation of the States in planning, implementation, maintenance and utilization of NOFN was missing affecting the project at all stages.

1.15 The issues in the implementation strategy identified by the Committee were as follows:

(i) Lack of accountability, financial or otherwise, in project implementation.

(ii) Lack of ownership of the project by the CPSUs and inability of BBNL in ensuring timely project implementation.

(iii) Fragmented nature of project implementation design both in terms of geographical spread while phasing implementation and in assignment of responsibilities for project components leading to inter-agency co-ordination problems that have arisen and also anticipated to arise in future.

(iv) In Phase I, the Blocks to be connected were selected based on the least length of incremental optical fibre to be laid. While this was intended to speed up implementation, it has meant non-contiguous coverage on ground which is likely to render service layer integration difficult, besides making alternative options of implementation an important

issue to be addressed.

(v) Excessive emphasis on cost controls leading to lack of empowerment of implementing agencies.

(vi) Absence of competitive price discovery for project management.

(vii) Network rollout on a nationwide scale through limited agencies.

(viii) The procurement process for PLB duct and tendering process for trenching and laying have been delayed due to BBNL's rigidity in decision-making along with the CPSU's trepidation of taking decisions that could be questioned later.

(ix) Inadequate human resource and technological tools available within BBNL to monitor and manage the project.

(x) Lack of adequate advance planning in BBNL to various elements of NOFN – service provision, bandwidth utilization, operations, repairs & maintenance etc.

(xi) Lack of adequate empowerment of BBNL has affected expeditious decision-making impacting project timelines.

(xii) The near absence of any inter-linkage with the providers of content and services is sure to lead to a situation where even if the network were established, its utilization would be extremely low, hindering the vision of Digital India.

1.16 The issues in the maintenance and utilization of bandwidth were identified by the Committee were as follows:

(i) With the design architecture of linear topology for optical fibre, the incremental fibre approach connecting with a single fibre at PoI and uncertainties about the health of BSNL fibre, the reliability and redundant provisioning of a network of this nature stands compromised. It would be impossible to achieve high levels of SLA (around 99.9%) which is essential for reliability in service provisioning. Thereby, the possibilities of gainful utilization of bandwidth for non-Government purposes have substantially reduced.

(ii) Planning for services provision using the network is missing. Although a separate proposal for a Government User Network (GUN) overlay over NOFN has been considered, approvals for the services layer is awaited. Therefore, the network cannot be utilized immediately on its commissioning.

(iii) The lock-in for service provisioning with one service provider i.e. BSNL, the high cost of bandwidth between Block and District charged for using the BSNL network and lack of appropriate interconnect arrangements at Block/ District levels inhibit competitive and reliable provisioning that would eventually affect broadband penetration in rural areas.

(iv) The lack of skilled manpower at the GP-level and inadequate planning in BBNL for repair and maintenance of assets at the GP raises issues of reliability and quality of network availability

(v) Provision of space for housing equipment at the GP, reliable electricity supply in GPs and security of equipment are unaddressed issues that have the possibility of affecting utilization of bandwidth.

1.17 The challenges faced in implementation of NOFN has affected its progress adversely. The Committee has been given to understand that optical fibre cable is likely to reach only about 15,000-20,000 GPs in Phase-I by March 31, 2015. The lock-in to one supplier for delivery of GPON equipment may affect the lighting of even the 15,000 GPs where optical fibre would have reached. The preparedness for service delivery is as yet unsettled. The implementation philosophy for reaching 150,000 GPs has not been decided while the targeted deadline is only 21 months away.

Vision of BharatNet

1.18 Broadband is the infrastructure of the future. The aspirations of a rising India led by its demographic dividend require a robust and reliable backbone of broadband across India. In a country which is transiting from backwardness to progress on social and economic fronts,

affordability of broadband to serve the needs of all is a central policy objective. Therefore, the Committee commenced its deliberations by focussing on affordability of services and its mass utilization riding on a reliable, advanced-nation broadband infrastructure.

1.19 The Committee felt strongly that it is absolutely essential to review the implementation of NOFN to raise the aspirational level to match that of Digital India. The Committee recommends that the project may be renamed as BharatNet to reflect the national aspiration through the vision articulated below:

"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 realise the vision of Digital India, in partnership with States and the private sector."

Conclusion

1.20 The context in the preceding paragraph explains the reason for its constitution. The Committee has given serious thought to the issues and challenges of NOFN. The Committee appreciates that resolution of these issues is crucial to the implementation of the Government's vision for a digitally empowered India. The Committee is conscious of the confidence reposed in it by the Government and the onerousness of its task. The Committee has tried to converse with every possible stakeholder in trying to search for solutions. The Committee hopes that the discussions in the subsequent chapters would provide a path forward for project implementation

Chapter - 2

Estimating Bandwidth and Sizing Infrastructure for BharatNet

Introduction

2.01 The National Telecom Policy-2012 had declared its mission of creating an inclusive knowledge society through proliferation of affordable and high quality broadband services across the nation. The NTP objective of achieving 175 million broadband connections by the year 2017 and 600 million by the year 2020 at a minimum of 2 Mbps download speed and making available higher speeds of at least 100 Mbps on demand is dependent on the success of the National Optical Fibre Network (NOFN). The original project report on NOFN prepared by Telecommunications Consultants India (TCIL) in 2011 estimated a uniform broadband speed of 100 Mbps across all Gram Panchayats in the country. The spread of the digital economy in the meanwhile and the rapid growth of broadband over the last year indicate the thirst for higher broadband capacities in the country. The vision of Digital India has further enhanced the need for reliable and fast connectivity to reach nook and corner of the country.

2.02 Having considered the emerging needs for enhanced bandwidth and the fact that a robust nation-wide network is one of the cornerstones for realizing the vision of Digital India, the Committee felt it imperative for the bandwidth requirement under BharatNet to be re-estimated (and commensurately size the other assets like ducts, fibre and Electronics). It is necessary to build Broadband Highways for a knowledge-intensive Digital India to meet the challenges of efficiency, scale, security and quality of service with a focus on long-term sustainability. The viability of the BharatNet depends substantially on the accuracy with which the demand for network services and bandwidth is assessed and the fibre and electronics are correspondingly sized. The modeling has to be made over a period of 12 years, i.e 2 years for the construction phase followed by 10 years of O&M phase.

Sizing Infrastructure

2.03 While a detailed planning would bring out all the items and aspects to be estimated and sized, the Committee felt that it is essential to lay down the **principles** for sizing the major components mentioned below:

(a) **Fibre and ducts required in various layers:** The original design of the NoFN had adopted 24-core fibre uniformly, considering an *incremental approach* instead of an end-to-end approach. Given that the size and population of GPs varies widely and that BharatNet aims to move away from the incremental approach to a comprehensive middle mile network that provisions bandwidth from DHQ-to-BHQ-to-GP, it is essential to lay down the norms for sizing the ducts and the fibre-count in various layers. Table 2.1 shows the wide variation in sizes of the GPs across 7 States used for the household (HH) population analysis:

Table 2.1: Percentage of GPs categorized on number of HHs per GP[1].

% GPs with more than 3000 HHs per GP	**3%**
% GPs with 1500 to 3000 HHs per GP	**11%**
% GPs with 500 to 1500 HHs per GP	**53%**
% GPs with 500 or less HHs per GP	**34%**

(b) **Local and International Bandwidth required:** The essence of BharatNet is to provide Bandwidth-on-Demand. If this vision is to be fulfilled, it is necessary to carefully assess the bandwidth requirements at various layers, and accordingly design the capacity of the fibre rings on which the entire technology architecture is built. The original design of the NoFN had adopted the norm of '100 Mbps to every GP' uniformly. The Committee considers that it was too simplistic an approach, considering the wide diversity in profile of the GPs in terms of population, number of households, socio-economic status, geographical differences that vary significantly across GPs, Blocks, Districts and States. Hence, the 'one size fits all' approach is likely to

[1] Percentage sum total is greater than 100% due to rounding off.

cause immense distortions in the design of the network and is bound to lead to suboptimal results.

Bandwidth requirement is of two types **–local and international** bandwidth. Local bandwidth is used to access content that is 'locally' available i.e. within a District, State or within India. International bandwidth is required essentially to access the content on servers located abroad. The bandwidth requirements need to be assessed for both for the reasons explained below.

(i) **Local Bandwidth:** Appropriately sized fibre coupled with commensurate electronics has the capacity to transport infinitely large amount of content and deliver large bandwidth. One can, therefore, safely assume that once a grid of fibre rings is established in conjunction with the electronics that can handle the appropriate capacity (i.e 1/10/40/100 Gbps rings), it is not necessary to do a hair-splitting exercise to assess the local bandwidth requirement at the GP, Block, District and State levels, as it costs minimally to transport content locally over these District and sub-district networks.

(ii) **Internet Bandwidth:** When the user has to access content from overseas, the International bandwidth is required. Internet bandwidth is expensive, and at the current rates, costs about Rs 70 lakhs per Gbps per annum. This cost is significantly (5X) costlier in India for 2 reasons – firstly, the current demand is small, and secondly, the traffic has to travel through expensive long-distance submarine cable from the landing points in India to server nodes. If we consider this high cost of international bandwidth, the Internet bandwidth requirement has to be assessed carefully, as it impacts the price at which broadband is delivered to the user impacting affordability.

(c) **Capacity of Electronics at various levels/access points/ Interconnects/ Rings:** As discussed above, when it comes to electronics it is a question of 'choosing' from among the industry standard slabs of capacity of the ring while designing the capacity requirements at various levels i.e. GP/Block/ District.

Sizing Objectives

2.04 An accurate assessment of the bandwidth requirement and the capacity of electronics would emerge only at the stage of designing of the network for unit. However, the Committee feels that it is necessary to lay down **'sizing objectives'** that should guide the project design:

2.05 The objectives of the sizing exercise should be to enable the BharatNet:

(a) to be able to provision bandwidth for the end-user, located in different geographies.

(b) to be able to provision bandwidth required at each GP/Block/District Node.

(c) to be able to provision bandwidth required for **scaling** at each GP/Block/District Node.

(i) due to coverage of **additional villages/ habitations** outside the GP HQ;

(ii) due to increase in the **number of users** over time and

(iii) due to increased usage of **high-bandwidth applications** by institutions and end users.

(d) to optimize the cost of electronics at various levels, especially in all the rings, and be able to scale it as per growth in the demand for bandwidth - local and international.

(e) to optimize the operational costs of the project.

Principles for Bandwidth Estimation

2.06 The Committee felt that it is necessary to lay down certain guiding principles to enable network design that will eventually integrate to form BharatNet. Accordingly, the Committee recommends the adoption of the following principles for bandwidth estimation and sizing of the network assets:

2.07 Principle #1: Recognize that the demand for bandwidth has to be estimated **along 4 dimensions**:

(i) Number of new broadband users during the year.

(ii) Number of new habitations added by extending the network.

(iii) Increase in per capita bandwidth requirement due to proliferation of new applications/services and high-bandwidth applications, especially video-based.

(iv) Socio-economic status of the user as in any targeted area, there is a variation in the amount of bandwidth demanded by different sections of the society. For instance, about 65% of the rural households covered may be low bandwidth users (2-10 Mbps in the median year), 30% may be medium bandwidth users (10-20 Mbps) and 5% may be large bandwidth users (20-50 Mbps).

The experience of the mobile revolution also indicates that in the initial years, the growth in broadband penetration is likely to be rapid. Keeping the above factors in view, a **time v/s bandwidth demand** assessment has to be made for each unit over a period of 10 years.

2.08 Principle #2: Adopt the **contention ratio** as recommended by the Telecom Regulatory Authority of India (TRAI) from time to time, the current ratio being 1:10 (as indicated in the Consultation Paper of TRAI dated October 2014).

2.09 Principle #3: Assess intra-nation traffic for content hosted in servers located in India likely to be accessed by users and to that extent, reduce demand for international bandwidth through appropriate caching infrastructure and peering arrangements.

2.10 Principle #4: Take into consideration the socio-economic profile of the population, especially in the rural areas, and assess the percentage of households that can be covered by the *BharatNet* over the first 5 years and 10 years of operation of the network.

2.11 Principle #5: Assess backhaul requirements of TSPs in the rural areas. The provision can be in the range of 15-20% of bandwidth estimated for the rural areas of a State/zone.

2.12 Principle #6: Assume statistical gain while sizing the bandwidth for the BHQ to DHQ and DHQ to SHQ segments.

2.13 Principle #7: The growth of high speed broadband is likely to push the delivery of traditional broadcasting media like cable T.V (CATV) over the proposed network. The table below indicates the additional bandwidth per GP per operator estimated for broadcasting applications:

Table 2.2: Bandwidth requirement per GP per operator for Broadcasting.

Broadcasting	Bandwidth Per GP (2015) (300SD & 10HD)	Bandwidth Per GP (2025) (500SD & 50HD)
IPTV/ CATV Video Streams	1Gbps	>2Gbps

2.14 An indicative template for estimating the bandwidth requirements over a 12-year period of the network, incorporating all the principles stated above, is provided in the **Annexure**. The basic parameters may be suitably amended to produce the picture of the estimated demand for bandwidth, for any given geography, District/ State/Zone.

Guidelines for sizing of Ducts, Fibre and Electronics

2.15 Permanently lubricated ducts and optical fibre cable infrastructure are laid to last for a long time, as it is the most tedious and expensive part of any fibre network. Hence the sizing of these has to be done 'super-ambitiously' to meet future demands expected for decades. While the technology allows a single pair of fibres, supported

by appropriate electronics, to carry over Terabits of traffic, in practice, more fibre cores are required due to network design and installation such as splitting and splicing, redundancy, requiring higher requirements in the middle mile and core layers.

2.16 Electronics, in contrast to ducts and fibre, can be provisioned more dynamically, and hence the estimate should be more realistic to meet the expected demand in the near future.

2.17 The Committee recommends that the principles (1 to 7) in paragraphs 2.07 to 2.13 and the guidelines in paragraphs 2.15 and 2.16 may be considered, while designing the network. The Committee also recommends that degrees of freedom be given to the States adopting the State-led Implementation model described in Chapter 4 in the following areas:

(i) to determine the minimum aspired per capita bandwidth for households and businesses
(ii) to include urban areas and business users in the coverage and
(iii) to design the demand estimation matrix suited to their State.

However, the funding commitment of the Central Government may be limited to the base network design that is suggested across all States.

Network Media

2.18 It is evident that optical fibre media would best be able to cater to future bandwidth requirements except in parts of the country where the household population density is low. A detailed planning exercise would need to be undertaken to optimize the architecture (ring or linear). The planning exercise carried out by the Government of Andhra Pradesh indicates that an optimized planning exercise can provide ring architected connectivity to 66% of GPs with the rest being on linear topology due to geographical and locational constraints. The Committee was unable to carry out this exercise for a few other States and in the absence of actual planning data, the Committee has relied upon household population data. The Committee has assumed that 66% of the GPs will be connected through optical fibre media on ring architecture for the purposes of its analysis although the intent has been to cover as many GPs as possible over ring architecture considering the high availability and reliability demands.

2.19 Out of the remaining 34% of the total GPs, there would be some GPs where the capital investment for providing connectivity on optical fibre would be very high. There may be a need to explore other media for providing broadband connectivity at a lower cost. The Committee has explored the possibility of using alternative media like Radio spectrum to cover GPs with a low population density or high fibre laying requirement in Chapter 3.

2.20 The key guiding principles for the alternative media options are low bandwidth requirements based on HH density (500 or less HH) at GP level and high fibre laying Block to GP distance of over 7.5 km. Certain States and regions where difficult terrain inhibits both fibre and radio for connectivity would need to be covered through satellite media.

2.21 Data obtained from Census-2011 indicates that in 4.3% (10,708 GPs) of the total number of GPs, there are 150 or less HH in the GP requiring bandwidth provisioning of 10-30 Mbps. Given the extremely low population density and the difficult terrain, satellite media may be most appropriate for delivery of broadband in certain parts of the country. The State of Arunachal Pradesh (1756 GPs) and parts of Himachal Pradesh (Lahaul & Spiti [41], Kinnaur [65] and Chamba [252] districts), Jammu & Kashmir (Leh [93], Kargil [95] and Kishtwar [134] districts), Uttarakhand (border districts [750 approx]), North-Eastern Region [250], Panchayats in Union Territories i.e Andaman & Nicobar Islands [30 out of 69 GPs], Dadra & Nagar Haveli [11], Daman & Diu [14] and Lakshadweep [10] are areas where satellite media provisioning needs to be explored.

2.22 The Committee has studied the inputs it received from the Indian Space Research Organisation (ISRO). The inputs indicate that availability of satellites may limit the availability of satellite media. ISRO states that it is feasible to serve concurrently 15000 locations each with 3 Mbps bandwidth through one high throughput

K_a-band satellite that can be made available within 30 to 36 months. Bandwidth of 3 Mbps may not be sufficient to meet requirements. Therefore, the number of GPs to be provided bandwidth of 10-30 Mbps using satellite media has to be restricted to 3000. Thereby, the Committee recommends that in areas mentioned above where the distance of the GP from the Block HQs is over 10 km, satellite media be used to provide broadband at the GP level.

2.23 The Committee estimates that around 20,000 GPs would need to be connected over Radio and around 3000 GPs over Satellite media. In the remaining 57,000 GPs out of the 34%, the Committee has assumed that bandwidth capacity may be provided through optical fibre media in linear architecture. In GPs linked on linear topology and located along border areas, redundant provisioning may be considered using radio or satellite media for strategic purposes.

National Information Infrastructure and Horizontal Connectivity

2.24 The Committee understands that the Government is contemplating to establish the National Information Infrastructure (NII) as a secure, dedicated public information infrastructure providing bandwidth to government agencies for delivery of citizen services. The Detailed Project Report (DPR) on NII plans to integrate the National Knowledge Network and the State Wide Area Network (SWAN). The bandwidth estimated at DHQ is 1 Gbps and at the SHQ is 10 Gbps scalable to 20 Gbps after 5 years. The Committee acknowledges that NII architecture is adequate to meet bandwidth requirements as a public information infrastructure above DHQ level. Therefore, the Committee does not intend to revisit the assumptions made in the DPR for NII above DHQ level.

2.25 The Committee understands that NII and the proposed Government User Network (GUN) have been proposed to provide horizontal connectivity to Government institutions at each DHQ, BHQ and GP. The table below encapsulates the number of locations to be connected horizontally by NII and GUN:

Table 2.3: NII and GUN: Horizontal Connectivity

Level	NII Number of Locations	GUN Number of Locations
DHQ	50	-
BHQ	10	-
GP	3	3

2.26 The Committee is of the opinion that provision of horizontal connectivity at the DHQ, BHQ and GP level which involves laying of optical fibre should be considered as an inherent component of BharatNet. However, the Committee feels that considering optical fibre connectivity to six locations at GP may not

Table 2.4: Number of GP level institutions

Institutions	Location	Total Number	Bandwidth requirement	Connectivity Reliability	Fibre (Y/N)
Primary Schools	GP/Village	7,90,600	High	Moderate	Yes
Secondary Schools	GP	1,31,300	High	Moderate	Yes
Sr Secondary Schools	BHQ/GP	1,02,600	High	Moderate	Yes
Primary Health Centres	GP	24,049	High	High	Yes
Community Health Centres	BHQ	4833	High	High	Yes
Post Offices	GP	1,39,144	Moderate	High	Yes
Anganwadis	GP/Village	14,00,000 (approx.)	Low	Low	No
Police Stations	BHQ/GP	18,000	Moderate	High	Yes

be necessary. The Committee tried to obtain the number of Government institutions that could be located at GP/Block level. The table below provides the data on such village-level Government institutions *(see table 2.4 on page 34)*

2.27 From the data above, the Committee believes that optical fibre connectivity should be provided to those Government institutions requiring high bandwidth requirements or high connectivity reliability. Only those primary schools which are located at the GP HQs may be connected at this stage leaving those primary schools located in other villages comprising the GP to be connected subsequently. Therefore, for planning purposes, the Committee is of the opinion that connecting 2 GP-level institutions with optical fibre may be adequate for the present purposes besides the termination point which is assumed as the Panchayat office or the Government school.

Conclusion

2.28 The Committee has followed the principles enunciated here for its recommendations in the subsequent Chapters. The Committee's attempt has been to base its recommendations in reasoned, rational and drawn from evidence.

Chapter - 3

Architecture, Planning and Technology Choice

Introduction

3.01 National Optical Fibre Network (NOFN) was envisioned as a deliverer of high-speed bandwidth redefining the rural landscape and reaching the "unreached" on the information super-highway. Designing the landscape of this information super-highway involves choices on its architecture and technology to be made. The Committee was conscious that the future potential of NOFN would be determined by these choices. There were several variables to be considered – developing NOFN as a national backbone infrastructure on which all kinds of services would ride, the ground realities prevalent in the rural hinterland, the cost of developing this infrastructure, the time within which the infrastructure could be created and the building of domestic capabilities by leveraging on the potential of the infrastructure and services. Optimizing these contrasting variables is a heavy decision, weighed heavier by the certain knowledge that the costs of being wrong are enormous. It is with this weight that the Committee has proceeded with its task of making recommendations on the architecture, planning and technology choice for the restructured NOFN.

3.02 The terms of reference of the Committee require it **"to suggest measures for augmenting the current design and architecture of NOFN in line with the vision and objectives of Digital India"** and **"to assess and recommend suitable technology options for fast track and cost effective implementation"**. The Committee has proceeded to discuss these two important issues in this Chapter.

Existing Architecture and Technology

3.03 NOFN was designed on the "strategic principle"[1] of being a pan-India network where traffic from GPs would be back-hauled to districts. The Technical Advisory Committee (TAC) in March 2012 had described NOFN as using technologies that are scalable, shareable, observable and controllable with fine-grain granularity that are easy to operate and maintain. The network architecture terms owas sought to be of highly resilient design to protect against node failures and fibre cuts. The TAC had described NOFN as having back-haul up to District and use District as the basic unit for forming topology. It sought to build the NOFN backhaul network by using dark fibre leased from the three CPSUs and laying incremental fibre from Block to GP. Simultaneously TAC was concerned about failures and promoted redundancy in topology. TAC specifically recommended a ring topology with available fibre and laying incremental fibre. In the 9th meeting of the High Level Committee (HLC) on June 14, 2012, it was decided on the "opinion expressed by technical experts of TCIL and C-DoT"[2] that linear architecture appears to be optimal from cost consideration and that the linear architecture may be converted into rings at later point in time when resources are available. It was suggested that where rings can be formed with minimal incremental expenditure (<10%), the necessity and financial feasibility may be examined on case to case basis. However, linear architecture was adopted by BBNL as the default option for NOFN.

3.04 On the applicable technology, the recommendation of TAC was influenced by ground realities of poor power availability, space availability and lack of skilled manpower. TAC stated that multiple technologies must be deployed depending on availability of grid power, space, maintainability considerations and demand. It built two scenarios – where power availability is poor and less fibre is available, passive technology be preferred and where power situation is good and fibre availability is good, the choice could be hybrid or active technologies. HLC in its 9th meeting on June 14, 2012, decided to adopt Gigabit Passive Optical Network (GPON) "owing to architecture and ground conditions of minimal power consumption etc."[3]

3.05 These decisions of the HLC, not apparently based on any study or comparison of

[1] Extracted from page 7 of the report of the Technical Advisory Committee on NOFN dated March 2012.

[2] Extracted from minutes of meeting of the HLC dated June 14, 2012.

[3] Extracted from minutes of meeting of the HLC dated June 14, 2012.

technology or topology alternatives, formed the basis for planning by BBNL. The roll out of the pilot projects in the three selected blocks in an environment of poor power availability sanctified the choice without evaluation of possible alternatives.

Guiding Principles

3.06 The Committee felt that it may be appropriate to state the guiding principles before proceeding to make choices on architecture and technology. The Committee identified the following basic principles:

(a) **Reliability:** It is expected that the infrastructure being created in this project will emerge as the national backbone communications infrastructure for connectivity to rural areas across the country. In order to give confidence to the multiple users – Government and private – expected to ride on this infrastructure and the credibility in providing carrier grade uptime, the network planning has to foster reliability as its core. This is more so because the investment in fibre on this scale is a one-time investment that has to serve the nation's needs for many decades to come. Reliability means consistent delivery of applications even in the event of single or multiple failures. If assured SLAs are ensured, only then would business models that effectively utilize the network infrastructure emerge. To put it simply, nobody will ride on a highway, if the reliability of driving through it and reaching the destination is not ensured in its design.

(b) **Services oriented:** The primary purpose of infrastructure creation is to ensure that services are delivered to the citizens. The architecture and technology choice must be services driven rather than other way round. Hence it becomes very important to choose those options that are capable of meeting current as well as future services demand. This is specially so in the context of the vision of Digital India where a multitude of citizen services are planned to be delivered to the citizen electronically at his or her house.

(c) **Scalability:** The only certainty fostered by the rapidity of technological change in recent times is that the thirst for bandwidth is expected to grow exponentially in the emerging future of a knowledge driven interconnected society where more and more services run on the information super-highway. Therefore, the network infrastructure must not only meet the needs of the present but also cater for the possibility of an expanded future. These should not be viewed from increasing speeds and feeds perspective but also account for operational scalability and business sustainability in the longer run. An infrastructure of this depth and breadth gets laid once, but it should provide the flexibility and suppleness for meeting the unforeseen demands of tomorrow.

(d) **Consolidation of network and non-discriminatory access:** The proposed national network infrastructure should act as a supporting network layer for multiple uses eliminating the need for overlapping networks and prevent inefficient use of national resources because of duplication of investment. At the same time, non-discriminatory access for service provisioning (with the exception of Government to citizen services) must be afforded. Therefore, the architecture and technology choices must permit existing and new service providers to connect to the proposed network at points where they are reasonably present and deliver traffic to the GPs where the last mile solution through multiple available technologies can be worked out.

(e) **Security:** Given the trend of more and more applications being delivered over the cloud and Internet whether public or Government, it is important to promote secure delivery of services over the network infrastructure by having secured end-to-end infrastructure. This is especially true in case of Government services as evidenced from the operation of the State Wide Area Networks (SWANs) and the National Knowledge Network (NKN).

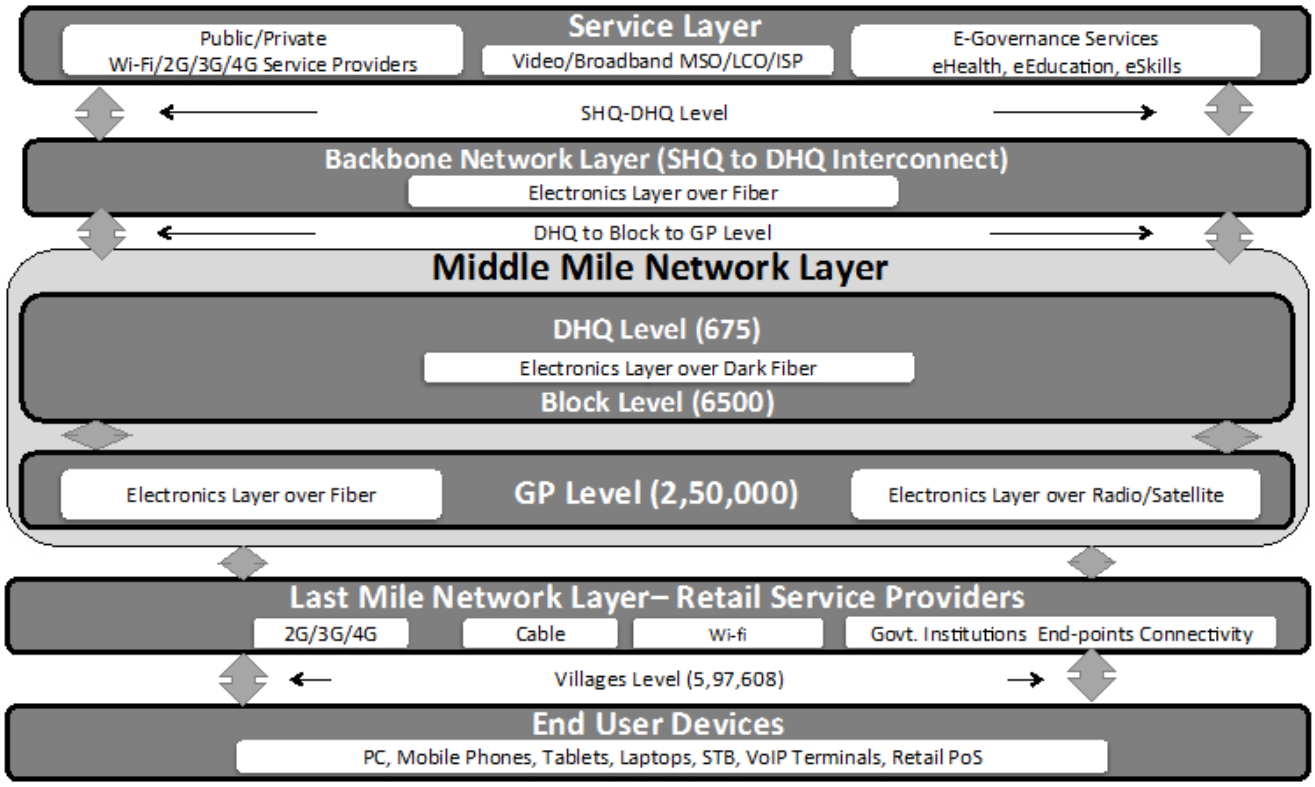
(f) **Ground realities:** While planning the network architecture and technology, the ground realities cannot be ignored. The experience of Bharat Sanchar Nigam Limited (BSNL) reveals that management of fibre is an onerous task given the propensity to frequent damages affecting services. The learning is that redundancy is a key requirement for planning backbone fibre deployment. Irregular rural power supply subjected to rostering is another unavoidable ground reality. Therefore, the choice of technology has to account for the lack of regular power availability either by opting for low power consumption or building adequate back-up for electricity supply.

(g) **Point of Interconnect (PoI) integration:** The proposed network layer should be able to provide consolidated point of interconnects (PoIs) at each level be it DHQ, BHQ or GP depending on requirements. PoIs will be interconnecting to various heterogeneous networks at the layer above DHQ as well as the last mile layer below GPs. The proposed network should be able to provide end-to-end services connectivity with the ease of integration and interoperability in order to enable delivery of services efficiently.

(h) **Quality of Service (QoS):** Different users of the network and different applications run by the users have different set of SLA requirements and specific QoS demands. These requirements need consolidation of different services on the same physical infrastructure to make sure each service gets the network resources and allow sharing of unused network resources between different services for optimization.

3.07 The Committee believes that these guiding principles should inform the exercise of choice on architecture and technology on examination of possible alternatives.

Figure 3.1: High Level Architecture



High Level Architecture Overview

3.08 Broadband infrastructure planning has to be based on the higher-level appreciation of what the network is expected to deliver and the components of this network interlink across multiple domains to provide the overall solution. The figure below attempts to capture the higher-level architecture of the proposed network built up to delivery of services *(see figure 3.1 on page 40)*

3.09 Generally the network eco-system is hierarchical with multiple layers and each layer and domain components provide specific functionalities. The domains and components of the network and their functions are described below:

(i) **Service Layer –** This layer comprises various core & service Delivery networks emanating from Government service delivery platforms such as National Information Infrastructure (NII), National Knowledge Network (NKN), National Informatics Centre (NIC), State Service Delivery Gateways (SSDGs), National Service Delivery Gateway (NSDG) as well as different private service providers carrying telecom, I.T and broadcasting services and other carriers of content.

(ii) **Core/Backbone Network layer -** The scope of this domain is interconnecting State Headquarters and connecting State Headquarters (SHQ) to District Headquarters (DHQs). The key objective of this layer is to carry aggregated traffic from DHQs to SHQs and across States.

(iii) **Middle Mile Network layer –** The middle mile layer provides connectivity services unifying the last mile access in the network below it carrying traffic from Gram Panchayats (GPs) to Block Headquarters (BHQs) and to District Headquarters (DHQs). It aggregates and consolidates demand emerging from the last mile into fewer interfaces at DHQ level providing point of interconnects (PoIs) for traffic to flow across multiple backbone networks. This layer provides media connectivity for service provisioning, both Government and private, for the last mile delivery to end-users.

(iv) **Last Mile Network layer –** Primarily the scope of this layer is to provide connectivity from GP to end-users and delivering services demanded by the end-users in the villages. Largely, the last mile layer closest to the end-user would be created and served by Access licensees and Internet Service Providers in the telecom sector or Multi-System Operators (MSOs) and Local Cable Operators (LCOs) providing broadband and entertainment services over wireless media such as 3G/4G/Wi-Fi and wired networks like cable broadband. Extension of horizontal connectivity to Government institutions such as schools, health centres, panchayat offices, post offices, police stations etc. would also form part of the last mile network layer.

Each of these domains has a set of physical network elements along with physical media options (fiber, radio or satellite) with electronics of appropriate technology in ensuring service provisioning designed to meet requirements.

Architecture choice: Media and Topology

3.10 During the consultations with stakeholders, the Committee was given to understand that many service providers have a presence in the backbone network between States and from SHQs to DHQs. Although there was some muted demand for extending connectivity from SHQs to DHQs, the Committee believes that there is sufficient competition through presence of multiple operators in this layer and there is no need to plan for an overlapping network. The Committee has also been informed that Government is planning the National Information Infrastructure (NII) for creating a backbone layer for Government services using existing physical network media. The Committee is, therefore, of the opinion that there is no cause for further Government investment in creating a fresh physical network media in the backbone layer beyond that already planned through NII.

3.11 The missing link for effective rural broadband is the middle mile layer. The

consultations with Telecom Service Providers (TSPs) revealed that with the exception of BSNL, there is a major gap in the DHQ to BHQ connectivity. There is almost negligent presence amongst TSPs in the BHQ to GP connectivity, which needs to be addressed. The Committee, therefore, felt that the proposed architecture should ensure connectivity across the missing middle layer from DHQ to BHQ to GP to address the gaps and build an end-to-end integrated middle layer network.

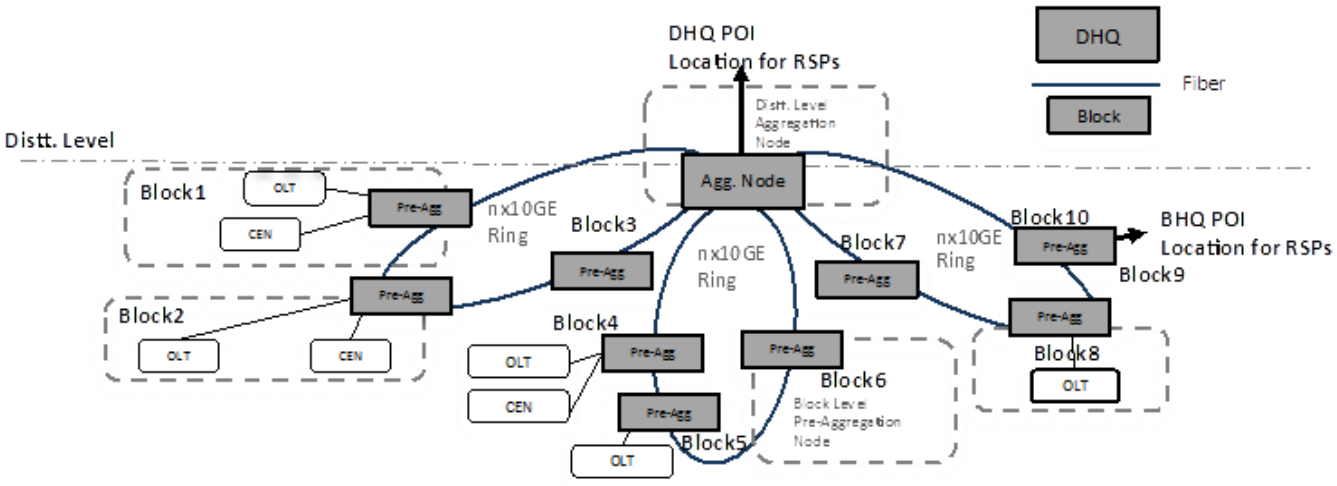
3.12 Investment in the network would be productive only if it is available to multiple users so that the energies unleashed by competition amongst them enable efficient service provisioning to people. The Technical Advisory Committee (TAC) in its recommendations in March 2012 had recommended that all available fibre, irrespective of source should be treated as a single administrative domain and an arrangement for accessing this available asset should be entered into. The efforts of BBNL to explore dark fibre leasing from private service providers have not borne much fruit. In the consultations, the Committee could notice reluctance in BSNL to share dark fibre especially from Districts to Block. The Committee was informed that the optical fibre cable had been laid by BSNL over 20 years and fibre cuts due to developmental activities over time had caused attrition in quality and availability. The Committee was also conscious that given the uncertainty over the long-term availability and health of BSNL fibre, constructing a business model for effective use of investment in the BHQ to GP connectivity layer may be restricted. The Committee was also informed of the problems in service provisioning in the existing architecture of NOFN as a result of which a new project, the Government User Network (GUN) overlay, was conceived. The Committee also noted the results of the three pilot projects where no private service provider or BSNL was interested in utilizing the infrastructure created. BBNL's Report on Pilot Projects of NOFN submitted in February 2014 stated that one of the reasons was that TSPs, ISPs and MSOs were reluctant to source bandwidth at commercial rates and were looking at different models given the poor return on investment in rural areas (section 5.4 of the BBNL report). The Committee gave a deep thought to all these factors, the experience of the pilot projects and the feedback obtained during consultations. The Committee was unanimous in its view that the DHQs to BHQs connectivity should also be factored in the project architecture, though it would mean higher project investment outlay, in order to ensure that the investment would be gainfully utilized in kick-starting a broadband eco-system in rural areas and not be limited to Government services provisioning alone. The Committee also was of the opinion that ring architecture for the DHQ to BHQ connectivity layer is an absolute must as this layer aggregates traffic across Blocks. Fibre cuts in the DHQ to BHQ connectivity layer could cause disruption in services affecting QoS and deter utilization of fibre assets by providers serving users by laying the last-mile network linked to the proposed network.

3.13 The Committee considered the cost implication for its recommendation of considering DHQs-BHQs connectivity as a component of the project. Based on a sample study of 499 blocks in 19 States[4], the average length of optical fibre cable per block for DHQs-BHQs connectivity works out to 28.65 km. Out of the 499 blocks, 52.4% are presently connected through ring topology and 47.6% are connected through linear topology. If all the blocks were to be connected on ring architecture, the average length per block would be approx. 40 km. For all 6500 blocks in the country, the total additional length of optical fibre to be laid, assuming ring optimization margin of 10%, would be 2.34 lakh km involving an investment of Rs 9360 crore. There would, however, be a saving on account of fibre leasing costs which BBNL would have had to pay to BSNL for leasing their fibre for District to Block connectivity. *(see figure 3.2 on page 43)*

3.14 Having come to a conclusion that the middle mile connectivity layer should be considered in its entirety, the Committee was confronted with three questions on architecture, media and topology:-

[4] The States considered were Assam, Bihar, Chhattisgarh, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Tripura, Uttar Pradesh and West Bengal

Figure 3.2: Middle Mile (DHQ-BHQ) Service Orchestration Layer



(a) Should the incremental fibre approach from point of interconnect (PoI) to GP be adopted to lower cost as in the existing design of NOFN or should fresh optical fibre cable be laid from BHQs to GPs?
(b) Should optical fibre be the only media of connectivity between BHQ to GP or other media should also be considered?
(c) Should linear topology be continued for BHQ-GPs connectivity or should ring topology be considered or should a hybrid approach be adopted and what are its implications on additional length of optical fibre cable to be laid with cost implications?

The Committee has given its considered thought on these questions on the basis of available data, BBNL's planning for NOFN and partly through a sample planning study conducted by the Government of Andhra Pradesh in Guntur district.

Incremental Fibre v/s Fresh Fibre: BHQ to GP connectivity

3.15 The existing architecture of NOFN is to lay incremental fibre from PoI to GPs leveraging on the existing fibre available from BHQ to PoI. Initially, it was felt that the optical fibre assets of all three CPSUs could be utilized. However, at the time of planning, it was realized that the optical fibre of PGCIL carried on their electricity transmission lines could not be practically included in network architecture due to right-of-way problems over private lands and practical issues in maintenance of fibre assets. Similarly, the optical fibre cables of Railtel were along railway lands and not easily conducive to link GPs. Therefore, for all intents and purposes, the existing fibre leveraged for the purposes of NOFN for laying incremental fibre were only BSNL fibre assets.

3.16 In order to understand the relative cost impact of laying fresh fibre from BHQs to GPs in comparison to the incremental fibre approach, geographically mapped data from the planning of BBNL was considered. Sample blocks from States - Assam, Haryana, Himachal Pradesh, Jharkhand, Kerala, Maharashtra, Odisha, Rajasthan, Uttar Pradesh (East), Uttar Pradesh (West) and West Bengal – were evaluated for additional length of optical fibre cable. The table below captures the data on incremental fibre and existing fibre in these States *(see table 3.1 on page 44)*

From the table, the average length of fresh fiber to be laid per GP to connect GPs to the BHQs is 4 km. On the other hand, the incremental fibre to be laid according to the existing design is 2.29 km obtained from the planning for 77,073 GPs.

3.17 The Committee was presented with the fibre health data of BSNL for a sample of 10 districts in Karnataka, Bihar and Haryana.

Table 3.1: Fibre length from Block to Gram Panchayat – Sample study

State	No. of GPs	Incremental fibre cable (km per GP)	Existing fibre cable (km per GP)	Total fibre cable Block to GP (km per GP)
Assam	490	2.04	2.77	4.81
Haryana	1349	1.71	1.55	3.26
Madhya Pradesh	7854	1.45	3.17	4.62
Maharashtra	184	2.00	2.15	4.15
Rajasthan	6241	3.09	2.96	6.05
Uttar Pradesh (East)	661	0.74	1.52	2.26
Uttar Pradesh (West)	535	0.85	1.87	2.72
All India	**77073**	**2.29**	**1.70**	**3.99**

The data showed fibre attenuation loss ranging from 0.3 dB per km to 2.6 db per km. Normally, acceptable fibre attenuation loss should be around 0.5 dB per km. In addition to the attenuation loss in the existing BSNL fibre, there would be losses on account of splitters, connectors and the incremental fibre being laid. The splitting of fibres in the present architecture would further exacerbate the problem of link losses. The adoption of GPON technology does not allow compensation for attenuation losses. If losses exceed the acceptable limits as would most likely be, then services provided would be substantially degraded. Prudent planning for a network of the scale being constructed requires that fresh fibre be laid at a marginal additional cost rather than be tied to existing fibre whose quality may be below acceptable limits. Therefore, the Committee strongly recommends that fresh optical fibre cable be laid for BHQ to GPs connectivity for acceptable quality and greater reliability.

Media for Connectivity

3.18 Where the number of HHs in a GP is less than 500, the capital investment in providing connectivity optical fibre would be very high. The sample data of 154,682 GPs shows that there are about 14% GPs which require over 5 km of incremental fibre under the existing architecture for connectivity with 11% of GPs falling in the range of incremental fibre laying of 5-10 km. The average cost for laying optical fibre per km has been estimated by BBNL at Rs 4 lakhs per km (excluding electronics). If the fresh fibre for BHQ-GP principle is followed then the fibre cable to be laid may exceed 7 km. Therefore, the average cost of connecting these GPs in the existing architecture would be in excess of Rs 28 lakhs per GP. There may be a need to explore other media for providing broadband connectivity at a lower cost. The Committee explored the possibility of using alternative media like Radio and Satellite to cover GPs with a low population density and high fibre laying requirement.

3.19 The Committee considered the possibilities of middle mile connectivity using licensed radio spectrum instead of optical fibre. Radio spectrum offers lower capacity and scalability options as compared to optical fibre. The table below captures the key features of licensed radio spectrum to deliver middle mile broadband connectivity *(see table 3.2 on page 45)*

3.20 The Committee considered another option of using unlicensed band radio (UBR) spectrum i.e. 5.8 GHz spectrum which has been delicensed for wi-fi usage for connecting GPs. UBR technology compared to licensed band radios requires lower power, lesser space requirements for poles/masts and supports point-to-multipoint connectivity. UBR by its very nature, is not exclusive and is, therefore, nor protected from interference. However, considering the nature of GPs proposed to be connected through radio (low population density and large distances), it appears unlikely that spectral interference would be a possibility. Spectral capacities of licensed and UBR are almost similar. Besides, the capital costs for UBR based connectivity arrangements are lower compared to licensed band radio connectivity. Hence, the

Table 3.2: Licensed Band Radio Spectrum Features

<table>
<tr><th>Key factors</th><th>Features of Licensed Band Radio Spectrum Backhaul</th></tr>
<tr><td>Service</td><td>Point-to-Point, Multipoint-to-Point Backhaul</td></tr>
<tr><td>Spectrum</td><td>15/18/23 GHz: Microwave Access (MWA);
7GHz: Microwave Backbone (MWB)
3.3 GHz: Broadband Access</td></tr>
<tr><td>Capacity</td><td>150-200 Mbps (~300Mbps with X-polarization)</td></tr>
<tr><td>Reach</td><td>Depends on antenna size
<table>
<tr><th>Antenna size</th><th>Distance</th><th>Antenna Size</th><th>Distance</th></tr>
<tr><td>0.6 m</td><td>0-3 km</td><td>1.2 m</td><td>3-8 km</td></tr>
<tr><td>0.8 m</td><td>8-12 km</td><td>2.4 m</td><td>>12 km</td></tr>
</table></td></tr>
<tr><td>Performance</td><td>High</td></tr>
<tr><td>Maintenance</td><td>Maintenance costs are higher than optical fibre.</td></tr>
<tr><td>Physical Infrastructure requirements</td><td>Towers Mast at Block and GP
GP Mast: 15 m
Block Mast: 20 m</td></tr>
<tr><td>Power requirements</td><td>70-120 Watts for 15/18/23 GHz
6.5-8 Watts for 7 GHz</td></tr>
<tr><td>Architecture</td><td>Split architecture with indoor rack space for 15/18/23 GHz
All outdoor; no rack space required; powered using Ethernet.</td></tr>
<tr><td>Cost</td><td>Rs 13.4 - 15 lakhs per hop.</td></tr>
</table>

Committee felt that both licensed and unlicensed band radios may be considered depending upon the surveys, ground realities of terrain and line of sight (LOS) requirements while deploying it. The table below captures the key features of licensed radio spectrum to deliver middle mile broadband connectivity *(see table 3.3 on page 46)*

3.21 Given the limitation of bandwidth capacity and scalability, recourse to licensed radio spectrum or unlicensed band radio spectrum, as the case may be, for broadband connectivity between BHQ and GP may be considered for those GPs where the estimation of bandwidth over 10 years is expected to be less than 300 Mbps. Table 2.1 indicates the percentage of GPs where number of HHs is less than 500 and in addition, where the fibre to be laid to connect the GP is 7.5 km or over, it may be more cost effective to serve the broadband requirements through licensed radio spectrum. The Committee estimates that in about 20,000 GPs (8% of all GPs), the reach to these GPs would be through radio spectrum. The capital investment for reaching 15,000 GPs through licensed band radio spectrum (assuming single hops) is Rs 3000 crore. On the other hand, if unlicensed band radio spectrum is used for connectivity, the capital cost would be Rs 200 crore. The Committee understands that microwave spectrum is allocated administratively

Table 3.3: Unlicensed Band Radio Spectrum Features

Key factors	Features of Unlicensed Band Radio Spectrum Backhaul
Service	Point-to-Point, Multipoint-to-Point and Multipoint-to-multipoint Backhaul
Spectrum	5.48 GHz (delicensed spectrum)
Capacity	P2MP of 150 Mbps (i.e. 5 GPs of 30 Mbps each), or P2Pof 200 Mbps
Reach	P2MP: up to 6 kms; P2P: up to 25 kms.
Performance	Medium due to possibilities of spectrum interference.
Maintenance	Maintenance costs are higher than optical fibre.
Physical Infrastructure requirements	Towers Mast at Block and GP lower than that required for Licensed Band Radio network due to better propagation characteristics of spectrum. GP Pole: 9 m Block Mast: 20 m.
Power requirements	8.5 W
Architecture	All outdoor; no rack space required; powered over Ethernet
Cost	Rs 1.1 lakhs per hop.

and regulatory compliances have to be completed before BBNL is able to provide services using licensed band radio spectrum.

3.22 Data obtained from Census-2011 indicates that in 4.3% (10,708 GPs) of the total number of GPs, there are 150 or less HH in the GP requiring bandwidth provisioning of 10-30 Mbps. The geographical terrain in such areas may make broadband connectivity difficult through optical fibre or radio. Given the extremely low population density and the difficult terrain, satellite media may be most appropriate for delivery of broadband in certain parts of the country. The State of Arunachal Pradesh (1756 GPs) and parts of Himachal Pradesh (Lahaul & Spiti [41], Kinnaur [65] and Chamba [252] districts), Jammu & Kashmir (Leh [93], Kargil [95] and Kishtwar [134] districts), Uttarakhand (border districts [750 approx]), North-Eastern Region [250], Panchayats in Union Territories i.e. Andaman & Nicobar Islands [30 out of 69 GPs], Dadra & Nagar Haveli [11], Daman & Diu [14] and Lakshadweep [10] are areas where satellite media provisioning needs to be explored.

3.23 The Committee has studied the inputs it received from the Indian Space Research Organisation (ISRO). The inputs indicate that availability of satellites may limit the availability of satellite media. ISRO states that it is feasible to serve concurrently 15000 locations each with 3 Mbps bandwidth through one high throughput K_a-band satellite that can be made available within 30 to 36 months. Bandwidth of 3 Mbps may not be sufficient to meet requirements. Therefore, the number of GPs to be provided bandwidth of 10-30 Mbps using satellite media has to be restricted to 3000. Thereby, the Committee recommends that in areas mentioned above where the distance of the GP from the Block HQs is over 10 kms, satellite media may be used to provide broadband at the GP level.

3.24 Based upon the inputs received from ISRO, the Committee estimates that 3 satellite

Gateways (11m/9m antenna, diversity terminals comprising of identical Gateway antenna and Radio Frequency electronics) and optical fiber connectivity to the Gateways would need to be established in the country. Each Gram Panchayat will have 1.2m or 0.8m size antenna user terminal capable of uplinking up to 2Mbps and downlink up to 40 Mbps. High data rate (uplink and downlink) can also be achieved by appropriate selection of antenna/Block Up Convertor (BUC) size and modems. ISRO has informed that if GPs are located in selected few areas, much more efficient satellite connectivity can be envisaged by adopting customized satellite-configuration.

3.25 ISRO has further informed that presently, no K_a-band satellite in Geostationary orbit is available with Indian coverage to provide the broadband services. The high throughput satellites like IPSTAR in K_u-band, O3B constellation in K_a-band (constellation of MEO satellites), INTELSAT Epic technology, etc. can be considered as possible options to meet immediate requirements. ISRO has suggested that hiring the services from these satellites for broadband usage needs careful study, review and assessment based on the offerings made by these manufacturers.

3.26 ISRO has stated that the cost of user-terminals and Gateways depends on multiple factors like bulk procurement, air-interface technology, redundancy, link-availability, etc. As a broad estimate, while each user terminal may cost about Rs 40,000 (US $ 600), the estimated cost of each Gateway including the diversity-sites is about Rs 50 crore (US $7 million). Therefore, the total cost for connecting 3000 GPs with satellite media would be Rs 162 crore. Additionally, the recurring expenditure in terms of satellite transponder (space bandwidth charges) would need to be paid. Department of Telecom and Department of Space would need to jointly work out a mechanism so that these charges are moderated. The other operations and maintenance charges also needs to be considered.

GP: Linear or Ring

3.27 For answering the issue of topology for the BHQ-GP connectivity layer, the Committee referred to the recommendation of the TAC in March 2012 which had advised that network topology using redundant paths or linear paths may be selected depending on the terrain, field survey and customer requirements. Clearly, for the utilisation model outlined in Chapter 6, service levels of three nines and higher (>99.9) is the bare minimum. The Committee has had the benefit of the desktop survey sample attempted by the Government of Andhra Pradesh in one district i.e. Guntur. The survey results indicate that for ensuring ring topology to two-thirds of GPs, the additional fibre cable requirement is 23%. The Committee, despite some efforts, could not complete studies for few other districts across the country. Therefore, the Committee accepts the findings of the single district survey results to postulate that the ring topology to 66% of GPs may be attempted for which it is assuming an additional cost of 25% of the capital investment estimated for BHQ to GP connectivity on linear topology as per the GIS-based survey conducted by BBNL. The Committee also recommends that GPs for which fibre has been laid in Phase-I may be re-planned from the viewpoint of ring topology and additional fibre, if required, may be laid for achieving fibre rings. *(see figure 3.3 on page 48)*

Last Mile Connectivity

3.28 The Committee feels that BharatNet should limit its aspirations to ensuring middle mile connectivity and putting together a business model that would incentivize private service providers of various hues to provide services by laying the last mile infrastructure, if needed, to reach citizens and households in the most efficient and economic manner and using the best technology available for providing the particular service required. This view was also echoed during consultations with different stakeholders. Therefore, the Committee refrains from making any recommendations on last mile connectivity except in respect of Government services.

3.29 As discussed in Chapter 2 in the section titled "National Information Infrastructure and Horizontal connectivity", the last mile connectivity layer for Government services through optical fibre cable to 25 Government institutions at the District level, 10 at the Block

Figure 3.3: Middle mile (BHQ-GP) Topology

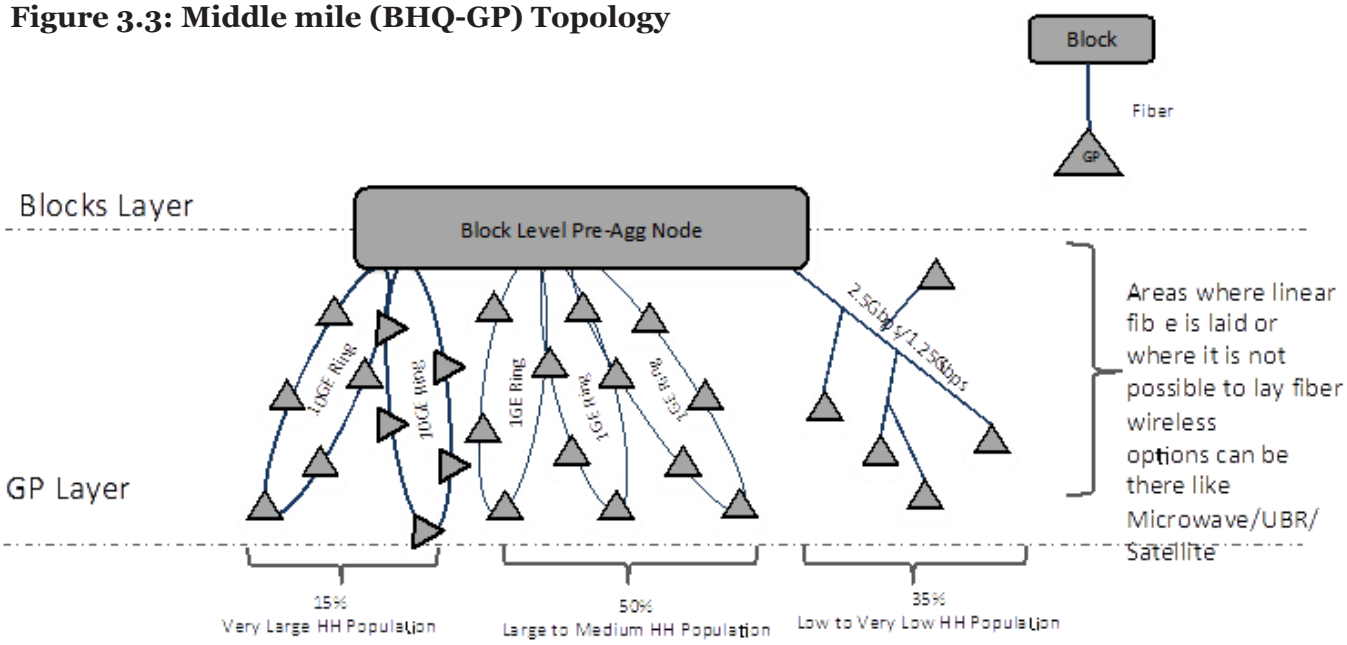


Table 3.4: Horizontal Connectivity to Government Institutions and its cost

Horizontal Connectivity Layer	Number	No. of institutions	Average distance (km)	Cost per km[5] (Rs lakhs)	Cost estimates (Rs crore)
District	675	25	2	2	675
Block	5825[6]	10	1	2	1165
GP	250000	3[6]	0.5	0.5	1250
Total		**825,125**			**3090**

level and 3 at the G.P level may be provided in the restructured network, including L3-CPE (Consumer Premises Equipment) at the institution's end. The Committee notes that a proposal by the Department of Electronics and I.T on the project structure for NII and the proposal by the Department of Telecommunications for Government User Network (GUN) overlay had planned and estimated horizontal connectivity to Government institutions at the three levels mentioned above.

3.30 The Committee assumes that horizontal connectivity to Government institutions at the District and Block level would be through 4/8-core optical fibre located at an average distance of 2 km per district and 1 km per block. The optical fibre to Government institutions at GP would be through 4-core optical fibre located at an average distance of 500 m per G.P with the fibre being carried overhead preferably on electricity poles

[5] Includes cost of L3-CPE device for connectivity to institutions (modem pair) and L3-Router switch.

[6] 6500 Blocks less blocks located at District Headquarters i.e 675.

[7] The third PoP would be at the termination point in the G.P (Panchayat Bhawan or school as may be determined by the State Government). Therefore, no extension of optical fibre is envisaged.

in the GP. Suitable arrangements for right-of-way over electricity poles will have to be arranged by the Department of Telecommunications and BBNL with State Government and State Electricity Utilities.

3.31 The Committee was of the opinion that the institutions that need to be connected through optical fibre at the three levels must be specifically identified and limited to those institutions where speed and reliability are of essence. If other Government institutions desire to connect to the PoP at the District, Block or G.P through optical fibre, they may be permitted by BBNL on payment of capital cost for laying fibre.

3.32 The average cost of OFC procurement, trenching and laying per km is estimated at Rs 2 lakhs at District and Block level and Rs 50,000 at GP-level. Based on these estimations, the cost of horizontal connectivity to Government institutions is indicated in the table 3.4 on page 48.

Fibre Parameters

3.33 Based upon the discussions in the preceding paragraphs, the Committee summarises its recommendations on optical fibre for the proposed network in the table 3.5 on page 50.

Technology Choice

3.34 The Committee considered the views that were received during consultations and the recommendations in the background of the technology choice made for the existing network architecture of NOFN. The technology choice was dependent on the architecture that promoted efficient service delivery, better QoS, reliability and redundancy. The growth in bandwidth usage expected over time required the technology choice to be scalable to meet emergent bandwidth needs.

3.35 The Committee felt that the technology choice must factor in the nature of services capable of being delivered over the network. The table below describes the characteristics of services that are expected to be delivered in the table 3.6 on page 51

Thereby, the chosen technology should be capable of delivering multipoint connectivity along with IP multicast efficiency at high reliability and security.

3.36 The world is moving away from point-to-point circuit switching to multipoint packet network due to low cost, better utilization of bandwidth due to statistical multiplexing of packets, and to support QoS for real time traffic (voice, video etc.) as well as non-real time traffic (email, browsing etc.). The advent of optical communication supported huge bandwidth along with good quality packet technologies and made the above low cost communication possible. In packet networks, the well-known routing protocols for IP traffic are based on IPv4/ IPv6 addressing schemes. Hence, backbone, aggregation and access networks are migrating towards IP like IP-based VoIP, video etc. which require real time communication over backbone and last mile.

Technology choice: DHQ-BHQ Layer

3.37 The DHQ-BHQ layer will be consolidating aggregated demand emerging from GPs into fewer interfaces at DHQ level and providing point of interconnects (PoIs) for traffic to flow across multiple backbone networks. It will be used as wholesale network infrastructure open to all without limiting it to only few or captive services requirement of a single network.

3.38 From the services point of view, it was suggested that many current and future services delivery will require not only Layer-2 point-to-point connectivity but also point–to-multipoint and multipoint-to-multipoint connectivity services with the option of both Layer-2 and Layer-3 virtual private networks (VPNs). In addition, efficient IP Multicast based connectivity services will be required for many video content based applications like e-Education, e-Health, e-Skills, video conferencing etc. as well as content delivery for IPTV & cable service providers.

3.39 Multi-Protocol Label Switching (MPLS) is one of the technologies well accepted for packet networks. The Committee examined as

Table 3.5: Fibre parameters for proposed network

	Layer	Recommendations	Remarks
Fibre	BHQ-GP	24 core fibre	Scalability, service oriented and non-discriminatory access by making fibre available for service provisioning through business models outlined in Chapter 4
	DHQ-BHQ	48/96 core fibre	Scalability, service oriented and non-discriminatory access by making fibre available for service provisioning through business models outlined in Chapter 4
	Horizontal connectivity	4/8 core fibre	Government services provisioning
Laying of fibre	BHQ-GP, DHQ-BHQ & Horizontal connectivity	Underground at 1.65 m depth Overhead fibre where laying of underground fibre is infeasible or expensive limited to GPs where linear topology for BHQ-GP is proposed to be adopted. Use of overhead fibre will be resorted to in the rarest of rare cases when no discernable option of laying underground fibre is possible.	Security, reliability and keeping in mind ground realities.
PLB Duct	DHQ-BHQ	50 mm	
	BHQ-GP & Horizontal Connectivity	32 mm	
Fibre topology	BHQ-GP	66% ring; 24% linear (Rest by other media)	Reliability, consolidation of network and keeping in mind ground realities for SLA maintenance.
	DHQ-BHQ	100% ring	Reliability, consolidation of network and keeping in mind ground realities for SLA maintenance.
	Horizontal connectivity	Linear	Government service provisioning

Table 3.6: Services requirements

Services	Multipoint connectivity	Point to Point connectivity	Asymmetric Bandwidth	IP Multicast capability	Other requirements
e-Governance	✓	x	✓	✓	Reliability and security
e-health, e-education	✓	x	x	✓	Delay & packet loss sensitive, reliability, security
e-banking	✓	x	✓	x	Delay & packet loss sensitive, reliability, security.
Multi-party video conferencing	✓	x	x	✓	Delay & packet loss sensitive, reliability.
Mobile backhaul	✓	x	✓	✓	Delay & packet loss sensitive, high IP efficiency, reliability, clock synchronization.
Cable TV/IPTV	✓	x	✓	✓	Delay & packet loss sensitive, high IP efficiency, reliability.
Cable Broadband	✓	x	✓	x	Delay & packet loss sensitive, high IP efficiency, reliability.
Wi-fi connectivity	✓	x	✓	x	High IP efficiency, reliability, security and web-based/SIM authentication.
Cloud services	✓	x	✓	✓	Delay & packet loss sensitive, reliability, virtualization readiness.
Networks convergence	✓	x	x	✓	Seamless interconnect with existing networks, reliability, security.

to whether IP/MPLS or MPLS-TP is the more suitable technology for the desired network infrastructure.

3.40 Technology options were examined from services delivery efficiency & scalability perspective, making it clear that any Layer-2 point-to-point only transport oriented technology impacts scalability due to large number of point-to-point circuits provisioning and their associated operations & maintenance, IP Multicast inefficiencies as well as scale requirements on associated Layer-3 devices due to high number of virtual circuits. Additionally, the lack of IP VPNs, point–to-multipoint, multipoint-to-multipoint connectivity services and efficient IP Multicast capabilities can limit the network monetization options due to the additional requirement of building and integrating multiple overlay IP networks.

3.41 This network infrastructure will be acting as converged backbone integrating various Government networks like NKN/NII and SWANs as well as existing DCN (Data Communication Network) of BBNL eliminating overlapping expenses across multiple networks. Any transport-oriented technology will not be able to provide these consolidated convergence capabilities as overlay IP networks will still be required to be retained.

3.42 IP/MPLS with Traffic Engineering (TE) helps in better IP traffic routing optimally and support for QoS. In case of congestion, TE technology will help to monitor and divert traffic through better available path.

3.43 The Committee also examined whether there can be mix of different MPLS technologies across DHQ, BHQ and GPs. Mixing of different MPLS technologies in a network will lead to two different control planes, fragmented provisioning across two different technologies – for static control plane and dynamic control plane - using two different Element Management Systems

Table 3.7: Middle Mile Layer - DHQ to BHQ- Comparative Technology Options

Criteria	Carrier Ethernet (IP/MPLS)	Carrier Ethernet (MPLS-TP)
Service Richness	**HIGH** • P2P, P2MP & MP2MP services • Both Layer 2 & Layer 3 services available • Optimized IP Multicast Delivery	**LOW** • P2P & Layer 2 Transport only • Not optimized for IP Multicast delivery, LTE & Wi-Fi multipoint Backhaul
	How MPLS-TP fares in comparison to IP/MPLS • P2P & L2 only service limits monetization capabilities of the network. • Inefficient IP Multicast transport for video applications. • Vendor specific/proprietary P2MP & MP2MP implementations in MPLS-TP hamper interoperability & services uniformity	
Service Oriented	**YES** • Provides multiple options for various onboarding services modules required for P2P, P2MP, MP2MP Layer 2 and Layer 3 VPNs • The use of mature IP or L3VPN technologies is particularly common in the design of LTE deployment plans • IP Multicast VPNs	**NO** • P2P Layer 2 transport circuits only • Sub-set of IP/MPLS technology largely to replace legacy transport technologies, such as SONET/SDH • MPLS-TP is not designed to replace the services support capabilities of such as L2VPN, L3VPN, IPTV, LTE RAN, etc.
	How MPLS-TP fares in comparison to IP/MPLS • Network not optimized for Broadband, IP services & video requirements. • Deploying overlay networks for L3 & Multipoint services increases costs & complexities • Convergence of overlapping IP networks not possible	
OAM Support	**GOOD**	**GOOD**
Adoption & Interoperability	**HIGH** • Well Standardized functionalities • Widely deployed in India as well as globally for 10+ years in networks • Wider OEMs support • Proven multivendor interoperability	**MEDIUM** • Standards still evolving (specially on P2MP and IP Multicast VPNs, MP2MP, Layer 3 VPNs not in scope of MPLS-TP framework) • Very limited deployments in networks • Limited OEMs support • Limited multivendor interoperability (labs only)
	How MPLS-TP fares in comparison to IP/MPLS • Vendor Specific/proprietary implementations for missing functionalities impacts interoperability • No service level secured & seamless interoperability with other IP/MPLS networks like SWANs/NKN etc. for creating CUGs with e2e SLA management. • Video inefficient network • Risk of Sustainability & of being “experimental network”	

<table>
<tr><td rowspan="2">Reliability & Availability</td><td>HIGH
• Both protection & restoration capabilities with established standards for ring/mesh topologies</td><td>MEDIUM
• Linear Protection only
• No OR manual with complex restoration planning during multiple fiber failures across rings/mesh
• Ring protection is not fully approved standard.</td></tr>
<tr><td colspan="2">How MPLS-TP fares in comparison to IP/MPLS
• Vendor specific implementations for 1:N linear or ring protection will impact interoperability
• Multiple failure across rings can impact SLAs in the event of lack of automatic restoration capabilities</td></tr>
<tr><td rowspan="2">Scalability & Traffic Efficiency</td><td>HIGH
• P2P, P2MP and MP2MP with L2 & L3 VPNs natively provides service scalability
• IP Multicast Efficiency
• IP Traffic transport efficiency
• IPv4 & IPv6 optimal traffic selection & routing</td><td>LOW
• 70% more overheads for IP traffic over L2 P2P circuits
• No IPv4 & IPv6 intelligence for traffic selection & routing</td></tr>
<tr><td colspan="2">How MPLS-TP fares in comparison to IP/MPLS
• n*(n-1) scale issues with P2P only circuits for P2MP and MP2MP services.
• Inefficient IP Multicast delivery</td></tr>
<tr><td>Power Requirements</td><td>75-80Watts</td><td>75-80Watts</td></tr>
<tr><td rowspan="2">Operational Complexity</td><td>MEDIUM
• Single touch provisioning when adding end points due to Dynamic Control Plane
• No need of multiple platforms integration due to native P2MP, MP2MP Layer 2/Layer 3 VPNs & IP Multicast services</td><td>HIGH
• P2MP or MP2MP connectivity using P2P only circuits adds complexities due to n*(n-1) scale issues
• Manual complex planning due to linear protection.</td></tr>
<tr><td colspan="2">How MPLS-TP fares in comparison to IP/MPLS
• No single touch provisioning when adding service end points to existing service making complex service provisioning
• Multiple platforms integration due to missing native support for Layer3 VPNs, IP Multicast routing support, P2MP & MP2MP Services
• Large Layer 2 networks become more complex to troubleshoot impacting MTTR & SLAs
• Scalability and Sustainability issues</td></tr>
</table>

Control Plane Complexity	**MEDIUM** • Complexity relative to the number of nodes in single network domain • Global and Domestic networks deployments experience of >500 to 1000 nodes in single domain	**LOW** • Static Control plane more suited for Point to point SDH to packet migration scenarios
	How MPLS-TP fares in comparison to IP/MPLS • IP/MPLS Complexity does not impact due to network being per District disjointed domains • NMS/EMS based Static control plane limits multi-vendor interoperability	
Faster Monetization of Network	**HIGH** • Because of Services richness	**LOW** • Lower due to bit pipe service.
	How MPLS-TP fares in comparison to IP/MPLS • Providing bit pipe transport only limits monetization options due to limited service capabilities. • Impacts quick onboarding of Smaller Enterprises, ASPs/ISPs/TSPs as each of them have to deploy multiple overlay IP routers with higher CAPEX & OPEX	
Software Defined Network (SDN) and Network Function Virtualization (NFV)	• IP/MPLS ahead of the technology curve w.r.t. SDN & NFV functionalities • High Industry traction and clear roadmaps towards SDN & NFV capabilities with IP/MPLS	• MPLS-TP behind the technology curve for SDN and NFV • Lesser industry traction & no clear roadmaps towards SDN & NFV capabilities with MPLS-TP
	How MPLS-TP fares in comparison to IP/MPLS • SDN and NFV complement each other and together will increase network control, QoS and reduce cost. • Helps delivering automated network connectivity services, applications like bandwidth on demand, bandwidth calendaring etc.	

(EMS) or Network Management Systems (NMS), fragmented operations & maintenance in the network impacting SLA, bringing in more complexities & challenges rather than simplifying the network from services delivery point of view. It will also not solve the challenges & issues associated with point-to-point Layer-2 only transport technology as outlined in paragraphs 3.38 and 3.40.

3.44 Considering all above aspects, the Committee recommends IP/MPLS as the technology of choice for DHQ-BHQ layer that would assist in creating a services oriented network. The table below encapsulates the technology comparisons between IP/MPLS and MPLS-TP *(see table 3.7 on page 52)*

Technology choice: BHQ to GP Layer

3.45 The Committee examined Gigabit Passive Optical Network (GPON) and Carrier Ethernet Network (CEN) i.e. IP/MPLS or MPLS-TP as the

technology choices for both ring topology and linear topology suggested for this layer. GPON has traditionally been a last mile technology for residential broadband without any large known ring based deployments between OLT & ONTs. Being passive technology, deploying GPON over ring topology is complex and economically unattractive which requires more complex planning, high number of passive splitters usage affecting link loss budgets resulting into wastage of fiber cores. Additionally deploying GPON over ring topology leads to inefficient port utilization on OLT since one port will always be in standby mode as well as would require dual PON port ONTs further leading to technical as well as economic inefficiencies.

3.46 The Committee, therefore, recommended that CEN would be preferable to GPON as the recommended technology option for ring topology providing services oriented network along with high reliability. For linear topology GPON may be preferred if the GPs are grouped and CEN if the GPs are dispersed also depending upon the distances as well as how many GPs can be connected over single fiber core using passive technology with the available power loss budgets.

3.47 The Committee also examined the better technology option amongst the two CEN choices (IP/MPLS or MPLS-TP) for the BHQ-GP connectivity layer. MPLS technology uniformity is important since technology heterogeneity for same network will result into more complex network due to two different control planes & two different EMS/NMS for provisioning, fragmented operations and maintenance, complex troubleshooting impacting end-to-end SLAs delivery from DHQ to BHQ to GP. Additionally the concerns and issues discussed earlier w.r.t. point-to-point transport technology still remains in the network while creating end-to-end Service Oriented network.

3.48 IP/MPLS with Traffic Engineering (TE) helps in better IP traffic routing optimally and support for QoS. In case of congestion TE technology will help to monitor and divert traffic through better available path. On the other hand, though MPLS with Transport Profile (MPLS-TP) is cheaper, the technology is vendor-specific/ proprietary due to management layer (EMS/ NMS) based static control plane as a result of which there would be a lock-in over time impacting easy multi-vendor inter-operability and scalability. Comparatively, IP/MPLS with TE technology is widely deployed globally and in India and due to dynamic control plane that is not proprietary, not dependent upon the management (EMS/NMS) plane, thereby ensuring freedom in multi-vendor inter-operability and scaling when required. There have been examples of very large IP/MPLS successful deployments with > 500 to 1000 nodes in single network, both India & globally making sure that technology is scalable. The Committee was also conscious that considering the size of investment in the project, the total expenditure on electronics is less than 10%. Therefore, it is more essential to retain flexibility for future scaling rather than select the technology based on cost considerations alone.

3.49 For the BHQ to GP layer, where technologies other than MPLS are used in the networks like GPON (linear fibre topology), radio or satellite, the BHQ level IP/MPLS node will become unifying layer integrating different access layer technologies onto single unifying IP/MPLS service layer delivering homogeneous services experience across the network.

3.50 Considering all above aspects, the Committee recommended the service oriented homogeneous technology option of IP/MPLS at the BHQ to GP layer where fiber ring topology is adopted with GPON for GPs where linear fibre topology is preferred. The table below encapsulates the technology comparisons between IP/MPLS, MPLS-TP and GPON *(see table 3.8 on page 56)*

3.51 During consultations, the general consensus was that Point of Interconnect (PoI) should generally be at District PoP. In order to provide the facility of "enter at any layer, exit at any layer", PoPs should be created at DHQ, BHQ and GP. The laying of optical fibre interlinking the respective PoP with the network of the TSP, ISP, MSO or LCO should be the responsibility of the concerned provider. However, the Committee recommends that BBNL shall facilitate the provision of free right-of-way available to it for

Table 3.8: Access Layer - BHQ to GP – Comparative Technology Options Points of Presence (PoPs)

Criteria	Carrier Ethernet (IP/MPLS)	Carrier Ethernet (MPLS-TP)	GPON
Service Richness	**HIGH** • P2P, P2MP & MP2MP Services • Both Layer2 & Layer3 Services • Optimized IP Multicast Delivery	**LOW** • P2P & Layer2 Transport Only • Not optimized for IP Multicast delivery, LTE & Wi-Fi multipoint Backhaul	**MEDIUM** • P2P or P2MP Layer2 only • Optimized IP Multicast
Speed	Scalable from 1GE to10GE or multiple 1GE without requiring forklift upgrade of the equipment necessarily	Scalable from 1GE to 10GE or multiple 1GE without requiring forklift upgrade of the equipment necessarily	2.5 Gbps downlink & 1.25 Gbps uplink (Effectively ~1Gbps only for symmetric applications) In GPON scaling from 2.5/1.25Gbps to 10Gbps (XG PON) requires forklift upgrade of OLTs and ONTs
OAM Support	**GOOD**	**GOOD**	**GOOD**
Adoption & Inter-operability	**HIGH** • Well standardized functionalities • Widely deployed for 10+ years in networks • Wider OEMs support • Proven multivendor interoperability	**MEDIUM** • Standards still evolving (Not much progress on P2MP and IP Multicast VPNs, MP2MP, Layer 3 VPNs not in scope) • Very limited deployments in networks • Limited OEMs support • Limited multivendor interoperability	**HIGH** • Well standardized • Mostly deployed as residential last mile • Limited multivendor interoperability • Wider OEMs support
Reliability & High Availability	**HIGH** • Both protection & restoration Capabilities with well established standards for ring/mesh topologies	**MEDIUM** • Linear protection only • No OR manual complex restoration planning during multiple fiber failures across rings/mesh • Ring protection is not fully approved standard yet	**LOW** • GPON most suited & deployed for Linear topologies • Technically may be possible but no deployments over ring topologies due to complexity & cost issues • Wastage of fibre.

Scalability & Traffic Efficiency	**HIGH** • P2P, P2MP and MP2MP with L2 & L3 VPNs natively provides service scalability • IP Multicast Efficiency • IP Traffic transport efficiency • IPv4 & IPv6 optimal traffic selection & routing	**LOW** • n*(n-1) scale issues with P2P only circuits for P2MP and MP2MP services • IP Multicast inefficiencies for Video applications/ traffic • Large Layer 2 Network broadcast flooding, security issues • 70% more overheads for IP traffic over L2 P2P circuits • No IPv4 & IPv6 intelligence for traffic selection & routing	**LOW** • No means of increasing capacity by using link aggregation in steps of nx1GE or nx10GE like CEN • Forklift upgrade for capacity increase • Large Layer 2 Network broadcast flooding, security issues • Carrier Ethernet offers load balancing on rings, which GPON cannot as one of the ports works in Standby leading to underutilization of network
Power Requirements	75-80 Watts	75-80 Watts	~10 Watts
Operational Complexity	**MEDIUM** • Single touch provisioning when adding end points due to Dynamic Control Plane • No need of multiple platforms integration due to native P2MP, MP2MP Layer 2/Layer 3 VPNs & IP Multicast services	**HIGH** • P2MP or MP2MP connectivity using P2P only circuits adds complexities due to n*(n-1) scale issues • Manual complex planning due to linear protection. • Multiple platforms integration due to missing native support for Layer3 VPNs, IP Multicast routing support, P2MP & MP2MP Services • Large Layer 2 networks become more complex to troubleshoot impacting MTTR & SLAs • Scalability and Sustainability issues	**MEDIUM** • Manual non-uniform planning of the network being a passive technology • Power budgets & planning gets impacted with every split of the fiber • Large Layer 2 networks become more complex to troubleshoot impacting MTTR & SLAs
Control Plane Complexity	**MEDIUM** • Complexity relative to the number of nodes in single network domain • Global and Domestic networks deployments experience of >500 to 1000 nodes in single domain • Complexity does not impact due to network being per District disjointed domains	**LOW** • Static Control plane more suited for Point to point SDH to packet migration scenarios • NMS/EMS based Static control plane limits multi-vendor interoperability leading to vendor-locking	**LOW** • NMS/EMS based Static control plane limits multi-vendor interoperability

Deployment span & fibre efficiency	**GOOD** • Connects high number of GPs over single fibre pair being an active technology	**GOOD** • Connects high number of GPs over single fibre pair being an active technology	**LIMITED** • GPON being passive technology, Link-loss Budget limits the deployment area to fewer GPs per PON port even if OLT has many ports • Require lots of fiber cores, OLT ports etc. due to above issue
Termination End points & Fan-out	• Easy fan-out option when moving >4 Ports at GP level with addition of Metro Ethernet Switch	• Easy fan-out option when moving >4 Ports at GP level with addition of Metro Ethernet Switch	• Additional ONT would require split of fiber for another 4 ports (complex) or for fanning out to School, PHC etc. disrupting link loss budgets and further reducing # of GPs/ end points per PON port • Putting Ethernet Switch subtending to ONT for fan out or extension becomes unmanaged solution

the project under the terms of the tri-partite Memorandum of Understanding (MoU) signed with the Central and State Governments for the inter-linking by considering it as an integral part of the project though it shall be paid for and laid by the private service provider.

Data Centres at District Headquarters

3.52 The Committee was conscious that the ultimate objective of creating the broadband infrastructure is the delivery of services to rural population at affordable prices for which the role of service providers including small providers like ISPs and local cable operators becomes an important factor.

3.53 Delivery of good quality service requires a number of servers and applications operating in a Data Centre environment. However, capital cost of having such a setup becomes a hindrance for many small service providers. This is more so in case of providing services to rural areas where the market is yet to be developed and returns on investment are uncertain thereby posing a greater risk on the investments made by the operator. Offering District-level Data Centre services as part of the project at affordable prices can become a very important consideration to promote rural innovation and entrepreneurship besides ensuring delivery of services to rural population.

3.54 Data Centres can offer a variety of services like application hosting, server hosting and managed services in a secure environment for processing, storage and backup, networking, management and distribution of data. Data Centre Services may be offered on non-discriminatory basis to all at affordable prices. It can ensure enhanced scalability to meet business growth. The virtualization platform (cloud) enables provisioning resources on the fly thereby improving time-to-market and agility.

3.55 The Committee suggests that District-level Tier-2 Data Centres of 5-10 racks, co-located with the PoP of the Network be provided, which will function as an integrated PoP interconnecting to different users of the Network including NII. Thereby, there would not be any need to create a separate PoP for the Data Centres. For the purpose, additional space of about 300 sq. ft. may be identified at the co-location point (preferably District Collectorate/Secretariat). Data Centres

Table 3.9: Cost Estimation for District Data Centres

Item	Requirement	Cost per District (Rs lakhs)	Total for 675 Districts (Rs crore)
Space requirement	300 Sq ft		
Civil Work		10	67.5
Electronics			
Servers	5 mid-servers	75	506.25
Storage	10 TB	20	135.00
SAN Switches	2	10	67.50
Security Systems		25	168.75
Management Automation		20	135.00
Virtualization	50 virtual machine licences	10	67.50
Operating Systems		10	67.50
Air conditioning	(5+1) x 2TR	2.50	16.88
Power	50 kVA	10	67.50
DG Set	2 x 50 kVA	8.50	57.38
UPS with 2 hr backup	(5+1) x 10 kVA	7.50	50.63
Total		**208.50**	**1407.38**

requires redundant or backup power supply, redundant data communications connections, environmental controls (e.g., air conditioning, fire suppression) and various security devices which need to be provisioned. The table below indicates the costs estimated for District-level Data Centres *(see table 3.9 on page 59)*

The Committee has estimated the cost of each District-level Data Centres at Rs 2.09 crores. Therefore, for providing District-level Data Centres at all districts, the additional cost would be approximately Rs 1407 crores.

Community Wi-Fi Infrastructure at Gram Panchayats

3.56 The Committee believes that the project should provide community Wi-Fi infrastructure at the GP termination point in wholesale deployment model for a low-cost community access to the public Internet at the G.P and act as broadband stimulant at GPs. The broadband services can be accessed by villagers, by connecting to Wi-Fi hotspot created at GP level.

3.57 The Committee recommends that Wi-Fi infrastructure alone may be provided by BBNL/ State SPV through public investment and the Wi-Fi services delivery could through any licensed Telecom Service Provider (TSP)/Internet Service Provider (ISP) (hereinafter called the "Community Wi-Fi services provider"). At least one hour of free Wi-Fi usage per day for each resident of the GP should be provided by the identified community Wi-Fi services provider for which wholesale bandwidth may be made available by BBNL/State SPV. The investment in the community Wi-Fi infrastructure can be monetized by inviting bids for Internet services using the infrastructure. The Committee feels that through this manner, the investment being made is optimized by creating community Wi-Fi infrastructure at the least cost through shared infrastructure while spreading the public use of the infrastructure and allowing the infrastructure to be monetized. The Wi-Fi service provider can build a business model around advertising revenues (similar to F.M radio) while permitting a base level of public Internet access to all residents of the GP irrespective of economic status. The Committee, however, strongly recommends

that BBNL should in no case become the Wi-Fi services provider to prevent issues of conflict of interest as the owner of infrastructure and provider of services.

3.58 Wi-Fi infrastructure at GP level should comply with Next-Gen Hotspot (Hotspot 2.0) requirement. Hotspot 2.0 is based on the IEEE 802.11u standard, which is a set of protocols published in 2011 to enable mobile like experience providing future proof infrastructure, enforce and encourage authentications and security as well as end-to-end encryption via standard protocols making it trusted to the core network.

3.59 In all carrier grade Wi-Fi networks, the Committee notes that it is a general practice to deploy controller-based architecture for centralized radio resource management (RRM) to maximize coverage and capacity, visibility of entire network in one place while providing visibility in terms of integration, monitoring diagnostics, controlled handoff points in the network with single security & interoperability points between radio access networks for scalability and located at DHQs. Deployment of carrier grade 802.11x (x=n/ac) outdoor Access points at GP level could be considered providing coverage within 100-200m radial distance with centralized controller based architecture located at DHQ PoP. The figure below provides a snapshot of a typical architecture for carrier grade Wi-Fi network *(see figure 3.4)*

3.60 The Committee has estimated the cost for the Wi-Fi infrastructure at each GP to be Rs 895 crore as reflected in the table 3.10 on page 61.

Power Availability

3.61 The Committee is conscious that the suggested technology consumes more power than GPON and therefore, appropriate arrangements for power supply and back-up would need to be made at the three levels of the network. For the DHQ electronics, the Committee has assumed that grid electricity supply would be available and the power back-up can be provided through that provisioned for the District-level Data Centre as shared infrastructure. Therefore, no additional costing for power supply back up for the DHQ electronics is provided. For the BHQ electronics,

Figure 3.4: Typical carrier grade Wi-Fi network architecture

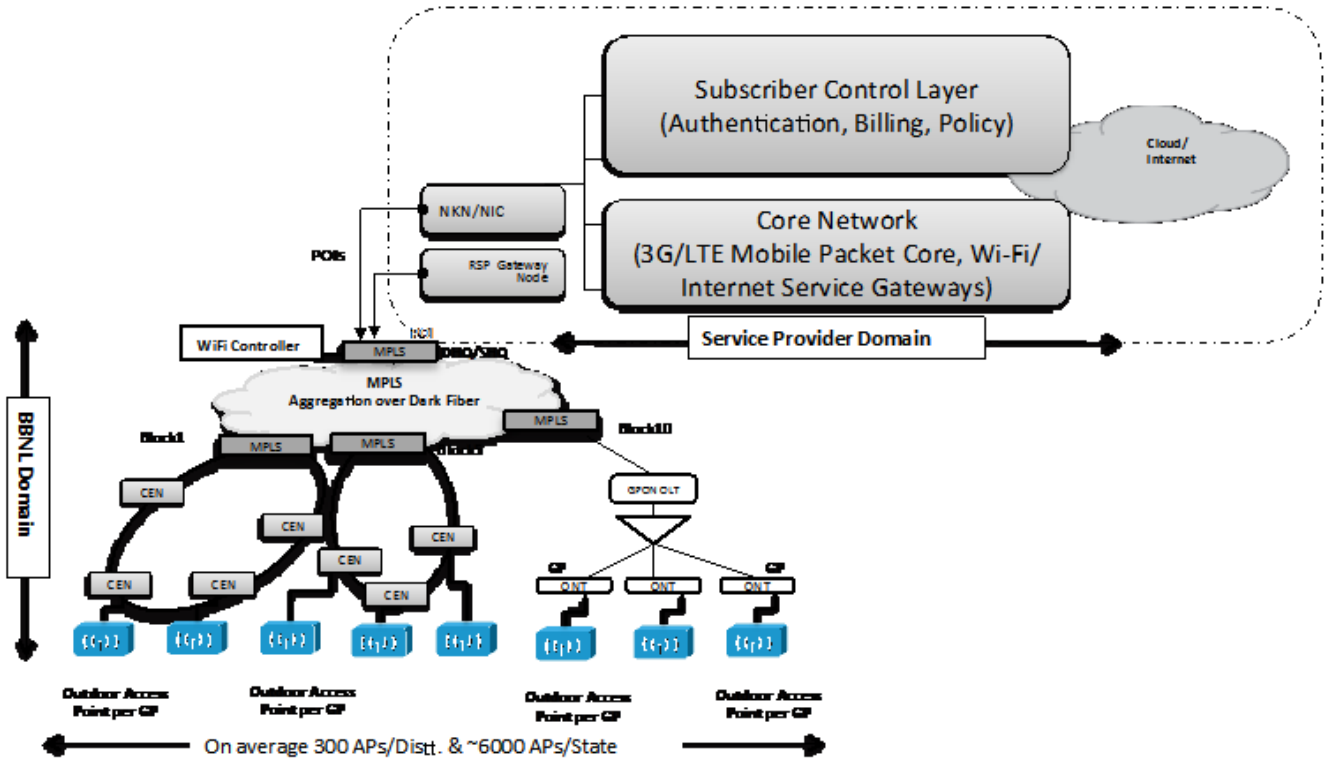


Table 3.10: Cost Estimation for Community Wi-Fi Infrastructure at GP

Item	Quantity	Cost per unit (Rs lakhs)	Total (Rs crore)
Outdoor Access point with External Antenna with accessories including PoE injector, power adaptor, power and data cable	2,50,000	0.35	875
ISP equipment and centralised radio controller at DHQ	675	3	20
Total			**895**

Table 3.11: Cost Estimation for Power back up at BHQ

Item	Capacity	Cost per Block (Rs)	Cost (Rs crore)
D.G set with AMF Control Panel	15 kVA	267750	174
Air Conditioning	2 Ton	36750	24
Online UPS	5 kVA	131250	85
Civil, electrical works and furniture		750000	488
Power connection at PoP (3 kVA)		150000	98
Total			**869**

the Committee has also assumed the availability of grid electricity supply. However, cost for power back up is being separately indicated in the table 3.11 on page 61

3.62 For power supply at GPs, the Committee is conscious of the unreliable electricity availability in rural areas across large swathes of the country. The Committee noted the thrust being given to solar power and improvements in solar energy technology to falling prices. The Committee notes that power availability at GPs will be an important determinant in ensuring SLAs, especially in the context of the suggested technology choice. The Committee also noted its recommendations that the responsibility for maintenance of SLAs rests upon the Implementation Partner defined in Chapter 4. The Committee felt that power solutions should be optimized in such a manner as to arrive at the least total cost (capital investment and operational costs), provided the SLAs are maintained. The Committee believes that given the variability in power solutions across States and the possibility of cheaper methods available at the GP level in the future, it may be best left to the Implementation Partner to arrive at the best solution and build the solution into the bid. Therefore, the Committee recommends that no single solution be suggested for power provisioning at the GP level and the solution be left to the Implementation Partner i.e. the private sector or Implementing CPSU as the case may be, with the specification that at least 8 hours of secondary power back up to go along with the primary power supply suggested by the bidder. The cost of the solution may be built into the annuity submitted by the bidders. Therefore, no upfront cost for power supply infrastructure at the GP level is factored into the capital cost.

Conclusion

3.63 The Committee believes that the proposed architecture and technology enables the building of robust, reliable, services oriented network that will lead India into the knowledge world envisioned under Digital India.

Chapter - 4

Implementation Strategy

Introduction

4.01 National Optical Fibre Network (NOFN) was approved by the Union Cabinet on December 25, 2011. The project was expected to be completed in two years. However, very little progress in project implementation was achieved till May 2014. The assessment of the quarterly progress from January 2013 to February 2015 indicates that although the pace of implementation has accelerated in recent months, it appears extremely unlikely that the target for Phase-I i.e 50,000 GPs expected to be lit by March 31, 2015, will be achieved. Requisite preparation for Phase II (100,000 GPs by March 2016) and Phase-III (100,000 GPs by December 2016) await the report of this Committee.

4.02 Government's vision of Digital India to transform India into a connected knowledge economy through high speed broadband infrastructure with a slew of digital services riding on the information super-highway is critically dependent on the timely completion of NOFN. The Committee, in its deliberations, has been mindful of the scale of the project, the progress achieved and the burst required to meet the deadline of December 2016.

4.03 As part of its Terms of Reference (ToR), the Committee was specifically asked ***"to recommend an implementation strategy so that provision of broadband connectivity is accelerated to connect all GPs by 2016"***.

Limitations of existing Implementation Model

4.04 The work of establishment, management and operations of NOFN was planned "keeping in mind the involvement of a large number of agencies and organisations of Central and State Governments as well as the private sector in creation, implementation and usage of NOFN as a national asset with aggregated and integrated vision"[1]. The Executing Agency (EA) was responsible for laying the incremental OFC connecting GPs to the existing core for broadband connectivity. The actual execution of the work was to be undertaken by the EA through a transparent bidding process. A Project Implementation Team comprising members from Bharat Sanchar Nigam Ltd. (BSNL), RailTel, Power Grid Corporation of India Ltd. (Power Grid), National Informatics Centre (NIC) and C-DOT was to look after various preparatory activities such as GIS mapping, finalization of network design, formulation of bid package and issue related to establishment of a Special Purpose Vehicle (SPV). Bharat Broadband Network Limited (BBNL) was incorporated and designated as the Executing Agency. The choice of the CPSUs – BSNL, RailTel and Power Grid – was made by a High Level Committee constituted for guiding the project architecture and oversight during implementation.

4.05 After the three pilot projects were successfully commissioned, GIS-based survey was undertaken by the three CPSUs – BSNL, RailTel and Power Grid. The acceptance of the results of the survey by BBNL after a protracted process culminated in the issue of a Technical Sanction Provisional (TSP) by BBNL. Procurement of optical fibre cable with accessories and electronic equipment – GPON - was taken up by BBNL and concluded in January 2014 and May 2014 respectively with the issue of the first advanced purchase orders.

4.06 Reference rates per metre were fixed for the components of the project, namely, procurement of optical fibre cable, GPON with accessories and PLB duct and trenching/laying of optical fibre. The last two activities were to be carried out by the CPSUs and the procurement of optical fibre cable and GPON was the responsibility of BBNL. The CPSUs adopted Block as the contracting unit for trenching and laying work and the District/Circle as the unit for procurement of PLB duct. The CPSUs were asked to approach BBNL for approval in case the discovered rates for each contracting unit exceeded 10% of the prescribed reference rates. This was not a practical approach to project management and was evidently not acceptable to the CPSUs. The issue went up to the Telecom Commission which in its meeting on July 2, 2013, advised that decisions on tenders for various components may be taken by BBNL in

[1] Reproduced from paragraph 6.1 of the Note considered by the Union Cabinet in October 2011.

accordance with provisions of General Financial Rules (GFR) and within the limits of the approval of the Union Cabinet for implementation of NOFN. The Telecom Commission also advised that the applicable schedules of rates including state schedule of rates, CPWD or implementing CPSU schedule may be considered for each unit for which tender had been issued. The Telecom Commission clarified this position in its meeting on September 10, 2013, approving the schedule of rates (SOR) followed by BSNL at its Secondary Switching Area (SSA) level or that of the State as on a reference date as the applicable schedule of rates.

4.07 There appear to have been several areas of differences between the CPSUs and BBNL of which the applicable schedule of rates was one instance. This was evident during the consultations that the Committee had with the CPSUs and BBNL. The CPSUs felt that they had not been sufficiently empowered - in project management and in cost compensation – to implement a project of this nature. BBNL, on the other hand, felt that there was a lack of ownership of the project by the CPSUs and lack of accountability in project implementation.

4.08 The Committee felt that it was important to clearly understand the limitations of existing implementation model to be able to suggest suitable alternatives for timely and efficient rollout of the network. The interactions with the CPSUs and BBNL and their written submissions gave a clue on the reasons that impeded the implementation of NOFN. The Committee identified the following factors:

(i) Lack of accountability, financial or otherwise, in project implementation.
(ii) Lack of ownership of the project by the CPSUs and inability of BBNL in ensuring timely project implementation.
(iii) Fragmented nature of project implementation design both in terms of geographical spread while phasing implementation and in assignment of responsibilities for project components leading to co-ordination problems that have arisen and also anticipated to arise in future.
(iv) Emphasis on cost controls leading to lack of empowerment of implementing agencies.
(v) Absence of competitive price discovery for project management.
(vi) Network rollout on a nationwide scale through limited agencies.
(vii) Inadequate human resource available within BBNL to manage the project.
(viii) Lack of adequate advance planning in BBNL for various elements of NOFN –service provisioning, bandwidth utilisation, operations, repairs & maintenance etc.

Framework for Alternative Implementation Models

4.09 The Committee deliberated on two other alternative models for project management and implementation in comparison to the existing CPSU driven model - one led by the State Government and the other led by the private sector. The Committee was fortunate to have the Andhra Pradesh Model piloted by the State Government of Andhra Pradesh before it which has received 'in-principle' approval by the Telecom Commission on January 7, 2015. During its interactions with stakeholders, the State Government of Tamil Nadu made a presentation on a State-led model to the Committee. The Committee feels that encouraging State Governments to lead project implementation may be desirable though not all States may have the knowledge, capacity or desire to implement, operate and maintain the State version of NOFN. Therefore, the Committee felt that leveraging private sector strengths available within the country in the form of system integrators (SI), engineering procurement & construction (EPC) companies, managed service providers (MSP) through the design of a suitable model could be harnessed for NOFN. Large infrastructure projects need strong project management capabilities, competence in risk management and the ability to coordinate across multiple agencies over a large geographical area. Providing avenues for participation of private industry as part of a nation building exercise for NOFN aptly leverages the experience available with these agencies.

4.10 The Committee felt that it should identify the fundamental guiding principles before designing a comprehensive model for project implementation, operations, utilisation and maintenance in the long-term. The principles are detailed below:

(a) **Ensure 'no monopoly' for any single operator or consortium managing the network**: The Committee was deeply conscious of the need to ensure that the implementation model should not lead to a single agency enjoying, directly or indirectly, the ability to control the network or market power in dictating prices.

(b) **Parallel Implementation**: Laying fibre is a time consuming and resource intensive task requiring coordination with multiple agencies. Parallel implementation across all States allows multiple stakeholders to contribute to project implementation. The vastness and diversity of the country requires multiple models to co-exist depending on the relative strengths and capacities. Thereby, the private sector led model need not supplant the State-led or CPSU-led model, but each model may find application in specific jurisdictions.

(c) **Overcoming inter dependencies**: NOFN is not only a large network but also a complex communication network with multiple layers (physical layer, network layer & application layer). Each of these layers is inter-dependent and requires specific capabilities during implementation and operations. While there is an option to construct NOFN layer-wise by implementing each layer through a separate agency, it adds complexity to the project due to the large inter dependencies that are created by partnering with multiple agencies. This also precludes the option of having a single window clearance for operations and maintenance of the entire network. Engaging with a single agency, preferably through a consortia approach, would eliminate the complexities involved in ensuring timely implementation and operations of an integrated network across different layers.

(d) **Competitive Price Discovery:** There is a need to ensure that the network is rolled out at an optimal cost. While the cost needs to be optimized it should make commercial sense for an organization to invest time and resources towards speedy implementation. This can be achieved through competitive tendering process for optimal price discovery without compromising on the specifications of the network.

(e) **Managed Services Model**: The availability of resources for planning, monitoring and operationalizing the network is a critical factor in ensuring success of the project. The dispersion of maintenance activities at the Panchayat-level across the country necessitates an outsourcing managed services project structure for managing NOFN post-commissioning. The alternative is to envisage BBNL as a monolith public sector leviathan employing personnel at all levels. The managed services model is a mature industry in the telecommunication sector operating on well-defined Service Level Agreements (SLA). A similar operational model riding on project infrastructure creation driven by defined SLAs with built-in incentives and disincentives may provide reliability of service provisioning – the most important element in ensuring utilisation of the network to spur broadband growth.

(f) **Implementation Granularity**: A countrywide single tender would entail complexities in implementation and operation with dependence of on a single implementation partner leading to the risk of failure or creation of a monopoly indirectly. There is a need to overcome the risk by controlling the granularity of scope of work. This can be achieved by limiting the geographical coverage for implementation.

(g) **Flexibility in infrastructure creation, firmness in maintenance:** The disaggregated, vast, inter-linked nature of infrastructure creation across different geographical terrains and regional disparities in the project

environment requires flexibility to be built into infrastructure design. Therefore, there should be sufficient incentive for the implementing agency to optimise network design without compromising on core principles regarding networks, technologies and operations, but at the same time prevent project costs from overshooting beyond reasonable limits. On the other hand, there cannot be any leeway in achievement of prescribed SLAs which needs to be closely observed, monitored and enforced.

(h) **Operated as a single integrated network nationwide:** Given the overall objectives of NOFN, which *inter alia* is to ensure seamless delivery of Government services to the citizenry at large, and as a single comprehensive platform which could offer nationwide connectivity to Government (e.g. administration) as well as those Government services involving citizen interface (e.g. hospitals, schools, post offices etc), it is recommended that the design of the network be such that it is capable of being operated as a single integrated national network with a single or multiple but operationally integrated Network Operations Control (NOC). Therefore, the technical architecture and interface protocols of the multiple networks established through alternate implementation models would need to be harmonized before actual implementation.

4.11 The Committee felt that a multiple model approach that spreads risks and builds on available capacities and drawing upon the above mentioned fundamental guiding principles would be the most appropriate way of working out an implementation strategy. The three models that lends itself to parallel implementation with multiple stakeholders collaborating in the project are detailed in the table 4.1 on page 68.

4.12 The choice of States for the CPSU-led model is based on three grounds:

(i) Where the private sector may either seek a premium on projected costs in the bidding process or be unwilling to implement the project due to the law & order situation in a State e.g. Chhattisgarh, Jharkhand, Jammu & Kashmir, Nagaland, Manipur.

(ii) Where the geographical terrain requires alternatives to optical fibre media to be adopted in the State across a significant part of the State or laying of aerial optical fibre using the electricity transmission infrastructure would need to be explored e.g. Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Arunachal Pradesh, Meghalaya, Mizoram, Tripura, Union Territories of Andaman & Nicobar Islands, Lakshadweep, Daman & Diu.

(iii) Where the CPSUs have completed a significant part of work in the State in Phase-I of the project currently under implementation e.g. Kerala, Karnataka, Haryana and Punjab.

4.13 The multiple models suggested above should be evaluated with reference to the lessons learnt during the Phase-I implementation and detailed in paragraph 4.08. A comparison on how each of the proposed models responds to the impeding factors of Phase-I is detailed in the table 4.2 on page 69.

Responsibility Matrix

4.14 Various activities would need to be undertaken at different stages during implementation and subsequent operations. There is a need to clearly define the role of each stakeholder at each stage so that ownership of each activity is maintained. Defining this matrix would facilitate rollout and operations during the lifetime of the project. The major activities that need to be undertaken through the lifecycle of the project are discussed in the table 4.3 on page 71.

Private Sector-led Implementation Model

4.15 This section describes the private sector-led Implementation Model through a Package Based mechanism. The essential features are given below:

(a) Issue of tenders with multiple packages for implementation of the network. Each

Table 4.1: Implementation Models and key principles

Type of Player	State Led	CPSU Led	Private Sector Led (EPC/ Consortia)
Key Characteristic	States to lead project by establishing Special Purpose Vehicles (SPVs) with equity participation of Central Government to establish, operate and maintain the project.	CPSUs - BSNL, RailTel, TCIL, Power Grid etc to establish, operate and maintain the project with adequate flexibility and autonomy in structuring project implementation and achieving prescribed SLAs through enforceable contracts.	EPC companies with manufacturers forming consortia to establish, operate and maintain the project. The selection to be done by BBNL on transparent, competitive basis with specified milestones for infrastructure creation, and defined SLAs for operations and maintenance with incentives and disincentives and defined incentives (revenue sharing) for bandwidth utilization beyond threshold limits.
Ownership of Asset	Ownership of assets to vest in the SPV.	Ownership of assets to vest in the Central Government.	Ownership of assets to vest in the Central Government.
Role of Central Government through BBNL	The Central Government through BBNL to retain capabilities for monitoring the project and issuing directions, if required.	BBNL to acquire capabilities for observing, monitoring and enforcing contracts.	BBNL to acquire capabilities for entering into, observing, monitoring and enforcing contracts.
Possible States	Andhra Pradesh Tamil Nadu Gujarat	North East (except Assam), Jharkhand, Chhattisgarh, Jammu & Kashmir, Himachal Pradesh, Uttrakhand, Kerala Karnataka, Haryana, Punjab	All other States

package can be sized as a single State or a group of States based on reasonable number of GPs to be covered and length of fibre to be laid in each package.

(b) The network at the State level would be complete by itself and have the ability to integrate with other States through a backbone network which could be a Government network i.e. the National Information Infrastructure (NII) or that of the service seeker.

(c) The pre-qualification criteria may be formulated to encourage competition while ensuring that Implementation Partners with appropriate financial and experience credentials are permitted to bid.

(d) Bids will be invited from a consortium on a 'Build and Maintain' basis with a lead bidder for single window clearance. The consortium should include EPC, network OEM or system integrator and managed services provider.

(e) An Implementation Consortium partner should be selected for each package based on technical and commercial evaluation. The selection would be based on lowest quote for annual annuity payments linked to benchmark SLA. The capital expenditure for each package shall be fixed and linked to specific project implementation milestones leading up to commissioning of the project with incentives and disincentives for early or late commissioning.

(f) The selected implementation partner

Table 4.2: Implementation Models and challenges witnessed in Phase-I

Challenges	State Led	CPSU Led	Private Sector Led (EPC/ Consortia)
Lack of accountability, financial or otherwise, in project implementation.	The structure of the SPV will have to be adequately defined and possess strong project management capabilities. It should have the autonomy to enter into contracts and incur financial expenditures for project implementation. BBNL shall perform the role of technical vetting of project architecture with the objective of integrating the State network into the National network. Role of BBNL and State will also need to be articulated in State-led model for accountability. **Post-commissioning:** The Utilization Model proposed in Chapter 6 will provide a strong accountability framework post-commissioning by tying availability of network to revenue generation. The users of the network will through commercial contracts exert pressure to ensure proper upkeep and availability of network.	Accountability can be achieved through contractual prescriptions on project milestones and specified SLAs with defined incentives and disincentives along with significant autonomy in project implementation to the CPSUs. The performance in project implementation should be a key indicator in the performance evaluation of the CMD, Director leading the project and the designated head of project implementation in each State. **Post-commissioning:** The Utilization Model proposed in Chapter 6 will provide a strong accountability framework post-commissioning by tying availability of network to revenue generation. The users of the network will through commercial contracts exert pressure to ensure proper upkeep and availability of network.	Accountability shall be enforced through contractual provisions and financial incentives and disincentives, but strong project management capabilities will have to be developed at BBNL for faster implementation. **Post-commissioning:** The Utilization Model proposed in Chapter 6 will provide a strong accountability framework post-commissioning by tying availability of network to revenue generation. The users of the network will through commercial contracts exert pressure to ensure proper upkeep and availability of network.
Lack of ownership of the project by the CPSUs and inability of BBNL in ensuring timely project implementation.	The structure of the SPV should allow it sufficient autonomy to manage the project. The same set of incentives and disincentives in achievement of project milestones should be applicable to the SPV as are applicable to CPSUs.	Autonomy in project implementation, acceptance of prices discovered by CPSUs for project components after following transparent bid process, incentives & disincentives for timely or delayed project implementation and performance evaluation of management of CPSUs on project implementation milestones.	Incentives and disincentives in project commissioning, operations and maintenance would ensure timely implementation and service levels.

Fragmented nature of project implementation design both in terms of geographical spread while phasing implementation and in assignment of responsibilities for project components leading to co-ordination problems that have arisen and also anticipated to arise in future.	Project is structured to include execution of all elements, operations and maintenance for a period of 10 years bundled in one entity.	Project is structured to include execution of all elements, operations and maintenance for a period of 10 years bundled in one entity. Risk needs to be mitigated by having a strong central project management team in the CPSU and BBNL and using technology to track progress in real time.	Project is structured to include execution of all elements, operations and maintenance for a period of 10 years bundled in one entity. Risk can be mitigated by following package level approach and having payments linked to actual milestone achievement and strong program management at the centre at BBNL.
Emphasis on cost controls leading to lack of empowerment of implementing agencies.	SPV should be structured to be autonomous for project implementation. Flow of funds from BBNL or State Government must be predictable and assured, tied to achievement of project milestones through simplified procedural compliances.	CPSUs should have autonomy in project implementation. Flow of funds from BBNL must be predictable and assured based on discovered prices for each project component with incentives/ disincentives tied to to achievement of project milestones through simplified procedural compliances.	Competitive bids, taking both quality and cost parameters and linked to project milestones/ SLAs for award for each package. Funds flow from BBNL must be predictable and assured contingent upon achievement of project milestones.
Absence of competitive price discovery for project management.	SPV shall follow a competitive process for price discovery through bidding, taking both quality and cost parameters into consideration for award.	Competitive bid process to be followed by CPSUs for price discovery of project components and the same shall be acceptable to BBNL. Benchmarking with the price discovered under the SPV/ Private Sector approach for similar work can help to incentivise CPSUs.	Competitive bids, taking both quality and cost parameters and linked to project milestones/ SLAs for award for each package.
Network rollout on a nationwide scale through limited agencies.	This is addressed by adopting three implementation models simultaneously to harness all available capacities – private sector and public sector.	This is addressed by adopting three implementation models simultaneously to harness all available capacities – private sector and public sector.	This is addressed by adopting three implementation models simultaneously to harness all available capacities – private sector and public sector.
Inadequate human resource available within BBNL to manage the project.	The restructuring of BBNL to have strong project management capabilities during rollout and commercial management and SLA monitoring after commissioning.	The restructuring of BBNL to have strong project management capabilities during rollout and commercial management and SLA monitoring after commissioning.	The restructuring of BBNL to have strong project management capabilities during rollout and commercial management and SLA monitoring after commissioning.

Lack of adequate advance planning in BBNL for various elements of NOFN – service provision, bandwidth utilisation, operations, repairs & maintenance etc	Implementation strategy along with Utilization Model proposed in Chapter 5 addresses this issue.	Implementation strategy along with Utilization Model proposed in Chapter 5 addresses this issue.	Implementation strategy along with Utilization Model proposed in Chapter 5 addresses this issue.

Table 4.3: Activity chart for Private-Sector led and CPSU-led Implementation Models

S No	Activity	Details	Responsibility
a.	Planning	Architectural design of NOFN network with technology specifications at a broad level.	BBNL
b.	Designing	Network design to be prepared at a detailed granular level involving preparation of a complete view of the network layout including the distribution of network and infrastructural elements. In case of State SPV, the network design prepared by the SPV will be validated and approved by BBNL with the objective of integrating the State network into the National network. This activity will culminate in arriving at an estimate of project capital investment and obtaining financial approvals of the competent authority for execution.	BBNL/State SPV
c.	Bidding and award of contract	Issue of tender with complete network implementation details including commercial aspects and award of contract after following standard competitive processes in case of Private sector-led and State-led Model. For CPSU-led Model, BBNL shall negotiate terms based on standard templates with CPSUs for assignment of work in specified States. The terms shall include appropriate incentives and disincentives benchmarked to timely achievement of milestones. The SLA benchmarks shall be the same as that for the Private sector-led and State-led models.	BBNL
d.	Optimizing	The successful bidders in the competitive tendering process /CPSUs would be required to optimize the network design.	Implementation Partner/CPSU.
e.	Approval	All the optimizations suggested by the Implementation Partner/CPSU would be evaluated keeping in view the overall network requirements and duly approved/rejected.	BBNL/State SPV

f.	Implementing	Post award of contract, the Implementation Partner/CPSU will be required to deliver as per approved milestones.	Implementation Partner/CPSU
g.	Monitoring	Building infrastructure at the national scale requires the implementation to be monitored closely to ensure that the quality of work is not compromised.	BBNL/State SPV. BBNL can engage State Govt. agencies or other third party project inspection and monitoring agencies to oversee implementation
h.	Accepting	Post implementation by the Implementation Partner/CPSU, relevant tests be carried out prior to commissioning. This activity would require large resources deployed over long duration on a nationwide basis. The activity may also be outsourced to a third party.	BBNL/State SPV through outsourced Agency.
i.	Establishment of NOC	BBNL shall take steps concurrently to establish Network Operations Control (NOC) such that the NOC is operational in tune with commissioning of the network. For the State-led implementation model, the issue is addressed in paragraph 5.24	BBNL/State SPV
j.	Operations & Maintenance	The contract with the Implementation Partner/ CPSU is bundled to provide O&M for the entire network segment based on well-defined, pre-determined SLAs ideally on two principal parameters i.e service uptime of 99.9% and reasonable mean time to repair (MTTR). The O&M responsibility will be for a period of 10 years. All network/service failures would have to be handled based on mutually agreed turnaround time.	Implementation Partner/CPSU
k.	Monitoring & Enforcing Contract	The network would be monitored closely based on approved SLAs through a centralized NOC. Billing & provisioning will also be carried out by BBNL/State SPV through the NOC.	BBNL and State SPV.
l.	Directing	BBNL shall have the right to issue directions to the State SPV, if required.	BBNL

would be required to complete the entire network segment on a turnkey basis. The broad scope of work in each package would include the following:

i. Optimization of network design.
ii. Trenching and laying of duct and pulling of optical fibre.
iii. Supply & installation of network elements.
iv. Supply & installation of infrastructure elements.
v. Provisioning of bandwidth.
vi. Maintenance and upkeep of optical fibre.
vii. Network element uptime.
viii. Infrastructure element uptime.
ix. Resource management.

(g) BBNL may engage third-party inspection

and monitoring agencies for exercising oversight over project implementation. While doing so, BBNL must ensure that possible areas of conflict of interest regarding the third-party inspection process must be addressed upfront. Engagement of third party agencies may help BBNL through placing feet on the street at the local level during the project implementation period without creating a long term liability.

(h) Post commissioning of the network, all necessary monitoring operations would be carried out through a centralized NOC facility under the management and control of BBNL.

(i) The payment terms defined in the contract should provide for a fixed capex outlay benchmarked to achievement of specific milestones in project infrastructure creation leading up to successful commissioning. There would also be incentives built-in for early commissioning and penalties for delayed commissioning. The quoted annuity payments would be paid on monthly basis benchmarked to base SLAs with incentives for over-achievement and penalties for under achievement. There would also be incentive in the form of revenue sharing if bandwidth utilisation exceeds a threshold level.

4.16 The proposed Package Based Model has the following advantages:

(a) The package approach optimizes network rollout by ensuring parallel execution across multiple packages through different Implementation Partners. This reduces risk by distributing the work across different packages. Further the success/failure of any package does not impinge upon the implementation of other packages.

(b) Fixed capex would provide the incentive for the Implementation Partner to optimize design architecture of the network to achieve the required SLAs.

(c) Multiple packages would entail partnering with different Implementation Partners thus providing a platform to leverage the strength of the Private Industry.

(d) Since the package is structured on a turnkey basis, the complexities of managing dependencies across different agencies are handled by the Implementation Partner. This enables BBNL to concentrate on project monitoring, ensuring deliverables and enforcing SLAs.

(e) The bundling of Managed Services Portion as part of the package overcomes the problem of non-availability of resources within BBNL.

4.17 While the package based model has certain advantages, it also has the following risks associated with it:

(a) Since multiple packages are proposed, it would involve capacity building in BBNL to manage, monitor and enforce several bid processes.

(b) While there are an adequate number of system integrators in industry, the success of this project would also hinge upon the willingness of companies to participate in the bidding process to ensure adequate competition.

(c) Since the network is proposed to be implemented through multiple packages, it is inevitable that the inventory supplied will vary significantly across each package. This adds complexity while provisioning through a centralized NOC.

CPSU-led Implementation Model

4.18 The CPSU would be required to complete the entire network segment on a turnkey basis. The broad scope of work in each package would include the following:

(i) Optimization of network design.
(ii) Trenching and laying of duct and pulling of optical fibre.
(iii) Supply & installation of network elements.
(iv) Supply & installation of infrastructure elements.
(v) Provisioning of bandwidth.
(vi) Maintenance and upkeep of optical fibre.
(vii) Network element uptime.
(viii) Infrastructure element uptime.
(ix) Resource management.

Post commissioning of the network, all necessary

monitoring operations would be carried out through a centralized NOC facility under the management and control of BBNL.

4.19 The CPSUs shall follow competitive bid process for price discovery of project components subject to a decision escalation matrix culminating at the level of the Board of Directors of the concerned CPSU and the same shall be acceptable to BBNL. Incentives linked to timely achievement of project milestones leading up to commissioning shall be negotiated between the CPSU and BBNL. There shall also be commensurate disincentives for delayed achievement. For the purposes of operations and maintenance, BBNL shall negotiate annual annuity payments linked to achievement of SLA parameters which shall be the same as in the case of the private sector-led model. The reasonability of the negotiated annuity payments can be compared with the discovered prices through the competitive process for the packages under the private sector-led model with appropriate weights, if required, based upon comparison of previous similar projects in the States. The incentives and disincentives for over-achievement or under-performance in terms of SLA parameters as applicable in the private sector-led model shall be applied to the CPSUs too.

4.20 The advantages of the CPSU-led model are as follows:

(a) The indirect support of the State machinery to CPSUs would be useful in States where law & order issues are likely to inhibit project implementation if the private-sector model is adopted.

(b) CPSUs would be in a better position to handle deviations from the buried optical fibre architecture especially where radio or satellite media or aerial optical fibre riding on other infrastructure is to be attempted.

(c) The incentives and disincentives built into project structure and the linkage of performance in project commissioning as key indicator in performance evaluation of the CMD, Director-in-charge and the project head in-charge in the concerned State would bring necessary accountability and ownership in implementation, a factor missing in the present design.

(d) Since CPSUs have to necessarily comply with the requirements of competitive procurement and contracting process being a State-entity, the risk of project cost escalation can be shifted away from the CPSU leaving the incentive structure clearly oriented to timely execution through better project management.

4.21 The failure of accountability mechanisms and non-enforcement of the incentive structure are the main risk factors in assigning project execution to CPSUs. The Board of Directors of the CPSUs and the Government Directors on the Board must be vested with the responsibility of monitoring accountability mechanisms. The project monitoring capabilities of BBNL must be enhanced to observe and supervise implementation and to keep the Government Directors informed to mitigate risk of delay or non-performance.

State Government-led Implementation Model

4.22 The Committee has considered the State Government-led implementation model proposed by the Government of Andhra Pradesh. The Committee believes that the concerned State Government should be afforded substantial degrees of freedom for customizing project architecture and technology, managing project implementation and post-commissioning activities. The conditions on which the freedom should be circumscribed should be the guiding principles for development of broadband utilisation models specified in Chapter 5, the integration of such State Government-led action with the National network and the provisioning of services carried by the Central Government over the State network. The State Government shall be free to extend the project coverage to other areas (urban areas and villages other than GP headquarters) without drawing from Central Government funds for the extension.

4.23 The State Government shall design, customize according to its requirements, implement, commission, manage and operate the network. For the purpose, the State Government

shall create or assign a State SPV for carrying out all project activities. While designing and customizing its network, the State SPV may adopt more advanced and more scalable technology architecture than adopted by BBNL, subject to the condition that the State Network so designed shall interoperate with the National network seamlessly and provide visibility at the national level. The State SPV would have the freedom to provide for a higher minimum bandwidth than 2 Mbps, say 10-20 Mbps per HH and 100 Mbps to 1 Gbps per Business/MDU, duly assessing the likely demand and uptake. It can make its own assessment of bandwidth requirements over the life of the project, keeping in view what is the percentage uptake that is actually achievable. The State SPV can suitably design its electronics based on its demand assessment.

4.24 The State SPV shall get its network design approved by BBNL from the objective of ensuring national interoperability, national traffic management and management of the Network Operations Control (NOC) operated by BBNL. BBNL shall either create the State NOC or issue specifications for the same so as to ensure that the State NOC and the NOC managed by BBNL operate on the same platform.

4.25 The demarcation of roles and responsibilities of the State SPV and BBNL, *inter se*, are specified in the table 4.4 on page 76.

4.26 Irrespective of the implementation model adopted, the responsibility of funding should be with the Central Government to ensure equality of treatment of all States. Therefore, the project implementation costs for infrastructure creation should be borne by the Central Government on similar lines as all other States. Thereby, the investment costs including incentives and disincentives for timely or delayed completion would be the same as for the CPSU model. At the same time, the State SPV should be eligible to receive viability gap funding for operations and management (O&M) after adjustment of revenues derived from fibre auctions and bandwidth provisioning on the costs for O&M discovered through a transparent mechanism. To incentivize the State SPV, any additional revenues obtained by the State SPV over after meeting costs could be retained by it. In a sense, the Central Government shall provide funding for O&M, if revenues do not match costs but allow State SPV to retain revenues if revenues exceed costs. The State SPV would be free to induct any private entity through equity participation provided the combined holding of State Government and the Central Government/ BBNL is not less than 50%.

4.27 The advantages of the State-led model are as follows:

(a) State Governments are the principal carrier of Government services and incentivizing States in participation in the project may lead to better delivery of Government services.

(b) Co-ordination with State Government agencies can be best managed by States leading to better project outcomes.

(c) Multiple models managed by multiple interested stakeholders may lead to better project management and timely completion by leveraging project management resources available at the State-level.

4.28 The primary risk in the State-led model is the availability of project management capacities in the communication space so as to technically design and manage a project of the complexity envisioned. However, States which are active in the I.T sector may be able to obtain or engage such expertise from the private and public sector.

Horizontal connectivity to Government institutions

4.29 The horizontal connectivity through OFC to Government institutions at the DHQ, BHQ and GP level shall also be provided and provisioned by the Implementation Partner/State SPV. The operations and maintenance shall also be undertaken by the Implementation Partner with well-defined, pre-determined SLAs different from that for the District to Block and Block to GP layers. Besides the identified institutions, the Committee recommends that any additional Government institution could be connected to be network on payment of capital cost for extending the optical fibre connectivity to the institution.

Table 4.4: Roles and responsibilities in State Government-led Model

S. No.	Responsibility	Responsibility Centre	Remarks
1.	Estimation of bandwidth requirements	State Government/ State SPV	This can precede or succeed responsibility activity at serial no. (2)
2.	Creation of State SPV or entrustment of work to existing SPV	State Government	
3.	Network Design and customization of architecture	State SPV	Subject to interoperability with the National network seamlessly, guiding principles for development of Utilization Models specified in Chapter 6, and the provisioning of services carried by the Central Government/ BBNL over the State network
4.	Approval of Network Design	BBNL	
5.	Submission of Detailed Project Report (DPR) with cost of investment and funding arrangements	State SPV	
6.	Approval of DPR from financial angle.	BBNL/Central Government	
7.	Signing of agreement	State SPV and BBNL	
8.	Project Implementation and monitoring including procurement and/or works contracting	State SPV	
9.	Release of funds including incentives/disincentives based on agreed milestones	BBNL	Funds provisioning agreed to in the agreement signed between State SPV and BBNL
10.	Project commissioning	State SPV	
11.	Establishment of State NOC and interface with National NOC for operations support.	State SPV or BBNL	Either BBNL shall establish the State NOC or provide specifications for State NOC so that the State and National NOC operate on a common platform.
12.	Establishment of Business Support Systems overlay over Operations Support at State NOC.	State SPV	

13.	Fibre auctions	State SPV	Auctions to be based on principles set by BBNL to ensure that there is no single monopoly in service delivery and non-discriminatory access is provided.
14.	Operations and Management of Network and marketing of bandwidth	State SPV	
15.	Viability gap for network operations	BBNL	BBNL shall provide viability gap for network operations after accounting for revenues derived from fibre auctions. Surplus, if any, shall be retained by State SPV.
16.	Service provisioning for inter-State traffic or Central Government services	State SPV on directions of BBNL	State SPV shall comply with directions of BBNL on service provisioning for inter-State traffic or Central Government services

Network Operations Centre

4.30 BBNL has signed an agreement with C-DoT on March 14, 2014 for design and deployment of Network Management System (NMS). A test bed has been established for NMS application deployment for validation. After several iterations, the upgraded version of the NMS has been deployed on the test bed and is said to be working satisfactorily. The Operations Support Systems (OSS) that interfaces with the Equipment Management System (EMS) supports network operations on five strands: fibre management, fault management, SLA monitoring, performance management and reporting. The OSS is being developed by C-DoT on the basis of the agreement signed with C-DoT. While the present design of the OSS essentially interfaces with GPON equipment, BBNL assured the Committee that the design could be modified to include any other technology. The Committee, therefore, believes that while the OSS to be deployed may have to be developed and tested for the new technology and architecture proposed, C-DoT could continue to work with BBNL for design and development of the OSS. If necessary, a new agreement with revised costs would have to be put in place.

4.31 The OSS constitutes the brain of the NOC and is the main instrument for the management of the network and monitoring its operations. Given the centrality of the NOC to the proper functioning of the network, the Committee believes that BBNL and C-DoT should rely on duly tested and deployed technologies in order to ensure that post-commissioning problems are kept to the minimum. The Committee strongly recommends that the OSS should be comprehensively tested and evaluated through a third-party process before it is inducted into operations.

4.32 BBNL is also planning to procure a Business Support System (BSS) riding on the OSS for managing the business and commercial aspects of the project including billing applications, service provisioning and customer relationship management. The BSS is being procured through a competitive tendering process which is at an advanced stage. The Committee was of the opinion that BBNL may have to rework the BSS based on the broadband utilisation models suggested by it in Chapter 6. The reoriented BSS would have to support business management of dark fibre linked to the fibre management module as well as the BSS for bandwidth provisioning. BBNL may also have to design and develop a module for auction of fibre to support the utilization models suggested by the Committee. Therefore, the Committee recommends that BBNL may revisit the tender for the BSS and also develop a module for fibre auctions.

4.33 BBNL is developing a modern Network Operations Control (NOC) at Shastri Park, New Delhi and a disaster recovery (DR) centre at Bengaluru. The contract for civil works for development of NOC in New Delhi has been awarded to National Building Construction Corporation (NBCC) whereas BSNL is being requested to undertake the civil works for the DR centre at Bengaluru. The Committee believes that no change is required in the light of the new structure proposed.

4.34 In case of the State-led model, the State SPV would have the primary responsibility for network management, whereas in the private sector-led and the CPSU-led models, the primary responsibility will devolve on BBNL to be enforced through the concerned Implementation Partner. Therefore, the NOC design would have to factor in the need for integration across the different models. The table below encapsulates the requirements in respect of the three suggested implementation models *(see table 4.5)*

Right of Way approvals

4.35 One of the possible causes for delay in project implementation could be hold ups caused due to right of way (RoW) approvals. Tripartite agreements have been signed between the Department of Telecommunications, State Governments and BBNL to facilitate free right-of-way for laying optical fibre. However, the actual implementation of existing NOFN has thrown up issues that have to be addressed if implementation delays are to be curtailed.

4.36 RoW approvals are not limited to State Governments. There are Central Government bodies such as National Highway Authority of India (NHAI), Indian Railways, Oil and Natural Gas Corporation (ONGC), Gas Authority of India Limited (GAIL) etc and Forest clearances where problems have been encountered by BBNL and the Implementing CPSUs. The table below indicates the position in respect of RoW delays in GPs where work has commenced *(see table 4.6 on page 79)*

Table 4.5: Requirements of NOC – Implementation Models

NOC Parameters	State-led Model	CPSU-led Model	Private-led Model
Primary NOC	State SPV	BBNL	BBNL
Mirror NOC	BBNL	CPSU Partner at State level	Private Partner at State level
Service Provisioning	Service provisioning to be managed by State SPV but BBNL shall have the power to give directions to State SPV for service provisioning	Managed by BBNL	Managed by BBNL
OSS	Either BBNL to procure and install OSS solution platform or State SPV to procure and install OSS solution platform based on specifications approved by BBNL to achieve integration	Procured and installed by BBNL	Procured and installed by BBNL
BSS	Procured and installed by State SPV	Procured and installed by BBNL	Procured and installed by BBNL
Security systems	Procured and installed by State SPV conforming to specifications laid down by BBNL	Procured and installed by BBNL	Procured and installed by BBNL

Table 4.6: RoW approval delays and agencies involved

State	No. of GPs in phase -1	No. of GPs where work started	Nos. of GPs affected					
			NHAI	Railways	Forests	Oil & Gas Pipelines (GAIL/ ONGC)	State Govt.	Total GPs
Assam	1042	479	0	0	1	0	46	**47**
Chhattisgarh	9770	717	0	1	0	0	0	**1**
Gujarat	13930	994	55	44	98	46	8	**251**
Himachal Pradesh	3243	5	2	0	0	0	3	**5**
Karnataka	5631	2803	60	27	3	0	1	**91**
Madhya Pradesh	23006	3242	3	83	491	19	105	**701**
Maharashtra	11869	3388	27	44	8	1	4	**84**
Odisha	2736	545	272	98	167	0	541	**1078**
Punjab	12947	3646	31	69	118	16	0	**234**
Rajasthan	7019	1525	127	67	7	20	0	**221**
Telangana	2084	643	54	26	60	0	0	**140**
Total	**93277**	**17987**	**631**	**459**	**953**	**102**	**708**	**2853**
Agency wise % of RoW issues			**22%**	**16%**	**33%**	**4%**	**25%**	

4.37 From the table, it appears that the tripartite agreement with State Governments has been extremely helpful in resolving RoW issues with States, as except for Odisha, few instances of RoW problems with States have been indicated. However, Central Government bodies have proved to be a major stumbling block for smoothening RoW approvals. One of the reasons cited by BBNL specifically in the case of Railways and NHAI is regarding case-by-case approvals in which payments of Bank Guarantee and RoW charges are insisted upon by these approving organisations for each individual case. The Committee recommends that BBNL may make a lump sum payment upfront to NHAI, Railways, and the Oil Companies against which adjustments could be made for each approval and the balance adjusted/reimbursed/ paid annually between BBNL and these agencies. This would obviate the need for case-to-case payments, one of the identified causes of delay in approvals while at the same time ensuring that money transactions at the local field level do not obstruct smooth implementation. Thereby, the local officers of these agencies who grant RoW approvals will only look at the technical aspects while granting approval.

4.38 As in the case of the State Governments, the Committee recommends that bi-partite agreements may be signed between NHAI, Oil Companies, Indian Railways on one side and BBNL on the other side duly overseen by the concerned administrative Ministries to work out a common procedure for RoW approvals and, if possible, grant free RoW permission. A similar agreement could be arrived at between Ministry of Environment & Forests and Department of Telecommunications for forest clearances. Appointment of empowered Nodal Officers in these agencies to come to the aid of BBNL for expeditious RoW approvals may assist project implementation.

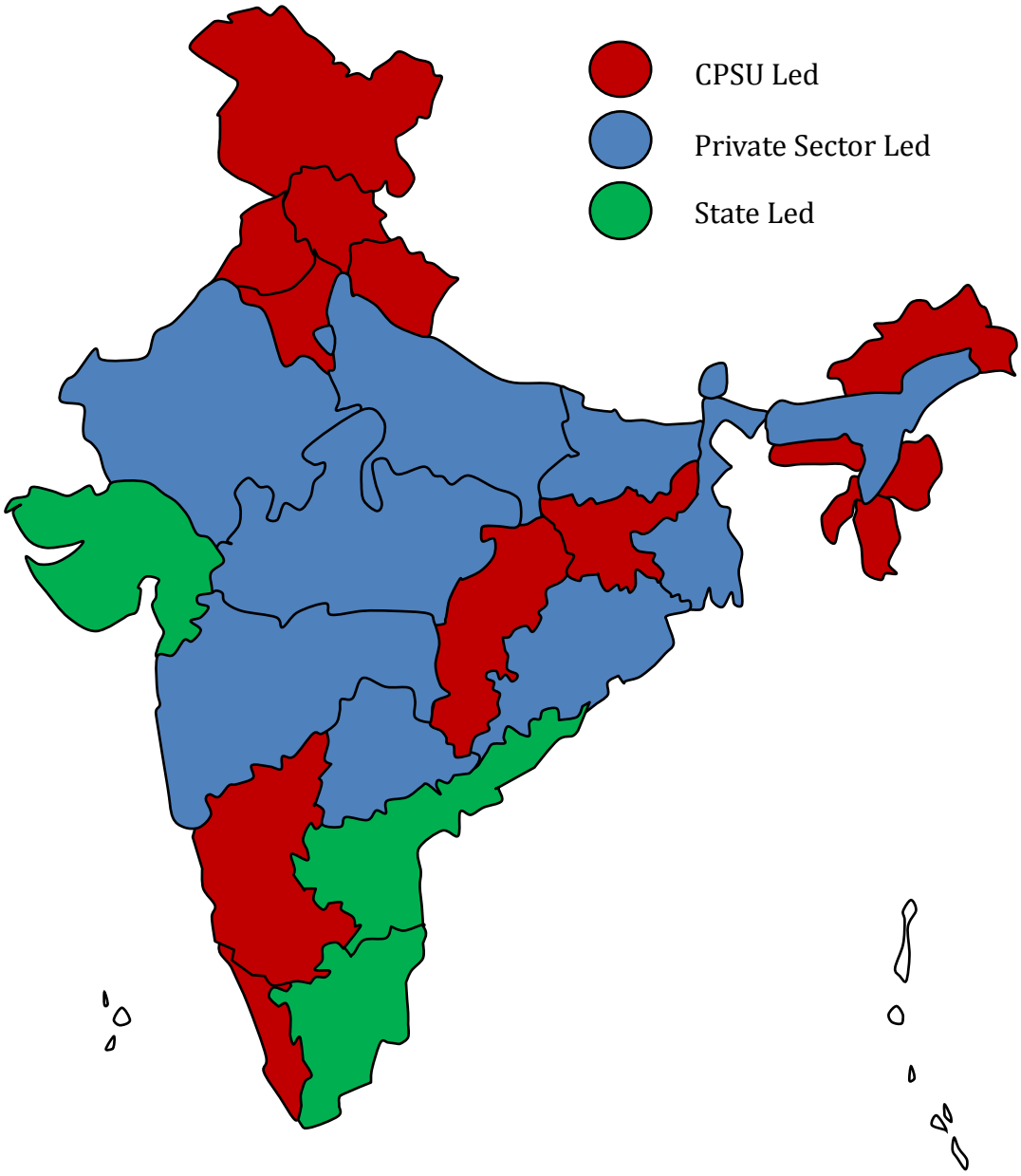
Pre-Implementation Planning and Project Management

4.39 Proper planning in the pre-execution phase i.e. desk-top survey, physical validation of survey, preparation of cost estimates and finalization of bill of material with the right quantities is an important start to implementation. Due diligence at the planning and estimation stage by BBNL or State SPV would enable the capital cost for the project to be estimated with the low margins of error. This is of immense importance for identification of the Implementation Partner and substantially minimises post-award risks when viewed in the context that the capital cost is a fixed component of the tendering process. If due diligence is not exercised at the planning stage, then the impact of project risks, timelines and costs would put the project in jeopardy. The Committee, therefore, recommends that the planning stage consisting of desk-top survey, physical validation of survey, preparation of cost estimates and finalization of bill of material with quantities, must be approached with great diligence and certainty so as to lend confidence to the subsequent stages of tendering, award of project and actual implementation.

4.40 The Committee has ascertained the planning process followed by BBNL for NOFN. The Committee was informed that BBNL has sought the services of the Geographical Information System (GIS) division of the National Informatics Centre (NIC) for developing a GIS platform for NOFN for providing capabilities to view, analyze and understand the optical fibre cable (OFC) network and enable planning of proposed incremental fibre cable network for connecting GPs to the Blocks. The GIS platform would provide an integrated platform for synergizing various business functions of BBNL. The Committee was also informed that NIC has already captured about 6 lakh kms of OFC network on GIS platform and developed base maps called NICMAPS at 1:50,000 scale which is being upgraded to 1:10,000 scale. GIS for NOFN will ride over the NIC's base map platform and leverage the data available on existing OFC assets. While appreciating this endeavour, the Committee was aware of the view of BBNL that the planning process consumed almost a year as the output capacity of GIS division of NIC was not very high. Considering the immense pressure on timely execution and the importance of the planning process, the Committee strongly recommends that the capacities of the private sector in GIS must also be leveraged so that both timeliness and accuracy are kept in the cross-hairs of project planning. The Committee feels that the base maps prepared by GIS-NIC on 1:10,000 scale can be adopted while the planning tool customised by C-DoT ("Primavera") could be improved upon by involving the private sector with global experience and industry bodies in the GIS-sector in GIS-based planning. The Committee was happy to learn that the Government of Andhra Pradesh, which has undertaken the planning process by involving the private sector, was willing to share its sourcing model and its experiences in designing the planning efforts. Considering the need for speedy, robust, accurate and timely planning, the Committee recommends that the planning process should be completed in 3-4 months for all States for the tendering process to commence immediately thereafter. This is an ambitious endeavour and can be undertaken only with pooling all relevant resources – public and private – in a common national effort.

4.41 During project implementation phase: i.e. trenching and laying of PLB ducts, pulling of OFC, splicing and end-to-end fiber testing, the Implementation Partner would be expected to provide data periodically in the GIS system, highlighting deviation from the approved network. After project commissioning, the Implementation Partner would be expected to provide ABD (as built diagram) with details of latitude and longitude at every 20-25 mts distance with route indicators, turnings, landmarks. This information, integrated with the GIS maps, will form the "Geographical Network Maps". The Implementation Partner will be able to make use of the Geographical Network Maps to extract data by mapping the available fibre or bandwidth to the demographic and other local information to assess the market demand for services. The Implementation Partner will be able to extract geographical data to identify cause of fault, location of fault, areas affected, services affected which will help to reduce the time taken to restore faults.

Figure 4.1: Implementation Models: State-Wise



4.42 The network being planned is a critical infrastructure for the future. Early identification of faults and restoring damage to fibre is extremely important from the service maintenance point of view. Optical fibre assets are located underground and failure to identify accurately the location of buried assets results in numerous practical problems, increased maintenance costs, disruptions in critical services and dangers while restoration activities are underway. This aspect becomes more acute when viewed in the dispersed nature of project assets practically all across the vast countryside. The pace of development activities and the location of adjacent buried utility assets increase risks to the optical fibre assets buried underground. During consultations, the Committee was informed that optical fibre cable laid by BSNL over a decade has become vastly deteriorated due to damage. The Committee, therefore, believes that collecting and maintaining positional intelligence through sensor-based geotagging of optical fibre assets should be included in the project. The additional costs due to geotagging will be

more than offset by substantially reduced direct repair and maintenance costs and the indirect costs due to service disruptions. The Committee also recommends that the Central Government, through legislative or executive instruments as may be appropriate, lay down a mechanism for severe punishment for causing damage, willfully or otherwise, to optical fibre assets. The Committee also recommends that obtaining prior clearance of BBNL or State SPV for any digging activity in the vicinity of buried optical fibre assets should be made mandatory as in the case of oil and gas pipelines.

4.43 The Committee realises that the immense complexities in project management requires adoption of advanced technology tools to monitor implementation and evaluate progress. The Committee recommends that a team with experience in project management using I.T tools be constituted to design and develop a project management tool to be put in place within three months in parallel to the planning process so that the tool is available for project management before the award of work to the successful bidders.

State-wise suggested Implementation Models

4.44 The Committee has suggested the apportionment of work State-wise towards the three Implementations Models as depicted in the figure 4.1 on page 81.

Conclusion

4.45 The Committee has attempted to introduce multiple players leveraging all project management resources whether in the private sector or in the public sector and both in the Central Government and the State Government to quicken implementation. The Committee has also attempted to devise a model that identifies the risks and incentives that a public sector company faces and that faced by the private sector and structure implementation strategy around promoting incentives and mitigating risks. The Committee believes that BharatNet has been viewed in 360° integrated manner so that co-ordination issues are resolved by the agency in the best position to do so i.e in matters of procurement and contracting by the Implementation Partner and in matters involving the State or Central Government agencies, by BBNL.

Chapter - 5

Project Cost : BharatNet and NOFN+

Cost summary: BharatNet

5.01 Based on the architecture and technology suggested for BharatNet and the cost components of the project discussed in detail in Chapter, the project cost estimates is summarized in the *table 5.1*.

5.02 The Committee discussed ways of optimizing project cost. One of the suggestions made to it was for using the existing duct infrastructure of BSNL from Block to GP for the purposes of the project. The health of the existing fibre, as already discussed in paragraph 3.1, is poor. BSNL informed that in the early years of laying optical fibre cable, High Density Poly-Ethylene (HDPE) pipes were used. These pipes would have most possibly cracked and would be unusable. It is only in the last decade that PLB ducts have been laid as protection for optical fibre cable. During consultations on this issue with BSNL, it was given to understand that

Table 5.1: Cost Summary

Connectivity Layer	Unit		No. of Districts/ Blocks/ GPs	Length (km)	Cost (Rs per unit)	Total cost (Rs crore)
Block OFC Rings	40	km per Block	6500	2,34,000	4,25,000	9,945
Block to GP: OFC	4	km per GP	226000	9,08,000	4,00,000	36,320
Block to GP: OFC ring	25%			2,28,000	4,00,000	9,080
Block to GP: Radio	15,00,000	Rs per GP	20000		15,00,000	3000
Block to GP: Satellite	40,000	Rs per GP	3000			12
	3	Gateways			50,00,00,000	150
Horizontal connectivity	25	per District @ 2 km	675	33,750	2,00,000	675
	10	per Block @ 1 km	5825	58,250	2,00,000	1,165
	2	per GP @ 500m	250000	2,50,000	50,000	1,250
Total				17,11,000		61,597
Electronics						7000
Network Operations Centre						1000
Planning						10
Data Centres	1	per District	675		2,08,50,000	1407
Community Wi-Fi Infra	1	per GP	250000			895
Power back up at BHQs	1	per Block				869
Total Project cost						72,778

in some portions these ducts may have choked with earth seeping in and the probability of usage was uncertain. However, given the immense advantages through lower project costs, BSNL agreed that the possibility could in explored by attempting to replace the existing optical fibre cable with new fibre as pilot in about 20 blocks where the existing OFC was laid after 2005. BSNL and BBNL agreed that OFC for the pilot project would be provided by BBNL and BSNL would attempt to pull the new fibre[1] through the existing duct infrastructure and replace the existing fibre. If the pilot succeeds then the cost of pulling fibre through existing duct infrastructure between Block and GP would reduce project cost by Rs 6900 crore even if only 50% of the existing infrastructure is usable. Given the substantial savings than exist, the results of the pilot projects may be looked into closely before the strategy for the project is finalized. If the pilots reveal the possibility of adopting this strategy, then BSNL may be incentivized in offering their duct infrastructure by giving 4 fibres in the 24 core optical fibre cable being laid along with responsibility for maintenance of the fibre as the payment in kind for lease of the duct, offering a win-win to Government, BBNL and BSNL.

5.03 The Committee recognizes that the project capital cost is higher than that estimated earlier. However, the Committee is of the strong opinion that the project as was planned earlier suffered from various inconsistencies that would have jeopardized the usage of the fibre infrastructure created and rendered the investment waste. The SLA promised by BSNL for its existing fibre is only 97% instead of 99.9% that is demanded for service provision. The promised SLA would mean that the network is down for 1 day every month – an outcome that is clearly unacceptable for an essential and reliable broadband infrastructure that is planned. The evidence and data collected shows that unreliable network, degraded quality of service and poor utilization of network would have been the result.

[1] The Committee was informed of available technologies like nylon jacketing for pulling optical fibre through existing ducts where loose earth may have entered into the duct. BSNL and BBNL could attempt pulling fibre using these technologies to ascertain feasibility.

BharatNet and NOFN+: A comparison

5.04 The Committee also notes that the project cost for NOFN is proposed to be revised for which a Cabinet Note is being circulated by the Department of Telecommunications. In addition, the project cost for GUN overlay over NOFN is estimated as Rs. 5300 crore[*] for capital cost and Rs. 2550 crore[*] as operational costs of which fibre leasing costs payable to BSNL forms a major component. Additionally, the investment in horizontal connectivity would have formed part of the expenditure approval for NII. Therefore, the comparable project cost for the existing NOFN would include GUN investment and horizontal connectivity and fibre leasing costs under the existing scheme. The Committee has attempted to work out the comparable life-cycle project cost for the two projects shown in *table 5.2 on page 63*.

5.05 The Committee has assumed that in the District to Block connectivity layer, 12 fibres are leased from BSNL and in the Block to GP layer, 4 fibres are leased. The fibre leasing cost has been assumed at Rs 12,000 per fibre per km per annum on the basis of the rate quoted by BSNL to BBNL for NOFN. It has also been assumed that 75% of the O&M costs in BharatNet would be recovered through fibre auctions by adopting the utilization model described in Chapter 6.

5.06 Table 5.2 shows that even in terms of cost comparison over 10 years, the restructured network, BharatNet, scores over NOFN+.

Expected Benefits

5.07 Various studies have been carried out to ascertain the impact of increased access to high speed broadband on the economic activity of a country. In 2009, the World Bank released its report that showed that access to broadband boosts economic growth in all countries, but most especially in developing ones. The study shows that for every 10 percentage points of broadband penetration, developing economies grew by 1.38%. McKinsey estimates that "a 10 percent increase in broadband household

[*] Including taxes

Table 5.2: Project Cost Comparison: NOFN+ and BharatNet

Project Cost Item	NOFN + GUN + Horizontal connectivity (Rs crore)	Project Cost Item	Restructured BharatNet (Rs crore)
NOFN	₹28,000		
GUN	₹4,942		
Horizontal connectivity (Districts & Blocks)	₹1,840		
NOFN+ project costs	₹34,782	BharatNet project costs	₹72,778
Fibre leasing costs p.a.[1]	₹6,286		
O&M costs p.a [2]	₹1,739	O&M costs p.a.	₹3,639
NPV of annual costs [3]	₹50,582	NPV of annual costs	₹5,734
Total cost	₹85,364	Total cost	₹78,512

penetration delivers a boost to a country's GDP that ranges from 0.1 to 1.4 percent." ICRIER (Indian Council for Research and International Economic Relations) released a report in 2012 with a key finding that "Indian States can be expected to grow by 1.08% points for every 10% increase in the number of internet subscribers." ICRIER report is of particular interest as it is the only study done at a sub-national level in India. The finding of the report is used here to provide an estimate of macro-economic benefits resulting from implementation of BharatNet. *See table 5.3.*

5.08 The estimated GDP is then multiplied with the expected GDP increase to calculate the potential economic benefit due to increased access to internet provided across the country. It is intuitive to expect broadband to create positive externalities and contribute to the growth of an economy. The above calculations showcase that investment in BharatNet would result in a

Table 5.3: Expected Benefits from BharatNet

GDP Impact in 2018-19	
No. of Gram Panchayats to be connected	2,50,000
Estimated additional users at each GP	100
Increased penetration due to BharatNet	2,50,00,000
Estimated Population[4]	1,31,24,93,837
Increase as a Percentage of population	1.90%
Percentage GDP Increase due to Increased Penetration as per ICRIER report[5]	0.21%
GDP at current prices 2014-15[6] (Rs crores)	1,05,27,936
Potential Economic Benefit (Rs crores)	66,465

[1] The fibre leasing assumptions are that 12 fibres are leased from BSNL for DHQ-BHQ layer and 4 fibres are leased from BSNL for Block to GP layer. The fibre leasing cost is Rs 12,000/- per fibre per km per annum which is the rate cited by BSNL to BBNL. The leasing cost increases by 3% every year.

[2] The O&M costs are assumed at 5% of the capital cost with costs increasing at 3% every year for both NOFN+ and BharatNet.

[3] Discount rate for NPV is taken as 12%.

[4] Based on P.N. Mari Bhat, "Indian Demographic Scenario 2025", Institute of Economic Growth, New Delhi; 2019 population calculated assuming growth rate of 1.41% per annum

[5] ICRIER report's key finding: Indian States can be expected to grow by 1.08% points for every 10% increase in the number of broadband subscribers

[6] Economic Survey 2014-15, Annexure A2.

Table 5.4: Implementation Timelines

Activity	2015				2016				2017			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Structural changes in BBNL and decision-making process												
Project Planning by BBNL												
Identification of States for State-led Model and setting up of State SPV												
Identification of CPSUs for CPSU-led Model												
Network Design by BBNL												
Approval of financial estimates												
Preparation & approval of tender documents by BBNL/State SPV												
Bidding process & award of contracts												
Optimization of project design												
Project implementation and commissioning for Private-sector and State-led Models												
Negotiations with CPSUs												
Optimization of project design by CPSUs												
Project implementation and commissioning for CPSU-led Model												
Post-commissioning and commencement of services												

significant growth in the economy and indirect benefits would lead to a pay-off within one year of commissioning.

5.09 McKinsey Global Institute's report "India's technology opportunity: transforming work, empowering people" highlights how the rapid adoption of a set of 12 technologies, including connectivity can add as much as USD 1 trillion to India's GDP in 2025, create productive jobs even for low or moderately-educated people, and help bring economic empowerment and the resources enhancing standard of living to millions of citizens. It has been stated that collectively, these 12 technologies can add 1 to 2 percentage points per year to India's economic growth, creating USD 550 billion to USD 1 trillion of additional economic impact in 2025. These estimates are based on specific technology applications across six sectors (healthcare, education, financial services, agriculture, energy, and infrastructure) that have the potential to create about half of the total economic impact. The reach of these technologies to the rural areas have significant spin off benefits in six fields, namely, Financial services, Education and skills, Health care, Agriculture and food, Energy and Government services. BharatNet would enable the benefits to be carried to the rural areas transforming them into engines of growth and leveraging on the demographic dividend by offering huge opportunities.

Implementation Timelines

5.10 One of the mandates of this Committee was to come up with solutions that could ensure project completion by December 2016. The

Committee has given considerable thought to this issue and is of the opinion that adherence to the timeline of December 2016, either in the existing framework or the revised framework suggested by the Committee, may not be feasible. Based upon discussions with EPC vendors who assured that 18 months would be sufficient to execute and commission the project after its award, the Committee has arrived at project implementation timelines given below, which the Committee believes is ambitious but achievable:-

5.11 The Committee strongly recommends that the duration and processes for initial decision-making may be expedited to the maximum so that sufficient time is available for re-planning the network architecture, the competitive processes for award of contracts and project implementation on the ground. The Committee hopes that with the revised methodology and framework and expeditious decision making, there will be no slippages beyond that indicated in the table above.

Chapter - 6

Rural Broadband through BharatNet

Introduction

6.01 Access to high speed broadband is a key infrastructure for socio-economic development of any country in the modern age. Its democratizing influence has the power to reshape the marginalized sections of the economy. Affordable and accessible broadband is a vital development enabler for building inclusive and sustainable knowledge societies. It enhances productivity and national competitiveness, acts as a crucible for innovation in social and economic sectors and enables better governance.

6.02 Government's vision of Digital India to transform India into a connected knowledge economy through high speed broadband infrastructure with a slew of digital services riding on the information super-highway cannot be achieved without creating the right business model that spurs efficiency through competition, affordability targeted at each section of society and innovation through access. Government's aim in creating the broadband infrastructure in rural areas through the National Optical Fibre Network (NOFN) is not for the purposes of earning revenues, but to close an essential infrastructure gap that can drive socio-economic progress in large swathes of rural India. The Committee strongly believes that competition, affordability and non-discriminatory access are the key elements of the business model that underpins the establishment of NOFN.

6.03 The lessons of the pilot project implemented under NOFN indicate that there was almost no utilization of bandwidth by three prominent service providers – the telecom service providers, the cable T.V providers and Internet service providers. The cited reasons ranged from poor return on investment for rural service provision, lack of market volumes and lack of assured service levels. Service provision in the pilot projects had to be sustained entirely by Government expenditure which makes the entire investment case uneconomic when scaled up across the country.

6.04 The Detailed Project Report (DPR) on the Government User Network (GUN) overlay over NOFN predicated the business case on seeking an "anchor customer" i.e. the Ministry of Rural Development. Essentially, GUN worked on the principle that Government as the anchor customer would foot operational expenses, thereby providing an indirect subsidy across the country for potential private sector bandwidth usage. This model also suffers from the limitation of the required environment for the right business model that can leverage the enormous potential of the infrastructure being created for broadband usage.

6.05 The Committee was conscious that if the network infrastructure usage is not properly positioned, the investment would either go waste or remain a drain on Government's resources for years to come. As part of its Terms of Reference (ToR), the Committee was specifically asked "to assess relevant business models for effective utilization of bandwidth created under NOFN". The succeeding paragraphs discuss this vital issue for the eventual success of the project.

Guiding principles

6.06 The Committee felt that in order to work towards outcomes and fulfill the vision of the Government for the Network to emerge as a catalyst in promoting socio-economic development of rural areas, business model(s) that inherently promote efficient and affordable usage at the rural citizen level should be encouraged. This would also ensure that the assets so created are utilized on an ongoing basis, are maintained and "remain gainfully alive" over the entire lifecycle of the assets.

6.07 The Committee recognises that the best way to promote usage at the end level would be to involve, incentivise and harness multiple players, including but not limited to those involved in the rollout. The Committee also appreciates that efficient providers of services to the users may not be same as efficient creators of infrastructure. The Committee, therefore, felt that it should identify the fundamental guiding principles for the development of the potential business model(s).

6.08 The Committee, through its deliberations with various potential users of the network, identified the following guiding principles as detailed in the *table 6.1 on page 69*.

6.09 During consultations, Telecom service providers (TSPs) indicated that the business model for NOFN should be built around provision of both dark fibre and bandwidth. They wanted assured network availability of at least 99.9% and the freedom to scale the network based on end-usage. The TSPs made it clear that failure to commit SLA of 99.9% would substantially affect their ability to utilise the infrastructure. With the exponential growth in data services, new technology opportunities in the communication sector, TSPs were in favour of having arrangements for extension of fibre from GP point-of-presence (PoP) to the tower location. However, between the cost of bandwidth for network provisioned and demand based on paying ability of the customer in rural areas, they were unsure about the commercial potential of 3G & 4G services in rural areas. The cost-plus method of bandwidth price fixation by BBNL was not preferred. TSPs stated that considering the market dominance of BBNL in fibre availability at GP level once NOFN is commissioned, bandwidth price fixation should be based on some fundamental principles and methods like market discovery, discount to price caps fixed by TRAI, etc needs to be deliberated. In

Table 6.1: Guiding Principles for designing Broadband Utilisation Models

S. No.	Principle	Effect
1.	Encourage competition to increase choice for the user	Foster the emergence of a multi-player ecosystem, including opportunities for local small scale services and applications, catering to a range of services by utilizing the network infrastructure, thereby ensuring choice for the user through inter-play of competition amongst service providers. The Business Model should rightfully prevent the emergence of monopoly service provision – whether public or private.
2.	Affordable broadband services	Make available the network infrastructure to a range of service providers at price points which match demand and supply at the level of each District, through a transparent market price discovery process. The price so discovered should encourage provision of services at affordable prices at the local level factoring in the stage of economic development and paying ability of local citizenry. This would mean that the infrastructure would be priced differently at different time periods and different Districts depending on the level of the market demand. Thereby, in effect where the broadband infrastructure serves an economically backward area, the subsidy determination for services would be through a market-determined competitive process.
3.	Promote quick and substantial usage of network	Aim to get the existing connectivity ecosystem to be tuned to local needs, ensure quick utilization of the assets and hence enhance the chances of the infrastructure being "kept alive" and "gainfully on" in the crucial initial period after commissioning. These would include, inter alia, TSPs/ ISPs/cable TV companies, as well as Government, with each class of service providers having the ability to size the available network to meet local requirements and needs by making available "plug and play bandwidth on demand".
4.	Non-discriminatory access	Ensure non-discriminatory access to the connectivity infrastructure created to multiple players so that every service provider within a category class has equal opportunity to access the potential of the network infrastructure.
5.	Minimise administrative burden on usage	Ensure "simplicity by design" so as to support minimal administrative oversight requirements, and harness market forces to drive on an ongoing basis the availability and price of broadband at the GP level.
6.	Provide market balance	Ensure service provision ability even in the absence of competition, control market dominance and prevent exercise of pricing power to the detriment of the citizen.

price fixation, TSPs wanted a balance to be drawn between business viability of service provisioning in the area vis-à-vis cost recovery.

6.10 During consultations with multi-system operators and cable T.V service providers, the MSOs indicated their requirement for dedicated fibre for delivering the entertainment content. It was suggested by them that 2 to 3 pairs of dark fibre could be dedicated for utilization by MSOs/ LCOs.

6.11 The Committee was informed by State Governments and Ministries of Government of India about their preference for bandwidth provisioning under NOFN and GUN for delivering education, health and e-governance services to rural areas.

6.12 The Committee strongly believed that using full cost recovery as the basis for bandwidth tariff may inhibit the growth of broadband in many areas and underprice investment in other areas. The consultations with various stakeholders made it evident that the determination of demand for bandwidth and pricing for the same is best left to market forces while keeping a ceiling on retail tariff to ensure affordability.

6.13 The Committee was of the opinion that there is market potential for both dark fibre and bandwidth delivery. While scalability of network electronics can ensure that market demand for bandwidth is provisioned, the availability of dark fibre being limited, the fibre resource would need to be allocated in a manner that the guiding principles detailed in paragraph 6.08 and the larger objective of affordable access to broadband are met. At the same time, the design of the business model would have to ensure that it does not lead to monopoly in service provision.

6.14 The Committee noted its recommendation in paragraph 3.32 of Chapter 3 to ensure reliability and network availability through laying of new optical fibre from District to GP on a ring architecture to two-thirds of GPs and linear architecture to one-third of GPs. The optical fibre so laid from District to Block is to be 48/96-core fibre and that from Block to G.P of 24-core fibre. The Committee was of the opinion that this enables adoption of a mixed business approach to make available both dark fibre and bandwidth from every District to every GP.

Rural Broadband through BharatNet: Utilisation Model

6.15 The Committee recommends that not less than 50% pairs of dark fibre at GP be set aside for allocation to telecom service providers, multi-system operators, local cable operators, Internet service providers and other service providers through forward-cum-reverse auction process, the mechanism for which is detailed in paragraph 6.17. 4 pairs of dark fibre shall be provisioned for bandwidth by the CPSU, State Government SPV or Implementation Partner in the three implementation models outlined in Chapter 4. Of this, at least some fibre pairs or bandwidth must be dedicated for Government services usage. Thereby, the model ensures availability of bandwidth and dark fibre while using the full potential of the infrastructure created through Government investment. Balance fibre(s) shall be retained as spare for maintenance purposes.

6.16 Auctions have been accepted as an economic method of allocation of scarce resources. Auctions offer the advantage of transparency and simplicity in determining market-based prices and economic efficiency; since certain auctions can guarantee that available resources are acquired by those that value them the most. The successful auctions for coal blocks to balance the multiple objectives has given the Committee a pointer to devising a mechanism for using auctions to balance the objective of affordable broadband tariffs and deriving the best value for the fibre.

6.17 In the Chapter on Implementation Strategy, the Committee has recommended parallel project execution through three implementation models – the CPSU-led model, the State Government-led model and the private sector-led model. The model proposed along with the forward-cum-reverse auction process would be equally applicable in all three models. In the State Government-led model, freedom may be provided to the State SPV to decide the number of pairs of dark fibres to be put to auction subject

to the condition that a minimum of 50% of the fibre pairs at Block-GP level is put to auction. The State SPV may also have the freedom to decide the number of pairs that could be used for Government services. The auction would be conducted for the District as a unit. The process for auction shall be as following:

(i) Dark fibre pairs from DHQ to GPs as a whole for a District as a unit shall be put to auction under the management and supervision of BBNL or State SPV, as the case may be. One pair of fibre may be set aside for auction from amongst ISP Category C (District-level) licensees to ensure promotion of local entrepreneurship and service delivery leveraging on the opportunities offered by the infrastructure.

(ii) The auction may be conducted District-wise as and when the District to GP fibre is tested and commissioned. Thereby, the auction process shall be commenced two months before actual commissioning by invitation of expressions of interest and evaluation of technical criteria. The auction shall not be delayed later than 3 months from date of commissioning of the relevant PoP.

(iii) Licensees who have duly obtained a licence for telecom service provision (UL, UASL, USAL etc.) or Internet service provision (ISP – Category A, B or C) or Multi-System Operators (MSOs) registered with Ministry of Information & Broadcasting or Local Cable Operators (LCOs) registered under the Cable T.V Networks (Regulation) Act, 1995, shall be eligible to participate in the auction. MSOs and LCOs would have to obtain Unified Licence or ISP licence of any applicable category within three months of the conclusion of auction. Any other company shall also be eligible to participate provided such company is eligible for Unified Licence or ISP licence of any applicable category which it shall obtain within three months of the conclusion of the auction.

(iv) The base price for the auction shall be fixed in the same manner in the coal auctions i.e. qualified bidders shall be asked to quote a price and the lowest of the quoted prices shall be the base price for the commencement of the auction. However, the base price shall not be lower than the annuity payments payable for the operations & maintenance divided by number of fibre pairs put to auction.

(v) The reverse auction will be operated on an electronic platform by soliciting bids from qualified parties, on the following terms and conditions:

  (a) The period of lease of dark fibre shall be for a period of 10 years and at the end of the lease period, the fibre shall revert back to BBNL/State SPV.

  (b) No single bidder can be awarded more than 1 pair in a District. However, a bidder can bid for fibre pairs across different Districts or States. It shall also be a condition imposed upon successful bidders that if a winning bidder is acquired by, or is significantly owned by another winning bidder in the same District, before, during or after the auction, the fibre pair shall revert back to BBNL or State SPV at the time of acquisition. This condition shall be imposed to ensure that sufficient competition is always present during the lease period.

  (c) Fibre availability and maintenance shall be ensured by the CPSU, State SPV or Implementation Partner during the period of the lease with disincentive penalties in case of failure to ensure fibre availability.

  (d) The bids shall be offered on "use it or lose it" basis i.e. dark fibre must demonstrably be utilized and roll out of services by the successful bidders within 6 months of award of lease; usage being evidenced by offering of their services and flow of traffic on the network, as the case may be, to any user at the relevant PoP.

  (e) The successful bidder would be free to induct technology of their choice for the electronics to facilitate service provisioning.

  (f) In case the TSP wishes to use the dark fibre for internal purposes (e.g., mobile backhaul), then the bids will be awarded to the TSPs which commit to making available mobile broadband.

  (g) The successful bidders shall be obligated to provide retail broadband services

Table 6.2: Indicative Retail Broadband price caps

State/U.T	Per capita NSDP 2013-14 (Rs at current prices)	Retail Broadband Tariff ceiling (Rs per month)
Andhra Pradesh	88876	222
Arunachal Pradesh	84869	212
Assam	46354	116
Bihar	31229	78
Chhattisgarh	58297	146
Goa	200514	501
Gujarat	96976	242
Haryana	132089	330
Himachal Pradesh	92300	231
Jammu & Kashmir	58593	146
Jharkhand	46131	115
Karnataka	84709	212
Kerala	88527	221
Madhya Pradesh	54030	135
Maharashtra	114392	286
Manipur	36937	92
Meghalaya	58522	146
Mizoram	63413	159
Nagaland	77529	194
Odisha	54241	136
Punjab	92638	232
Rajasthan	65096	163
Sikkim	176491	441
Tamil Nadu	112664	282
Tripura	60963	152
Uttar Pradesh	37630	94
Uttarakhand	103349	258
West Bengal	69413	174
Andaman & Nicobar Islands	107418	269
Chandigarh	156951	392
Delhi	219979	550
Puducherry	148784	372

for a base bandwidth per household (as may be determined by the Central Government in case of BBNL and State Government in case of the State SPV[1] prior to the auction) at tariffs lower than a ceiling which shall operate as the price cap. The price ceiling shall be capped at 3% of the per capita District Net Domestic Product, if available, failing which it shall be capped at 3% of the per capita State Net State Domestic Product (NSDP)[2]. The table below calculates indicative retail broadband price caps on the above formula based on data obtained from the Economic Survey for FY 2014-15:

(vi) There shall be specific roll-out obligations imposed on the successful bidders to ensure that broadband reaches every household over a period of time. The successful bidders would be subject to penalties in case the roll out obligations are not achieved which can be pooled by BBNL or State SPV to fund last mile reach on a competitive basis to reach the unreached.

(vii) The bidders will participate in the auction by quoting the annual lease price for a pair of dark fibre.

(viii) If sufficient numbers of bidders for pairs of dark fibre on offer are not available, then the new offer price shall be marked down (lowered) from the base price for the next round.

(ix) On the other hand, if the demand for dark fibre pairs exceeds supply, then the new offer price shall be marked up (increased) from the base price for the next round.

(x) The auctions shall continue for such time till all the dark fibre pairs on offer are utilized i.e. demand is equal to supply and the annual lease rental shall be the price at which demand for dark fibre pairs equals supply.

1 This differentiation is being suggested as the State Government in case of the State SPV would have made capital investments in the Network and would meet O&M costs in addition to that being made by the Central Government.

2 The Report of the Broadband Commission of the International Telecommunications Union (ITU) -2014 states that broadband ecosystem takes off if the broadband tariff is less than 5% of per capita annual income (page 39, Chapter 3).

(xi) In case, the price falls to zero and the supply of dark fibre still exceeds demand, then the number of fibre pairs put to auction shall be reduced and auction commenced afresh.

6.18 Of the balance fibre pairs[3], 4 fibre pairs shall be provisioned by the CPSU or State SPV or Implementation Partner. Bandwidth shall be dedicated for Government services, including education, health and other services. Other available bandwidth shall be available at wholesale rates for any retail services provider by laying the necessary infrastructure. BBNL shall ensure that the wholesale prices are calibrated appropriately so that it does not distort the retail market and uses these prices to bring stability to services pricing. The CPSU, State SPV or Implementation Partner shall be incentivised if bandwidth utilisation exceeds 50% of the bandwidth provisioning. In so far as the balance fibre in the DHQ-BHQ layer is concerned, the same may be available in case of diversion of traffic, splicing for architecture purposes and maintenance.

[3] A few fibre pairs (1-2) shall be kept spare for compensating any auctioned fibre pair that becomes unusable due to some reason during the lease period.

6.19 The evaluation of the proposed business model with reference to the guiding principles is elaborated in the *table 6.3*.

Government Services Provision

6.20 Government services provisioning will continue to remain the mandate of BBNL or State SPV (in a State-led model). Horizontal fibre connectivity extended to Government institutions at the District, Block and GP level would be provisioned by BBNL or State SPV through the Implementation Partner. The Committee recommends that service provisioning for public health, school education and Government-sponsored multi-skilling institutions be provided free to the Government user institution, considering the immense societal benefits and the pressing public interest in providing better education and health facilities. The tariff for connectivity for Government services provisioning will be fixed by BBNL with the approval of the Central Government in case of the CPSU-led and Private-sector led model and by the State SPV with the approval of the State Government in case of the State-led model. With the comprehensive network for Government services envisaged from

Table 6.3: Evaluation of Business Model against Guiding Principles

S. No.	Principle	Evaluation
1.	Encourage competition to reach the user	The proposed model enables 9 service providers (eight identified through auction process and BBBL/State SPV through the Implementation Partner) providing a range of services catering to the local market
2.	Affordable broadband services	By fixing a price ceiling for retail broadband services pegged to the economic development and per capita income of a State, the business model ensures availability of affordable broadband services.
3.	Promote quick usage of network	With the condition of quick roll out of services –"use or lose" – the usage of network will be ensured in the shortest possible time.
4.	Non-discriminatory access	Every service provider has equal opportunity to access the potential of the network infrastructure at the same price through the auction process.
5.	Minimise administrative burden on usage.	The administrative oversight and compliances are kept at the barest minimum causing the least burden on service provisioning.
6.	Provide market balance	The bandwidth provisioned by BBNL through the CPSU/State SPV/ Implementation Partner would prevent market distortions and market dominance through calibrated action.

the District layer to the GP layer including Blocks, the Committee recommends that the Department of Electronics & I.T may re-work its proposal for the National Information Infrastructure upwards of the District layer and subsume the State Wide Area Network (SWAN) and the National Knowledge Network (NKN) below the District layer with the restructured BharatNet.

6.21 The Committee is of the belief that unless the States are active in creating content and the platform for delivery of Government services through the electronic platform, the real impact of the infrastructure being created for improved governance would be marginal despite the best of intentions. The Committee is aware that the Government of Andhra Pradesh is proposing the establishment of a State Digital Services Corporation to aggregate and provide Government services to citizens. The Committee recommends that State Government could follow this example and either establish a State Digital Services Corporation or convert one of the existing State PSUs into a Digital Services Corporation by expanding their mandate so as to ensure that focussed attention on creating the right content, inducting information technology platforms in Government departments and digitisation of Government records/services is given to truly create transformative change through "minimum government, maximum governance".

6.22 The Committee wishes to draw specific attention to three key areas in content creation: school education, skill development and primary health care (including maternal and child health, early childcare and education, sanitation practices). The Committee believes that the right content riding on the right infrastructure in these three key areas can completely change the face of rural India and unleash the tremendous potential that lies dormant in rural India enabling the Nation to leapfrog into the future.

Bandwidth Provisioning by Implementation Partner

6.23 The Committee recommends BBNL or State SPV, as the case may be, provide wholesale bandwidth to retail service providers as a market balancing mechanism and ensure alternative supply channel for the broadband bandwidth market. The Committee also recommends that the tariff for wholesale bandwidth provisioning be fixed by BBNL, in case of the CPSU-led and Private-sector led model, and by the State SPV in case of the State-led model. The tariff so fixed shall be in accordance with and comply with the applicable regulations of the Telecom Regulatory Authority of India (TRAI).

Conclusion

6.24 The Committee believes that its recommendation on the utilisation model encourages effective and efficient utilisation of infrastructure in a manner dovetailed to making available rural broadband services at affordable prices, thereby meeting the objectives of Digital India. The Committee observes that the concept of auctions outlined is not new yet it is novel in its application to dark fibre allocation and pricing. The Committee, therefore, recommends that consultations with the probable users of the network may be conducted before firming up the auction model. The Committee believes that the suggested mechanism has the potential to kick-start a broadband revolution reaching every nook and corner of rural India.

Chapter - 7

Migration from NOFN to BharatNet

Introduction

7.01 The Committee in the previous chapter outlined three implementation models for the project to be carried forward. The course correction suggested in the previous chapter has to be effected while the project implementation according to the existing methodology is underway. Orders for optical fibre cable and GPON electronic equipment have been placed and supplies are being received. The three implementing CPSUs have proceeded to procure PLB ducts and place work orders for trenching and laying of ducts and fibre. Therefore, for the recommendations of the Committee for a new project execution framework to be effectively followed, there has to be a plan for migration from the existing to the new framework while ensuring that investments already made are protected and contracts entered into are modified or closed without significant loss to BBNL or Government.

7.02 The first step towards migration to the new framework would be to survey and re-plan the entire network based on the architecture and technology suggested in Chapter 3. While undertaking the planning activity, due diligence would have to be exercised to ensure that the work already completed and investments made are optimally utilized through planning. The following sections detail the process of migration on three areas of the project – existing procurement contracts, work taken up and completed by the Implementing CPSUs and the Network Operations Control philosophy.

Procurement of fibre and electronics

7.03 The Committee has studied the existing contracts for procurement of optical fibre cable (OFC) and GPON electronic equipment entered into by BBNL. The supply contracts for OFC have been placed in 6 packages upon 14 vendors. Of a total requirement of 6 lakh km of OFC, supply orders have been placed for 30% of the requirement. The table below indicates the present status of supplies of OFC *(see table 7.1 on page 85)*

7.04 The broad specifications for OFC proposed by the Committee for Block to GP connectivity is the same as that being procured by BBNL. The length of fibre to be laid would be higher by virtue of the proposed topology of ring architecture in two-thirds of GPs. This fibre could also be utilized for horizontal connectivity to Government institutions at the Block and GP. Thereby, the Committee recommends that the OFC that has already been procured could be utilized in the new implementation structure by CPSUs in the first instance, and the balance offered to the successful bidder in the private-sector led model at the purchase rate.

7.05 BBNL estimates that out of the purchase orders placed for a quantity of 1,78,715 km of OFC, 1,33,081 kms would be supplied by the end of the contracted delivery period. The Committee notes that the contracted supply period has been extended by BBNL and the expected supply indicated is in the extended delivery time. The Committee recommends that no further extensions be permitted and BBNL should not place any further purchase orders beyond the supplies of OFC received within the extended delivery period.

7.06 The technology proposed for electronic equipment in the new design of NOFN means that the possibility of usage of GPON and accessories being procured in the existing contract will have to be reassessed. BBNL has indicated that the sole supplier has defaulted in the original delivery period and the supply period stands extended up to March 31, 2015. The expectation of supplies of OLT and ONT by the supplier assessed by BBNL is given in the table 7.2 on page 85.

7.07 The GPON equipment likely to be supplied to BBNL by the end of the delivery period would be sufficient to cover 8500 GPs with ONT with a maximum tree architecture for 25,000 GPs. The supply that is likely to be made could be utilized for horizontal connectivity at District and Block level to Government institutions or in the approximately one-third GPs (less those GPs to be covered using radio and satellite) proposed to be connected in linear topology. Here too, BBNL should not permit further extension in the

Table 7.1: Status of supply contracts for optical fibre cable - BBNL

S. No.	Date of Purchase Order (2014)	Contract Delivery Date (2015)	Quantity of contract (km)	Quantity supplied till March 9, 2015 (km)	Quantity expected to be supplied by contract delivery date (km)
1.	January 7	Feb 23	23,756	14,530	14,530
2.	March 7	March 15	24,940	15,479	15,479
3.	March 7	March 15	19,000	19,000	19,000
4.	March 7	March 15	13,000	12,400	12,400
5.	March 7	March 15	11,400	6,838	8,383
6.	March 25	March 27	5,500	4,400	5,500
7.	March 25	March 27	10,000	10,000	10,000
8.	March 25	March 27	10,416	10,416	10,416
9.	March 25	March 15	7,000	3,186	3,186
10.	March 25	March 27	13,050	13,050	13,050
11.	March 28	April 9	4,086	3,269	3,269
12.	March 28	April 9	9,200	9,200	9,200
13.	March 28	April 9	3,670	2,304	2,304
14.	March 31	April 9	5,189	1,617	2,076
15.	April 16	April 9	2,900	1,089	1,089
16.	May 8	March 27	13,650	2,050	2,050
17.	Sept 19	March 19	1,157	692	925
18.	Sept 19	March 19	281	168	224
			178,195	**129,688**	**133,081**

Table 7.2: Status of supply contracts for GPON – BBNL

Date of Purchase Order (2014)	Extended Delivery Date (2015)	Quantity to be supplied		Quantity supplied till March 9, 2015		Quantity expected to be supplied by March 31, 2015	
		OLT	ONT	OLT	ONT	OLT	ONT
Sept 3	March 31	3000	59,980	556	5755	1000	8500

already extended delivery period of the contract which has overshot the original supply period.

7.08 BBNL has expressed a view that whether procurement of GPON through a fresh tendering process or induction of another technology is conceived, the testing, certification and quality assurance for the new supply would have to be undertaken afresh. Therefore, in a composite tendering process as envisaged in Chapter 4 on Implementation Strategy, the time duration to be expended for testing and certification can be taken up in parallel with the optimization of network and work on trenching/laying of PLB duct and optical fibre.

Procurement and Work Contracts of Implementing CPSUs

7.09 The progress in laying duct pipes has been tardy though the pace appears to have picked up in recent months with 8000 to 10,000 kms of duct being laid in the last month by the implementing CPSUs as the issues initially faced

on procurement of duct have been resolved. However, out of a total length of 209,098 kms of duct pipe to be laid to connect GPs in Phase-I, only 14% of the total work has been completed. The performance is best in States such as Karnataka, Kerala, Chhattisgarh, Jharkhand and Haryana – States which have been recommended by the Committee for implementation in the CPSU-led model. The table below indicates the status of the laying of ducts *(see table 7.3)*

7.10 Out of a total of 2765 Blocks in Phase-I of NOFN, work has been awarded (up to March 9, 2015) in 1604 Blocks. Of these Blocks, work has been started in 1421 Blocks comprising 26,520 GPs. In so far as the progress in work on pulling of OFC, the table below captures the present status *(see table 7.4 on page 88)*

7.11 The strategy for migrating project implementation to the new methodology would

Table 7.3: Status of laying of ducts – Implementing CPSUs

State/U.T	% GPs in Phase - I	Duct laid till March 9, 2015	% duct laid for Phase-I	Implementing CPSU	Suggested Model
SOUTHERN REGION					
Karnataka	100%	5608	48%	BSNL	CPSU-led
Andhra Pradesh		1651		State-led	State-led
Telangana	25%	875	16%	PGCIL	Private sector-led
Tamil Nadu	4%		0%	MoU not signed	State-led
Kerala	100%	602	55%	BSNL	CPSU-led
Puducherry (U.T)	100%	61	65%	BSNL	CPSU-led
Lakshadweep (U.T)	100%	0	0%	BSNL	CPSU-led
Andaman & Nicobar Islands (U.T)	100%	0	0%	BSNL	CPSU-led
NORTHERN REGION					
Jammu & Kashmir	15%	7	0%	BSNL	CPSU-led
Himachal Pradesh	40%	3	0%	PGCIL	CPSU-led
Punjab	47%	766	9%	BSNL	CPSU-led
Haryana	72%	1709	25%	BSNL	CPSU-led
Rajasthan	77%	2925	15%	BSNL	Private sector-led
Chandigarh (U.T)	100%	15	83%	BSNL	CPSU-led
Uttarakhand	23%	407	12%	BSNL	CPSU-led
Uttar Pradesh (West)	55%	1096	10%	BSNL	Private sector-led

Uttar Pradesh (East)	38%	2534	12%	BSNL	Private sector-led
EASTERN REGION					
Bihar	62%	2618	21%	BSNL	Private sector-led
West Bengal	79%	702	10%	BSNL	Private sector-led
Jharkhand	32%	911	28%	PGCIL	CPSU-led
Odisha	59%	1442	13%	BSNL	Private sector-led
CENTRAL & WESTERN REGION					
Madhya Pradesh	46%	6472	23%	BSNL	Private sector-led
Chhattisgarh	20%	1869	32%	BSNL	CPSU-led
Gujarat	38%	1600	16%	RailTel	State-led
Maharashtra	41%	2403	10%	BSNL	Private sector-led
Dadra & Nagar Haveli (U.T)	0%	0		RailTel	CPSU-led
Daman & Diu (U.T)	65%	0	0%	RailTel	CPSU-led
NORTH EASTERN REGION					
Sikkim	33%	0	0%	BSNL	Private sector-led
Assam	39%	881	32%	BSNL	Private sector-led
Arunachal Pradesh	25%	14	1%	RailTel	CPSU-led
Nagaland	22%	64	7%	RailTel	CPSU-led
Manipur	11%	167	17%	RailTel	CPSU-led
Meghalaya	49%	0	0%	RailTel	CPSU-led
Tripura	100%	487	21%	RailTel	CPSU-led
Mizoram	45%	0	0%	RailTel	CPSU-led
Total		**37889**	**14%**		

Table 7.4: Status of project – Implementing CPSUs

State/U.T	Total Number of Blocks	Blocks in Phase - I	Work orders awarded - Blocks	OFC pulling up to March 9	OFC laying up to March 9 - GPs	Suggested Model
SOUTHERN REGION						
Karnataka	176	176	135	33%	2097	CPSU-led
Andhra Pradesh						State-led
Telangana		115	93	1%	14	Private sector-led
Tamil Nadu	385					State-led
Kerala	152	152	152	53%	851	CPSU-led
Puducherry (U.T)	10	3	3	65%	67	CPSU-led
Lakshadweep (U.T)	0	0	0	0%	0	CPSU-led
Andaman & Nicobar Islands (U.T)	9	7	0	0%	0	CPSU-led
NORTHERN REGION						
Jammu & Kashmir	143	22	3	0%	0	CPSU-led
Himachal Pradesh	77	30	4	0%	0	CPSU-led
Punjab	139	66	47	5%	234	CPSU-led
Haryana	122	94	83	15%	741	CPSU-led
Rajasthan	247	188	111	10%	669	Private sector-led
Chandigarh (U.T)	1	1	1	78%	9	CPSU-led
Uttarakhand	95	28	18	9%	176	CPSU-led
Uttar Pradesh (West)		126	47	5%	388	Private sector-led
Uttar Pradesh (East)	821	223	72	8%	798	Private sector-led
EASTERN REGION						
Bihar	534	315	167	15%	408	Private sector-led
West Bengal	333	262	71	4%	83	Private sector-led
Jharkhand	259	74	71	6%	48	CPSU-led
Odisha	314	195	124	6%	143	Private sector-led
CENTRAL & WESTERN REGION						
Madhya Pradesh	313	140	113	14%	548	Private sector-led
Chhattisgarh	141	34	29	19%	201	CPSU-led
Gujarat	223	86	49	6%	282	State-led
Maharashtra	352	167	69	7%	558	Private sector-led

Dadra & Nagar Haveli (U.T)		0	0		0	CPSU-led
Daman & Diu (U.T)		1	0	0%	0	CPSU-led
NORTH EASTERN REGION						
Sikkim		9	0	0%	0	CPSU-led
Assam	191	91	75	16%	92	Private sector-led
Arunachal Pradesh	155	43	8	0%	0	CPSU-led
Nagaland		12	2	0%	0	CPSU-led
Manipur		13	13	0%	0	CPSU-led
Meghalaya		28	0	0%	0	CPSU-led
Tripura	26	44	44	8%	17	CPSU-led
Mizoram		20	0	0%	0	CPSU-led
Total	**5218**	**2765**	**1604**	**10.37%**	**8424**	

depend on the model proposed by the Committee. The Committee recommends that:-

(i) For States suggested to be operated on the State-led model i.e. Andhra Pradesh, Tamil Nadu, Gujarat etc., the work being undertaken by the CPSUs has already been stopped or should be stopped immediately after the State makes a submission for adopting the model.

(ii) For States recommended for implementation through CPSUs, the work may be continued, except for blowing the fibre, for the time being by the CPSUs. The revised planning exercise may incorporate the work already undertaken by the CPSUs in Phase-I. Additional CPSUs – Telecom Consultants India Limited (TCIL), Indian Telephone Industries Limited (ITI), Engineers India Limited (EIL) - may be inducted for project execution.

(iii) For States recommended to be taken up for implementation through the private sector, the duct being procured by the implementing CPSUs in these States may be reassigned to the States proposed for implementation through CPSUs under the new methodology. The balance ducts, if supplied, may be offered to the successful bidder at the purchase rate. No work orders for trenching and laying may be awarded in these States after March 31, 2015. The implementation of trenching and laying of ducts and pulling of OFC in the blocks for which work orders have been issued by March 31, 2015 may be completed by August 31, 2015. By this time, the Committee hopes that the tendering process for the private-sector led model would have commenced. The work already done may be integrated into the planning process and included as pre-existing fibre in the tender documents to be prepared for inviting bids.

The Committee recommends that the interim orders on the above lines could be considered till the planning process for a new network is completed.

Conclusion

7.12 The Committee is of the opinion that its recommendations in this Chapter enable the migration to the new implementation methodology and architecture without any substantial loss of investment and additional costs. Due diligence and care in the new planning process as per the revised architecture as proposed in Chapter 3 can smoothen the migration to BharatNet.

Chapter - 8

Empowered Structure and Empowering BBNL

Introduction

8.01 Bharat Broadband Network Limited (BBNL) was incorporated on February 25, 2012, as a Special Purpose Vehicle (SPV) for the establishment, management and operations of the National Optical Fibre Network (NOFN). BBNL was envisaged as a project management company with implementation in the field handled by the three Implementing Central Public Sector Undertakings (CPSUs) – BSNL, PGCIL and RailTel. NOFN implementation involves unprecedented scope and complexity. For planning, implementing, commercially and technically operating and maintaining the restructured BharatNet, BBNL must possess the requisite managerial and technical capacities and must be duly empowered financially, operationally and administratively for efficient management.

8.02 During consultations, it was evident that BBNL feels financially, operationally or administratively disempowered. The flow of funds is not predictable and subject to procedural complexities. BBNL functions with rudimentary employee strength, most of whom are either on deputation or seconded from sister organisations in Government, with little experience of project management, understanding of the complexities involved and appreciation of the co-ordination required with multiple Governments and agencies. It is unable to sanction higher level posts according to its requirements or recruit employees with the required expertise in the absence of duly vested powers. Unless these issues are resolved, the structural problems with BBNL would jeopardise the project even if the implementation strategy and business models are rightly designed.

8.03 The Committee noted that as part of its Terms of Reference (ToR), the Committee was specifically asked ***"to recommend an effective and empowered structure and mechanism for implementation of NOFN in mission mode"***. The Committee has given deep thought to the issue and has discussed the structural issues in the succeeding paragraphs.

Structural Challenges

8.04 The consultations with BBNL brought forth the following structural challenges:

(a) **Layered decision-making process:** Presently, decisions on the project move across several layers that delays decision-making and inhibits initiative in resolving issues impacting cost and timelines. The figure below captures the layers in the decision-making process *(see figure 8.1)* As an example, the Committee was informed that BBNL referred the standard, uniform schedule of rates to be followed for project estimation and tender evaluation to Universal Service Obligation Fund (USOF) who further referred the matter to the Telecom Commission which decided that applicable schedules of rates including State Schedule of Rates (SoR), CPWD or implementing CPSU schedule may be considered for each unit for which tender had been issued. When this was found to be inadequate, the issue was referred again to the Telecom Commission following the same route after three months that the SoR followed by BSNL at the level at which it issues tenders or corresponding State SoR as on a reference date, be taken as applicable SoR by BBNL. This example shows the problem where project implementation issues are pushed to higher levels for decision.

(b) **Inter-agency coordination and collaboration mechanism:** The successful execution of NOFN depends on collaborating effectively with a number of agencies, both at Centre and State. NOFN is further envisaged to integrate with various initiatives such as NII and the NKN. Most importantly, it offers a wide

Figure 8.1: Layered Decision Making

range of stakeholders (including State Governments and Central Ministries) a new tier of governance and service delivery capabilities. For NOFN to be effectively delivered and leveraged, these stakeholders must be helped to find administrative coherence with BBNL initiatives. There is a need for appropriate mechanisms at the National and at the State level to ensure timely implementation, integration with other planned networks and to drive effective usage.

(c) **Organisational autonomy:** Given the magnitude and unprecedented nature of NOFN and the large number of stakeholders with which it has to engage, BBNL's leadership would be key in dealing with the complexities of implementation and usage of NOFN besides driving the creation of a vibrant service and demand ecosystem. The original Cabinet mandate for NOFN had indeed envisaged the SPV as a fully empowered administrative and financial entity with the wherewithal to carry out its mandated tasks. However, in terms of actual functioning, BBNL has tended to function more as a constrained CPSU, subject to greater disabilities than a normal CPSU, rather than as a dynamic performance-oriented SPV single-mindedly focused on the project. As an example, the Scheme approval had explicitly stated that the estimates approved were broadly indicative, given the complex nature of the NOFN project, its widespread geographical area, and the fact that the actual quantum of work to be done would be known only after a detailed survey, and had therefore provisioned for actual fund approvals and allocations by the Department of Telecommunications and the Telecom Commission based on the actual competitive bids received. However, the Committee understands that the contract that USOF signed with BBNL and correspondingly that signed by BBNL thereafter with the three Implementing CPSUs does not adequately reflect this principle of allocating funding based on actual requirements. BBNL has made it incumbent upon the implementing CPSUs to seek prior BBNL approval in a number of cases where changes have to be made in the estimates or quantum of work to be done (against the defined deliverables) – for instance, in case of any cost escalation beyond 10% of the indicative estimate. It is seen that this has been a severe cause of delay, bottlenecking NOFN tendering and contracting on several occasions.

(d) **Organisational structure and Human Resources:** As a CPSU, BBNL is subject to the norms and principles that apply to all CPSUs in Government. Over time, certain principles have been evolved in Government to allow a degree of operational autonomy in human resources management to CPSUs based upon many parameters including size, turnover, profitability, strategic importance. The Committee was also informed that BBNL was not categorized and due to non-categorization of BBNL, it has been deprived of the operational freedom that is normally allowed to other CPSUs. As a result of which it has to seek approval of two Departments – the Department of Telecommunications and the Department of Public Enterprises for matters such as creation of posts necessary for project management. It has not had a regular Chairman-cum-Managing Director since its inception. The post of Director (Operations) has remained vacant for over 6 months and is likely to remain vacant for a long time if normal process for appointment is followed. Since inception, BBNL does not have any independent Director on its Board to advise and counsel the management. The dearth of human resources has constrained the ability of BBNL to undertake project management and monitoring to the extent required. The table below indicates the human resources position in BBNL *(see table 8.1 on page 93)*

The Committee felt that the current organizational structure and human resources capacity severely inhibits the capacity of BBNL to plan, manage, monitor or operate NOFN in a professional way

Table 8.1: Human Resources in BBNL

Positions	Sanctioned	Working	Corporate Office	Field Units
Board of Directors	4	2		
Level-I: Senior Management				
E7 and above	117	99	26	73
Level II: Junior Management				
E-5 (Asstt. GM)	20	0		
Manager	64	15	11	4
E-1 (Asstt. Manager)	93			
Total	**298**	**117**	**40**	77

8.05 The Committee, on reviewing BBNL's organisational structure, identified the following factors as fundamental to restructuring the organization into an effective and performance oriented entity:

(a) **Professional capacity gaps undermine effective delivery**: The Committee noted that BBNL's professional cadre is heavily weighted towards technical expertise, leaving large gaps in domains crucial to successful delivery: a structural factor that will undermine BBNL's ability to implement, manage, operate or maintain BharatNet.

(b) **Cadre-based staffing pattern limits talent acquisition.** BBNL is staffed entirely by encadred officials, from CPSUs and the Central Civil Services. This comes with significant advantages: cadre-based staffing allows for organisational capabilities to be gradually built and sustained, within a dedicated corps. However, by adopting a purely cadre-based staffing model , BBNL has been unable to leverage the huge project planning, design, management and execution capabilities that are required for successful implementation of a world-class infrastructure.

(c) **Dispersed accountability, distributed across multiple organisational levels:** BBNL's current management structure needs to be radically overhauled to ensure that executives are assigned and held accountable for specific operational results. The structure also does not empower executives adequately to manage and deliver results. Instead, in several important cases, operational authority is distributed across several individuals at different layers within the organisation. This disincentivises performance, making it difficult for company leadership to allocate performance responsibility to its executives and structurally undermining BBNL's performance. It also subjects project delivery decisions to multiple approvals – within and outside BBNL - leading to unnecessary delays.

(d) **Augmenting regional capacities:** Regions and States will form a key operational locus for NOFN delivery. State-level activity will occur at a scale and complexity that would typically merit the focus of an entire State PSU. It may be self-evident to State that there is no parallel to the proposed BharatNet either in scale, diversity or complexity anywhere in the telecom sector in India or in any CPSU currently. However, BBNL's current organisational structure allocates minimal resources to State-level project monitoring and execution. For example, no more than two individuals are held responsible for any State, in some cases, as with the North East, an entire region.

Guiding Principles

8.06 The Committee is of the view that

if BharatNet is to be executed on time, at performance levels above global benchmarks, its governance must be boldly restructured – both external and within BBNL. In the Committee's view, this is the single most urgent, important factor that would determine BharatNet's implementation success.

8.07 To successfully deliver BharatNet, the Committee recommends a governance structure that operationalises three strategic administrative principles:

(a) **Delayering decision-making to promote initiative in project implementation:** BharatNet needs de-layered governance arrangements, both within and external to BBNL, optimised for swift decision-making. BBNL project execution will be slowed if operational decisions are subject to multi-level administrative and approval processing. BharatNet is a unique project, unprecedented in scale, scope and range. It is natural that the project implementation path will encounter many stones as one proceeds ahead. Hard-coding operational parameters besides elemental decisions will impact pace of implementation. Further, NOFN implementation also risks delay if programme-level approval processes are placed within standard Departmental administrative systems – sharing overstretched administrative time and capacity with other schemes. It may be essential to create a new de-layered decision-making process external to BBNL in Government that expedites decision-making. To ensure timely delivery, BBNL will have to be empowered with organisational autonomy vis-à-vis its parent Department and USOF, making its operational decisions less dependent on multi-layered approvals. BBNL would also need to be given the authority to frame more streamlined internal management processes, allowing it operate more efficiently. The real challenge would be to create the right oversight, transparency, and accountability mechanisms that engender accountability without impinging on the autonomy for BBNL to deliver its mandate.

(b) **Establish predictable and adequate funding flows, to stabilise project implementation**. Frequent changes in funding levels will add uncertainty to BBNL's project management, making it harder to decisively commit resources to speedy execution. It will also interfere with operational momentum, periodically slowing down implementation. To build and maintain a consistently swift implementation programme, funding arrangements must provide BBNL with a steady, assured stream of finance depending on the pace of implementation.

(c) **Build a world-class, professional company, with requisite talent in identified areas and industry-standard management practices:** To meet current timeframes, BBNL must implement BharatNet at performance rates an order of magnitude above global benchmarks. This necessarily requires a global-standard project delivery organisation. BBNL must be structured as an empowered, autonomous, professionally managed organisation, recruiting and deploying talent across each of the identified operational focus areas. The example of the Delhi Metro Railways Corporation (DMRC) shows that it is possible to create such an autonomous, empowered institutional structure within the Government.

(d) **Create formal channels of communication for BBNL to interact with State Governments, Ministries in Central Government and Agencies involved in the project for smoother implementation:** There is a need to improve inter-agency and intra-Government and inter-Governments communication and construct formal mechanisms tasked with finding solutions and smoothening hurdles in project implementation and ensuring readiness in content delivery. There is no part of Government that is conceivably untouched by BharatNet and its impact and communication between the agencies involved through formal channels can lead to harmonious settlement of otherwise contentious issues.

Empowering BBNL

8.08 The Committee recommends that in order to transform BBNL into a Board-led Company and professionalise decision-making at the Board-level, the following steps be taken:

(a) **Separate the posts of Chairperson and Managing Director and appoint a globally-renowned and eminent Indian with proven expertise in project management, preferably from industry, as non-executive Chairperson** of the Board. The Chairperson would be expected to bring professional experience in management of large projects to the Board and provide credibility, strategic guidance, sound oversight and leadership to guide the project. The Committee suggests that the Chairperson may be selected by the Prime Minister along with the Finance Minister and the Minister of Communications & I.T through a search process.

(b) **Appoint an experienced executive from Government as Managing Director and Chief Executive Officer of BBNL** for a defined term of 5 years. The Managing Director would have a highly accomplished, objectively credible track record of managing and delivering projects in the telecommunications, infrastructure or information technology sectors. At the time of appointment, quarterly project milestones would be negotiated with the Managing Director-select and these milestones would comprise part of the order of appointment. The Managing Director would be eligible to receive a consolidated pay and would face incentives and disincentives in emoluments in case of early or delayed achievement of quarterly milestones. The performance of the Managing Director shall be reviewed annually in terms of achievement of the quarterly milestones by an Empowered Project Group as detailed in paragraph 8.11 (a) to determine the incentives and disincentives.

(c) **Expand and professionalise the Board**, to include both wider representation from key Government agencies and from industry, finance, telecommunication, project management project management and consultancy. At least 50% of the Board of Directors shall be drawn from outside Government. The suggested composition of the Board of Directors is as follows:

(i) Chairperson
(ii) Managing Director and Chief Executive Officer
(iii) Administrator (USOF)
(iv) Member (Finance), Department of Telecommunications
(v) Additional Secretary, Department of Electronics & I.T
(vi) Additional Secretary, Department of Economic Affairs
(vii) 5 independent directors who shall be professionals of credibility, of which one shall be the head of a public sector bank, and the others from infrastructure, telecommunications, I.T, consultancy sectors.

(d) The Committee observes that a Search-cum-Selection Committee has been constituted under the chairmanship of Chairman, Public Enterprises Selection Board (PESB) for selecting a person for post of CMD BBNL on deputation basis for a period of 5 years, the post being open only to officers in Government substantively holding the post of Joint Secretary or equivalent. The Committee recommends that **this decision be reviewed urgently** in the light of the recommendations above and steps initiated afresh to select a CEO as described above.

(e) **Professionalise BBNL's human resources and talent pool to world-class standards**, in an organisation run according to best management practices. BBNL must be empowered to recruit the best professional talent available in the country, across technical and managerial functions. BBNL will be maintained as a lean organisation, building an internal pool of informed experts for planning the network and for designing, managing, and overseeing contracting functions. Building this internal capacity will be

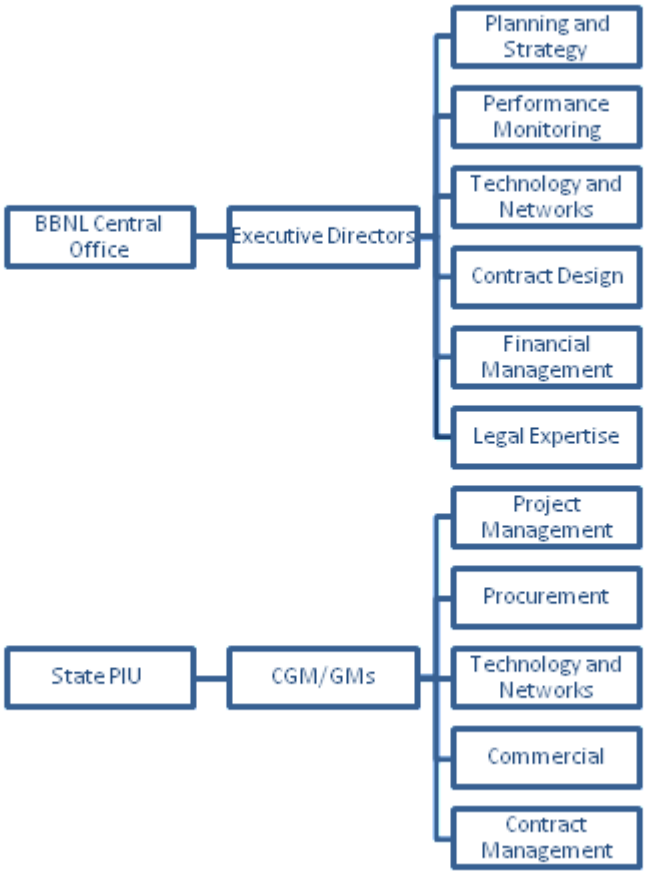
vital to BBNL's task. Reflecting the diverse nature of BBNL's tasking, BBNL should be free to recruit talent across professional backgrounds – including cadre civil servants and PSU officials well versed with public policy, interface with Central Government Ministries and State Governments, public finance management and administrative approval systems, as well as more specialised expertise (in areas such as network planning, GIS mapping, auction design and performance monitoring, for example) from the private sector. BharatNet is a network designed to serve the citizens (delivery of Government services) and customers (delivery of demanded services) and the human resources within BBNL should reflect the amalgamation of the best in Government and outside. As an indicative measure, the Committee recommends that at least a significant proportion of all senior management positions should be drawn from amongst those who have previously not worked in Government.

(f) **Design for accountability** so that BBNL's professional staff would operate in an organisational framework with clearly defined, coherently allocated responsibilities and powers. BBNL must be reorganised to localise both administrative responsibility and operational authority to appropriate executives – simultaneously empowering them to perform, and enabling performance monitoring to ensure sustained effective implementation. All officers in the senior management (E-7 and above) would face two levels of incentives and disincentives – one related to the achievement of quarterly project milestones committed by the Managing Director for the company as a whole and the other related to performance of the Units within BBNL as assessed by the Board of Directors. The first incentive parameter works to harmonise functioning within BBNL aligning individual performance to organizational goals and the second parameter propelling the individual Unit to excel beyond the organizational goal. The performance of every head of a Business Unit within BBNL shall be assessed annually by the Chairperson and Managing Director jointly and this report placed before the Board of Directors. Based on the assessments made, the Board of Directors can order the repatriation of termination of contract of the head of the Business Unit.

(g) **Develop a two-tier operational framework, with centralised planning; distributed execution at State/Regional level**. BBNL's entire asset base will be built in rural India, through operations that are localised in States and regions and dependent on collaboration with State governments. Its organisational structure must reflect this – deploying significant project management and coordination resources to the States, while ensuring operational coherence at the national level through centralised project planning and coordination. The Committee therefore recommends that BBNL be designed around a two-tier framework. Strong, capable, highly empowered State or Regional Project Implementation Units (PIUs) would manage and perform the bulk of BBNL's tasking: project planning, contract and procurement management, and operational administration. BBNL's Corporate Office would exercise central oversight and coordination functions, including strategic planning, performance monitoring, auction design, service enablement and partnerships, legal support and other related functions. The proposed 2-tier organisational structure is as given in the figure 8.2 on page 97.

8.09 The Committee recognizes that contract management would be a key area of expertise for BBNL. BBNL would have to manage two kinds of contracts – implementation contracts with the Implementation Partner specifically related to project milestones and SLA maintenance and the utilization contracts entered into with successful bidders in the auction of dark fibre. The Committee suggests that BBNL should develop strong legal expertise to manage disputes that are

Figure 8.2: Two-Tier Organisational Structure of BBNL



likely to arise in interpretation of contract clauses. Settlement of disputes expeditiously is extremely important to ensure continued service delivery to citizens. Therefore, the Committee recommends that a credible third party dispute resolution and arbitration mechanism should be put in place for expeditious resolution of disputes.

8.10 The Committee appreciates that the vagaries of the budgeting processes constrain the ability of BBNL predictably source funding for the project as budgeting processes are subject to overall fiscal management and Parliamentary approvals. However, unpredictability in financial flows can seriously jeopardise the project, increase risks and inflate costs. Therefore, smoothening capital flows for project execution is extremely critical. The Committee, therefore, recommends that USOF should be permitted to borrow from the financial market to smoothen short-term capital flows. The interest cost on this account shall be legitimately accepted as an element of project expenses by Government.

Supporting External Environment and Structural Changes

8.11 The Committee recognizes that structural changes in the external environment would have to be dealt along two dimensions: de-layering the decision-making structure outside of BBNL and providing a platform for interaction between BBNL and user Ministries and between State Governments and BBNL.

8.12 The Committee recommends a two-pronged approach for de-layering decision-making process. These are:

(a) Establish an Empowered Project Group headed by the Union Minister of Communications & I.T and including the Secretaries of the Departments of Telecommunications, Electronics & I.T, Economic Affairs, Industrial Policy & Promotion, Rural Development and Power, Vice-Chairman of the Niti Aayog and Chairperson of BBNL. The Empowered Project Group will have Additional Secretary, Telecom, as its Secretary. This Group may be empowered by the Union Cabinet to take decisions on matters referred to it by BBNL which is beyond the purview of BBNL to decide. The Empowered Project Group can also invest BBNL with the authority to decide on matters in future that fall within the penumbra of jurisdictional uncertainty. Matters which the Empowered Project Group feels requires the consideration of the Union Cabinet shall be placed before the Cabinet along with its recommendation. The Empowered Project Group shall monitor project implementation, the flow of funds from Government for the project and the overall performance of BBNL. The Empowered Project Group shall directly report to the Prime Minister on progress in achievement of milestones and anticipated areas of shortfall. Matters which the Empowered Project Group feels requires the consideration of the Union Cabinet shall be placed before the Cabinet along with its recommendation. The Empowered Project Group shall substitute the Telecom

Commission in so far as matters concerning BharatNet are concerned. Thereby, BBNL can directly refer, with the approval of its Board of Directors, matters to the Empowered Project Group through the Additional Secretary, Telecom-cum-Secretary to the EPG, for decision.

(b) Establish a Council for BharatNet which shall be chaired by the Union Minister of Communications & I.T and include Ministers of I.T of all States, Union Ministers of prominent user Central Ministries, Vice Chairman of the Niti Aayog, Chairperson of BBNL with Secretary, Department of Telecommunications as the Secretary to the Council. The Council shall meet once every six months for inter-agency co-ordination in project implementation and assess readiness for network utilization in the context of Digital India. The Council may establish an executive body of 7 Members chaired by the Minister of Communications & I.T and including Ministers of I.T of 6 States – one from each region of the country to meet more often to settle co-ordination issues.

(c) Establish a Committee at the State Level to be chaired by the Chief Secretary of the State and including user Departments of the State Government with the CEO or a functional Director of BBNL as Member to support and troubleshoot BharatNet implementation, to formulate institutional mechanisms that exploit BharatNet capabilities and to integrate BharatNet with existing State networks.

8.13 The Committee mulled over the ownership structure of BBNL. Various options were considered –a joint venture between the Centre and the States, involving the private sector through equity participation and different shareholding patterns, constituting BBNL into an authority etc. The Committee preferred to let the options unanswered for the moment and let this issue be addressed at the later stage when BharatNet is closer to reality. However, the Committee was unanimous that the single important factor that will determine project implementation is the speed of decision-making, the ability of BBNL to harness resources – human, financial and material - and the autonomy of BBNL to decide on issues which would certainly arise during implementation. The Committee hopes that the Government gives serious thought to the processes outlined and endeavour at every stage to invest BBNL with the autonomy and ability to take BharatNet forward.

Conclusion

8.14 The Committee feels that an empowered but accountable implementation structure, within and outside BBNL, that is built on de-layered decision-making processes will accelerate project implementation to deliver the intended fruits of Digital India to the people. The Committee appreciates that the suggested structure represents a deviation from the standard structural system prevailing in CPSUs. However, just as Digital India requires a new architecture, the vehicle for delivering Digital India has also to be founded on a new structure primed to achieve the vision of a new India on the information super-highway.

List of Abbreviations

ABD	As Built Diagram
ASP	Access Service Provider
BBNL	Bharat Broadband Network Limited
BHQ	Block Headquarters
BSNL	Bharat sanchar Nigam Limited
BSS	Business Support System
C-DoT	Centre for Development of Telematics
CAPEX	Capital Expenditure
CATV	Cable TV
CEN	Carrier Ethernet
CEO	Chief Executive Officer
CPE	Customer Premises Equipment
CPSUs	Central Public Sector Limited
CPWD	Central Public Works Department
DCN	Data Communication Network
DeiTY	Department of Electronics and IT
DG Set	Diesel Generetor Set
DHQ	District Headquarters
DMRC	Delhi Metro Railways Corporation
DoT	Department of Telecommunications
DPR	Detail Project Report
DPR	Detailed Project Report
DR	Disaster Recovery
e2e	End to End
EA	Executing Agency
EIL	Engineers India Limited
EMS	Element Management System
EPC	Engineering Procurement & Construction
EPG	Empowered Project Group
Gbps	Giga bit per second
GDP	Gross Domestic Production
GDP	Gross Domestic Product
GE	Gigabit Ethernet
GFR	General Financial Rules
GIS	Geographical Information System
GPON	Gigabit Passive Optical Network
GPs	Gram Panchayats
GUN	Government User Network
HD	High Defination
HDPE	High Density Poly-Ethelene
HH	Household
HLC	High Level Committee
ICRIER	Indian Council For Research and International EconomIC
ICRIER	Indian Council for Research and International Economic Relations
IP	Internet Protocol

IPTV	Internet Protocol Television
IPv4	Internet Protocol version 4
IPv6	Internet Protocol version 6
ISP	Internet Service Provider
ISRO	Indian Space Reaserach Organisation
IT	Information Technology
ITI	Indian Telephone Industries
L2	Layer 2
L3	Layer 3
LCO	Local Cable Operator
LOS	Line of Sight
LTE	Long Term Evolution
LTE RAN	Long Term Evolution Radio Access Network
Mbps	Mega bit per second
MDU	Multi Dwelling Unit
MEO	Medium Earth Orbit
MoU	Memorandum of Understanding
MP2MP	Multi Point to Multi Point
MPLS	Multi Level switching Protocol
MPLS-TE	Multi Level switching Protocol-Traffic Engineering
MPLS-TP	Multi Level switching Protocol-Transport Protocol
MSO	Multi System Operator
MSP	Managed Service Provider
MTTR	Mean Time to Repair
MWA	Microwave Access
MWB	Microwave Backbone
NBCC	National Building Construction Corporation
NDP	Net Domestic Product
NFV	Network Function Virtualization
NHAI	National Highway Authority of India
NIC	National Informatics center
NII	National Information Infrastructure
NKN	National Knowledge Network
NMS	Network Management system
NOC	Network Operations Centre/ Control
NOFN	National Optical Fibre Network
NSDG	National Service Delivery Gateway
NSDP	Net State Domestic Product
NTP	National Telecom Policy
OAM	Operations and Maintenance
OEM	Original Equipment Manufacturer
OFC	Optical Fibre Cable
OLT	Optical Line Terminal
ONGC	Oil and Natural Gas Corporation
ONT	Optical Network Terminal

OPEX	Operating Expenditure
OSS	Operations Support Systems
P2MP	Point to Multi Point
P2P	Point to Point
PESB	Public Enterprises Selection Board
PGCIL	Power Grid Corporation of Indian Limited
PIU	Project Implementation Units
PLB	Permanently Lubricated Pipes
PMC	Project Management Consultant
PoI	Point of Interconnect
PON	Passive Optical Network
PoP	Point of Presence
QoS	Quality of Services
RoW	Right of Way
RRM	Radio Resource Management
RSP	Retail Service Provider
SAN	Storage Area Network
SD	Standard Defination
SDH	Synchronous Digital Hierarchy
SDN	Software Defined Network
SHQ	State Headquarters
SI	System Integrators
SLA	Service Level Agreemnt
SONET	Synchronous Optical Network
SOR	Schedule of Rates
SPV	Special Purpose Vehicle
SSA	Secondary Switching Area
SSDG	State Service Delivery Gateway
STB	Set-top Box
SWAN	State-wide Area Network
TAC	Teechnical Advisory Committee
TB	Terabyte
TCIL	Telecommunications Consultants India Limited
TCIL	Telecom Consultants India Limited
TE	Traffic Engineering
ToR	Terms of Reference
TRAI	Telecom Regulatory Authority of India
TSP	Telecom Service Provider
UASL	Unified Access Service License
UBR	Unlicensed Band Radio
UL	Unified License
UPS	Uninterrupted Power Supply
USOF	Universal Services Obligation Fund
VoIP	Voice over Internet Protocol
VPN	Virtual Private Network

List of Tables

List of Figures

List of Annexures

Notifications of Government dated January 14, 2015

No. 2-1/2015-Policy-I
Government of India
Department of Telecommunications
(Policy-I Section)
***

Date: 14th January, 2015

NOTIFICATION

Subject: Constitution of a Committee on National Optical Fibre Network (NOFN).

National Optical Fibre Network (NOFN) was approved by the Union Cabinet on October 25, 2011 to be implemented through an Executive Agency. For its implementation, Bharat Broadband Network Limited (BBNL) was incorporated as a Special Purpose Vehicle (SPV). NOFN aims to reach broadband to all Gram Panchayats (GP) in the country. The larger vision of NOFN is to catalyse the broadband ecosystem and promote rural broadband penetration to foster overall socio-economic development.

2. The Digital India initiative encompassing the larger vision of a digitally empowered country delivering governance and rural needs to citizens at their doorstep riding on the high speed broadband highway established through NOFN critically relies on timely project implementation which has fallen behind the targeted schedule.

3. In view of the above, it has been decided to constitute a Committee to review the strategy and approach towards speedy implementation of NOFN as under:

(i)	Shri J. Satyanarayana, Adviser for e-governance, Andhra Pradesh and former Secretary, Dept. of Electronics & Information Technology	Member
(ii)	Shri Kiran Karnik, former President, NASSCOM	Member
(iii)	Shri Som Mittal, former President, NASSCOM	Member
(iv)	Dr. Rajat Moona, Director, C-DAC, New Delhi	Member
(v)	Prof. S. Sadagopan, Director, IIT, Bangalore	Member
(vi)	Shri Anil Bhargava, Member in-charge (Technology), DoT	Member
(vii)	Smt. Aruna Sundararajan, Administrator, USOF	Member
(viii)	Shri V. Umashankar, Joint Secretary, DoT	Member-Convenor

Continued overleaf.....

4. The Terms of Reference of the Committee shall be as under:-

(a) To suggest measures for augmenting the current design and architecture of NOFN in line with the vision and objectives of Digital India.
(b) To recommend an implementation strategy so that provision of broadband connectivity is accelerated to connect all Gram Panchayats by December 2016.
(c) To assess and recommend suitable technology options for fast track and cost effective implementation.
(d) To recommend an effective and empowered structure and mechanism for implementation of NOFN in mission mode.
(e) To assess relevant business models for effective utilization of bandwidth created under NOFN.

5. The Committee shall consult with State Governments, industry and other stakeholders in the course of its deliberations. The Committee shall have the liberty to associate other experts in relevant fields as it may deem fit. The Committee shall also have the liberty to engage consultants to assist it in data analysis. The Committee may also seek the views of those who are working in the field. The logistics and administrative support to the Committee shall be provided by BBNL. The Committee shall endeavour to submit its recommendations in one month.

6. The date and time of the first meeting will be intimated in due course.

7. This has the approval of Minister of Communications & IT.

(Anand Agrawal)
Director (Policy)
Ph: 2303 6032

To:

1. Shri J. Satyanarayana, Adviser for e-governance, Andhra Pradesh and former Secretary, Dept. of Electronics & Information Technology
2. Shri Kiran Karnik, former President, NASSCOM
3. Shri Som Mittal, former President, NASSCOM
4. Dr. Rajat Moona, Director, C-DAC, New Delhi
5. Prof. S. Sadagopan, Director, IIT, Bangalore
6. Shri Anil Bhargava, Member in-charge (Technology), DoT
7. Smt. Aruna Sundararajan, Administrator, USOF

Copy to:
Sr. PPS to Secretary (T)/PPS to SS (T)/PPS to JS(T)

Copy for information to:
PS to Minister of Communications & IT

Notifications of Government dated February 18, 2015

No. 2-1/2015-Policy-I
Government of India
Department of Telecommunications
(Policy-I Section)
***

Date: 18th February, 2015

NOTIFICATION

Subject: Inclusion of representative from Department of Electronics & Information Technology (DeiTY) in the Committee on National Optical Fibre Network (NOFN).

With the approval of Competent Authority, a Committee has been constituted to review the strategy and approach towards speedy implementation of National Optical Fibre Network (NOFN) vide Notification dated 14th January, 2015 (copy enclosed). Now, the constitution of the Committee has been amended. The revised constitution of the Committee is as under:

(i)	Shri J. Satyanarayana, Adviser for e-governance, Andhra Pradesh and former Secretary, DeitY	Member
(ii)	Shri Kiran Karnik, former President, NASSCOM	Member
(iii)	Shri Som Mittal, former President, NASSCOM	Member
(iv)	Dr. Rajat Moona, Director, C-DAC, New Delhi	Member
(v)	Prof. S. Sadagopan, Director, IIIT, Bangalore	Member
(vi)	Shri Anil Bhargava, Member in-charge (Technology), DoT	Member
(vii)	Smt. Aruna Sundararajan, Administrator, USOF	Member
(viii)	Shri Tapan Ray, Additional Secretary (e-Governance Division), DeitY	Member
(ix)	Shri V. Umashankar, Joint Secretary, DoT	Member-Convenor

(Anand Agrawal)
Director (Policy)
Ph: 2303 6032

To:

1. Shri J. Satyanarayana, Adviser for e-governance, Andhra Pradesh and former Secretary, Dept. of Electronics & Information Technology
2. Shri Kiran Karnik, former President, NASSCOM
3. Shri Som Mittal, former President, NASSCOM
4. Dr. Rajat Moona, Director, C-DAC, New Delhi
5. Prof. S. Sadagopan, Director, IIIT, Bangalore
6. Shri Anil Bhargava, Member in-charge (Technology), DoT
7. Smt. Aruna Sundararajan, Administrator, USOF
8. Shri Tapan Ray, Additional Secretary (e-Governance Division), DeitY

Copy to:

Sr. PPS to Secretary (T)/PPS to SS(T)/PPS to JS(T)

Copy for information to:

1. **PS to Minister of Communications & IT**
2. **Secretary, Department of Electronics & Information Technology (DeiTY), Electronics Niketan, CGO Complex, New Delhi-110 003.**

Annexure
Template for Estimation of Bandwidth for a Geography

Rs

Template for Estimation of
Bandwidth for a Geography

Number of Households/ businesses / Govt Establishments

Rural Households	9,065,000
Urban Households	3,700,000
Businesses	200,000
State Government Users	200,000
Central Government Users (20% of State Govt)	40000
Assumptions for Bandwidth provisioning & Cost	
Contention ratio	1:10
Net requirement after reducing caching (domestic content)	40%
Cost of bandwidth (International and domestic blended) per Gbps (Rs cr)	0.50

Demand Assumptions (% of Households covered)	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y12.5
Rural	10%	15%	20%	25%	30%	35%	40%	45%	50%	50%	50%	50%
Urban	10%	13%	15%	20%	25%	30%	30%	35%	40%	40%	40%	40%
Business	5%	10%	15%	20%	24%	28%	32%	36%	40%	40%	40%	40%
State Govt	25%	50%	75%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Central Govt	25%	50%	75%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Assumptions on Speed (Bandwidth speed in Mbps)
Low= Low Bandwidth Users
Medium= Medium Bandwidth Users
High= High Bandwidth Users

Rural (Low)	10	10	10	10	10	10	10	20	20	20	20	20
Rural(Medium)	10	10	10	20	20	20	20	20	50	50	50	50
Rural (High)	20	20	20	50	50	50	50	50	100	100	100	100
Urban (Low)	10	10	10	20	20	20	50	50	50	50	50	50
Urban (Medium)	20	20	20	50	50	50	50	50	50	50	50	50
Urban (High)	50	50	50	100	100	100	100	100	100	100	100	100
Business (Low)	10	10	10	20	20	20	20	20	50	50	50	50
Business (Medium)	50	50	50	100	100	100	100	100	100	100	100	100
Business (High)	100	100	100	100	100	100	100	100	1000	1000	1000	1000
State Govt (Low)	10	10	10	10	10	20	20	20	50	50	50	50
State Govt (Medium)	20	20	20	20	20	50	50	50	50	50	50	10
State Govt (High)	100	100	100	100	100	100	100	100	1000	1000	1000	1000
Central Govt (Low)	10	10	10	10	10	20	20	20	50	50	50	50
Central Govt (Medium)	20	20	20	20	20	50	50	50	50	50	50	10
Central Govt (High)	100	100	100	100	100	100	100	100	1000	1000	1000	1000

Number of Users												
Rural	906500	1359750	1813000	2266250	2719500	3172750	3626000	4079250	4532500	4532500	4532500	4532500
Urban	370000	462500	555000	740000	925000	1110000	1110000	1295000	1480000	1480000	1480000	1480000
Business	10000	20000	30000	40000	48000	56000	64000	72000	80000	80000	80000	80000
State Govt	50000	100000	150000	200000	200000	200000	200000	200000	200000	200000	200000	200000
Splitup of Low, medium high bandwidth users	Low	Medium	High									
Rural	65%	30%	5%									
Urban	50%	40%	10%									
Business	80%	15%	5%									
State Govt	80%	15%	5%									
Central Govt												
Number of users by bandwidth use, year												
Rural (Low)	589225	883837.5	1178450	1473062.5	1767675	2062287.5	2356900	2651512.5	2946125	2946125	2946125	2946125
Rural(Medium)	271950	407925	543900	679875	815850	951825	1087800	1223775	1359750	1359750	1359750	1359750
Rural (High)	45325	67987.5	90650	113312.5	135975	158637.5	181300	203962.5	226625	226625	226625	226625
Urban (Low)	185000	231250	277500	370000	462500	555000	555000	647500	740000	740000	740000	740000
Urban (Medium)	148000	185000	222000	296000	370000	444000	444000	518000	592000	592000	592000	592000
Urban (High)	37000	46250	55500	74000	92500	111000	111000	129500	148000	148000	148000	148000
Business (Low)	8000	16000	24000	32000	38400	44800	51200	57600	64000	64000	64000	64000
Business (Medium)	1500	3000	4500	6000	7200	8400	9600	10800	12000	12000	12000	12000
Business (High)	500	1000	1500	2000	2400	2800	3200	3600	4000	4000	4000	4000
State Govt (Low)	40000	80000	120000	160000	160000	160000	160000	160000	160000	160000	160000	160000
State Govt (Medium)	7500	15000	22500	30000	30000	30000	30000	30000	30000	30000	30000	30000
State Govt (High)	2500	5000	7500	10000	10000	10000	10000	10000	10000	10000	10000	10000
Central Govt (Low)	8000	16000	24000	32000	32000	32000	32000	32000	32000	32000	32000	32000
Central Govt (Medium)	1500	3000	4500	6000	6000	6000	6000	6000	6000	6000	6000	6000
Central Govt (High)	500	1000	1500	2000	2000	2000	2000	2000	2000	2000	2000	2000
Bandwidth Requirement (Gross) in Gbps												
Rural (Low)	5892	8838	11785	14731	17677	20623	23569	53030	58923	58923	58923	58923
Rural(Medium)	2720	4079	5439	13598	16317	19037	21756	24476	67988	67988	67988	67988
Rural (High)	907	1360	1813	5666	6799	7932	9065	10198	22663	22663	22663	22663
Urban (Low)	1850	2313	2775	7400	9250	11100	27750	32375	37000	37000	37000	37000
Urban (Medium)	2960	3700	4440	14800	18500	22200	22200	25900	29600	29600	29600	29600
Urban (High)	1850	2313	2775	7400	9250	11100	11100	12950	14800	14800	14800	14800
Business (Low)	80	160	240	640	768	896	1024	1152	3200	3200	3200	3200
Business (Medium)	75	150	225	600	720	840	960	1080	1200	1200	1200	1200
Business (High)	50	100	150	200	240	280	320	360	4000	4000	4000	4000
State Govt (Low)	400	800	1200	1600	1600	3200	3200	3200	8000	8000	8000	8000
State Govt (Medium)	150	300	450	600	600	1500	1500	1500	1500	1500	1500	300
State Govt (High)	250	500	750	1000	1000	1000	1000	1000	10000	10000	10000	10000
Central Govt (Low)	80	160	240	320	320	640	640	640	1600	1600	1600	1600
Central Govt (Medium)	30	60	90	120	120	300	300	300	300	300	300	60
Central Govt (High)	50	100	150	200	200	200	200	200	2000	2000	2000	2000
Total Gross Bandwidth Requirement in the year (Gbps)	17344	24933	32522	68875	83361	100848	124584	168361	262774	262774	262774	261334
Total Bandwidth Requirement with a contention ratio of 1:10	1734	2493	3252	6888	8336	10085	12458	16836	26277	26277	26277	26133
Total Bandwidth requirement with caching at specified %	694	997	1301	2755	3334	4034	4983	6734	10511	10511	10511	10453

Corrigendum

The following corrections may be read in the "Report of the Committee on National Optical Fibre Network" dated 31st March, 2015:

1. "Network Operations Control" may be read as "Network Operations Centre" in Contents at Page no. 7.

2. Summary of Recommendation, Sl. No. 12, "15000 GPs" may be read as "20,000 GPs" at page no. 11.

3. In para 3.21 at page 45, "15000 GPs" may be read as "20,000 GPs".

4. In **Table 3.7 : Middle Mile Layer - DHQ to BHQ- Comparative Technology Options,** under the criteria "Power requirements", the power requirement for Carrier Ether-net (IP/MPLS) and Carrier Ethernet (MPLS-TP) may be read as "1-2 kW at BHQ and 2-4 kW at DHQ" in place of "75-80 watts" at page no 53.

5. In para 8.12 (c) at page no 113, "functional Director" may be read as "Executive Director".

6. Abbreviations given on page no. 114 to 116 stand corrected as follows:
   a) ASP as "Application Service Provider" instead of "Access Service Provider"
   b) CEN as "Carrier Ethernet Network" instead of "Carrier Ethernet"
   c) MPLS as "Multi-Protocol Label Switching" instead of "Multi Level switching Protocol"
   d) MPLS-TE as "Multi-Protocol Label Switching -Traffic Engineering" instead of "Multi Level Switching Protocol Traffic Engineering"
   e) MPLS-TP as "Multi-Protocol Label Switching -Transport Profile" instead of "Multi Level Switching Protocol Transport Protocol"

7. List of Annexures at page 118 may be read as:

List of Annexures