TRAI QoS Monograph

# Quest for a good quality network inside Multi-Storey Residential Apartments

## Reimagining ways to improve quality

Telecom Regulatory Authority of India

September 2020

# Executive Summary

**Evaluating Quality of Service**

The traditional method of evaluating Quality of Service has followed a two-pronged approach: (a) collect statistics from the network and (b) make field measurements. Then compare the values so collected with defined benchmarks. Field measurements include crowdsourced data collected from user devices by means of an app, like the TRAI's MySpeed.

The working hypothesis behind the method is that improving the accuracy of measurements and tightening the benchmarks would automatically lead to improvement in quality. Largely it has served us well so far.

However, this approach is not dissimilar to depending exclusively on standardized testing as the means for improving education. We know that beyond a point, it is individualized testing and individualized teaching that deliver better outcomes.

This monograph suggests a blended approach in improving the network, i.e., both general interventions and solutions that are specific to a user's requirement. It also advocates the involvement of users in defining and achieving the optimum outcomes for themselves.

While TRAI was rethinking the approach for improving the Quality of Service, especially in the indoor environments, the spread of COVID-19 brought the users' expectations from the network (mobile, Wi-Fi or, fixed line) into sharp focus.

Therefore, TRAI's own case studies, inputs from stakeholders, and those from technology and policy experts from around the world were discussed in an online conference on September 4, 2020, which was jointly hosted with the Ministry of Housing and Urban Affairs.

The discussions at this conference and its conclusions are presented in this monograph.

**One size doesn't fit all**

Solutions must be specifically designed for the case. For example, the requirements would be very different in each of these cases:

1. a tall, multi-storeyed residential building;
2. a mall;
3. a cluster of row houses; and
4. an office complex or building.

An antenna system on ground-based (external) towers may be adequate for row houses, but fail to reach the higher floors of a tall building. A mall may require good coverage for supporting voice calls, but not nearly the same bandwidth for data connectivity as an office of equivalent floor-area.

In a work-from-home scenario, where adults and children alike need stable and high bandwidth connectivity everywhere, nothing but a network engineered to suit the flat might deliver the needed experience.

**Markets know best, when they function properly**

Solutions, therefore, must be customized for the need of the individuals. This can be best delivered by a market that responds to those needs.

The failure to deliver the desired quality of network may be traced to such classic reasons of market failures as:

1. Principal–agent problems:
   Do the RWA's decisions work in the interest of the flat owners?
2. Information asymmetries:
   How much is a reasonable price for a small-cell? Will the solution work in my specific area?
3. Time-inconsistent preferences:
   Can property developers' package and sell network quality as part of their offering?
4. Emergence of monopoly:
   Will the incumbent infrastructure owner or maintenance agency charge monopoly rents from service providers?

**Rules to correctly align the incentives of stakeholders**

The regulations regarding the Right of Way or the creation of Building Codes and rules for their enforcement are government interventions that aim to correct market failures. But do they work as effectively as hoped for? Can they be improved based on the experience of the last few years?

There are other government interventions too, such as the ones to protect the customer, to allow orderly competition, or to take care of the national security, etc. In this bucket fall restrictions on import of telegraph equipment or licensing of spectrum, etc.

Collectively, these interventions could distort the market and create what economists call “government failure”.

**Technological solutions available for home or business**

As technologies develop, markets can find new solutions for existing problems. Experts from technology companies showcased some of the newer approaches and products that could be introduced in India.

These products may be obstructed today due to government restrictions or lack of interest by the service providers who cannot absorb the cost of the solution. Or it may be that the users' unmet demand is not sensed by the market, and the user hasn’t been enabled to obtain the solution.

**Advocating a set of consistent solutions**

The monograph assesses the effectiveness of the existing rules and practices, the technological solutions that are emerging, and the experience of policies in the other parts of the world to suggest the way forward for India.

The main recommendations on the following aspects are given in Chapter 5:

1. To build a good quality network with collaborative partnerships
2. Engaging with the end users while designing the networks
3. Developing processes and practices which assures a good quality network

4. Aligning incentives of Principals and Agents in a manner which do not conflict

# Content

# Chapter 1

## 1 Introduction

Where to place antennae inside a building is a knotty problem for the Telecom Service Providers (TSPs) looking to deploy wireless and broadband infrastructure.

The logistics and coordination are confounded by the fact that the building owner or management and the incumbent service or utility provider are separate entities, each with their own point of view. The burden of negotiating with both and obtaining agreement falls on the provider looking to deploy wireless or broadband systems.

For a TSP trying to enter the building or premises, it can be hard, if not impossible, if the TSP is dependent on other entities to make room for them. Today, a TSP that wants to set up equipment in a building must first wait for permission and then pay for the space, whether it is too small or too large for its purposes. It is a problem once again if the telecom/ICT infrastructure provider needs to expand or upgrade the existing equipment and wires, which can take months.

Good quality network requires deployment of more extensive infrastructure, which isn't possible without the involvement of all decision makers and the larger community in its planning and creation.

For telecom subscribers to get fair and satisfactory quality of service (QoS) from the networks, assessment of its performance and initiatives to address the shortfall in QoS plays an important role. QoS as defined by International Telecommunication Union (ITU) is "*Totality of characteristics of a telecommunications service that bear on its ability to satisfy stated and implied needs of the user of the service.*" To achieve these objectives, the regulator might adopt various methods and approaches for carrying out assessment and take enabling initiatives.

The Quality of Service (QoS) offered to the customer may be characterized by certain parameters and corresponding benchmarks, which are helpful for the regulators to assess the performance of TSPs. They may also be helpful for TSPs in measuring their own performance and comparing it with that of the competitors to gain or maintain market share. Customers are also benefitted by the performance assessment based on quantifiable parameters, as this is useful to them in making informed choices while subscribing to or porting from a network.

In general, Key Performance Indicators (KPIs) for assessment of QoS are based on standards, while benchmarks differ from country to country or TSP to TSP. After introduction of packet-based networks to deal with variety of traffic composed of real-time and non-real-time services, performance assessment matrix is also getting evolved. Types of KPIs are not only increasing significantly but also vary across vendors and TSPs. The complexities and varieties of KPIs are difficult for the customers to comprehend because of which only a standard set of base KPIs are usually considered. Regulators also prefer the standard set or base KPIs to assess the performance of the TSPs as a part of their licence requirements. However, simplification of KPIs for ease of use should not lead to loss of the information needed to characterise customers' experience.

TRAI has a regulatory framework for QoS in place and has defined certain parameters and benchmarks. TSPs are required to submit quarterly Performance Monitoring Reports (PMRs) on the basis of data collected at the network level. If benchmarks are not met by the TSP, then Financial Disincentives (FDs) may be imposed on them. In addition to the network side assessments, field measurements are also conducted and published in the public domain. Field measurements may have limitations as data set may be practically collected from limited number of locations and for only few days. To get bigger data set, Mobile Apps are also used to collect data using crowdsource-based approach. Mobile App may also conduct surveys about the quality of service as experienced by the customer. Whether

assessments made using variety of methods and approaches reflects on the users' perspective about quality is an issue to be examined.

## 1.1 Do the assessments of QoS reflect the real picture?

It has been observed over a period of time that the assessment of quality through PMRs, field measurements, and data collected via mobile apps, which largely does meet the specified benchmarks, does not reflect the quality perceived by the end users, and they continue to complain about the quality. This gap seems to be especially bigger when users are in the indoor environment.

To improve the assessment on the basis of PMR, the methodology to assess Drop Call Rate (DCR) was changed; and to improve assessment on the basis of Field measurements, test drive activities were extended to larger number of cities and on longer routes, especially in the metro cities.

These initiatives helped improve the assessment, and the performance of TSPs did not turn out to be as rosy as before the changes were introduced. However, the changes did not seem to yet reflect the quality experienced by the users, especially in the indoor environments. One reason for the inadequacy of the assessment could also be due to the variations within the day and even within a cell. Capturing such variations through field measurement is impractical because it is a humongous task.

Improvement in QoS should be in TSP's business interest as it would increase service consumption. Improvement would also help a TSP to maintain or get a larger share in the market because consumers gravitate towards the service providers that offer them the best service experience at the ruling price. Therefore, it is fair to everyone for the Quality of Experience (QoE) to be assessed in the most realistic manner possible and to also communicate it to the customers. To make such assessment of QoE remains a challenge, especially with non-intrusive techniques.

It is important to find the reasons that prevent the TSPs from improving the quality of their network and to identify the Regulatory interventions that could improve the connectivity to the desired level.

## 1.2 Obstacles in improving quality inside buildings

To improve connectivity outside and inside the buildings, DoT and TRAI have taken several initiatives, and recommended the measures for providing Right of Way (RoW) to TSPs for deploying their networks, and enabling Infrastructure Providers (IPs) for erecting the infrastructure to support the networks. These initiatives have definitely helped TSPs deploy more base stations, and it is seen that more than 1.5 million base stations have been deployed across the country in the last six years.

But even after all initiatives by TSPs to improve the connectivity, quality inside buildings remain a concern. One could argue that imposition of more stringent regulatory provisions might help in improving the quality, but there is no licensing requirement to provide coverage inside each building. Regulatory provisions are based on entire License Service Area (LSA) as that is the area awarded to licensee. Even if legal measures are taken to put the burden on TSP to cover the buildings, important ones if not all, there is a need to look into the issues which act as the constraint. In summary, the key questions to ask is: Why quality of network inside the buildings is not up to mark? Could it be that the market has failed for some structural reasons?

## 1.3 A detailed study is required to get more insights

For better insights, TRAI conducted a study on the quality of service within the buildings. Although there are various types of buildings, such as commercial buildings, government offices, public transport hubs, residential buildings, the study focused only on a particular type. Even though it is quite possible that a solution for commercial buildings would be devised and deployed more quickly, as the TSPs and real-estate developers would come to an agreement sooner. Residential buildings were considered as the right choice for the study, as TRAI had earlier published a report on the QoS at the Delhi Airport area along with the route of the Airport Express metro train.

Residential buildings can further be divided into different types. Some of them might get covered within macro sites, while for others special efforts and deploying of different solutions would be required. For example, low-height buildings are easily covered by macro sites; however, reaching higher floors of multi-storey buildings is difficult for macro sites. Taking this into account, the scope of the study was restricted to medium- or high-rise multi-storey residential buildings. Other types of buildings may be required to be dealt with separately.

For the purpose of the study few buildings were selected from Delhi, Gurugram, Bengaluru, Kolkata, Hyderabad, Jaipur, and Bhopal. The selected buildings were well maintained, and already had some network to improve the quality, which was deployed by TSPs or the Infrastructure Providers. The purpose was to identify solutions to the problem with sincere efforts or to identify if a different approach is required altogether. If the network coverage was not up to mark, there was no point in devoting efforts to understand the issues of the selected buildings. However, the outcome of this report can help to take up any future study that is relevant for getting deeper insights into the issue.

## 1.4 Connectivity during COVID-19 times

As a result of COVID-19, most organizations adopted/switched to work from home or remote-working provision. Educational institutions, public offices, courts, doctors, etc., were/are operating through video conferencing. Hence, more people relied on internet services, and the internet traffic increased manifolds. Within a family, almost every member was simultaneously using telecom services within the same premises. This further increased customers' expectations of better, uniform, and more reliable services within every nook and corner of the apartment/house.

## 1.5 Structure of the study report

The report is structured into eight chapters, in addition to the Introduction chapter:

- Chapter 2 is on Measures taken to assess the performance of TSPs, it describes the reasons of gaps in perception of quality, and assessment made through various means;
- Chapter 3 is on removing barriers to improve the connectivity inside the buildings; it covers various initiatives taken by TRAI, DoT, MoHUA, and state governments to facilitate the connectivity; it also captures international practices adopted in other parts of the world;
- Chapter 4 is on case studies taken up by TRAI conducted to understand issues related to indoor building scenarios and identifies key factors and aspects required to be considered to improve the connectivity;
- Chapter 5 is on the way forward, suggesting specific action points to improve quality inside multi-storey medium/high-rise new upcoming buildings.

# Chapter 2

## 2 Measures taken to assess the performances of TSPs

### 2.1 Measures to monitor and report QoS Parameters

Presently TSPs are required to meet the quality parameter benchmarks of network and customer services and submit a quarterly performance report.

Performance Monitoring Reports (PMRs) are evaluated on an entire License Service Area (LSA) basis and are published publicly with details of TSPs not meeting the benchmarks. Financial Disincentives (FD) are imposed for not meeting the benchmarks, and the amount for FD has been increased time and again. Provisions have been made to impose a higher FD if the violation of benchmarks is repetitive, and Graded FDs have been introduced to increase the amount based on the deviation from the benchmark.

### 2.2 Measures to verify and assess performance

At periodic intervals, TSPs are required to measure their service coverage through drive tests of the mobile network, and take remedial actions to address the problems revealed during such tests, viz., coverage, interference, call drop, and voice quality. The Authority may jointly verify and objectively assess the performance of TSPs or conduct independent audits from time to time.

#### 2.2.1 Performance assessments through Joint drive tests

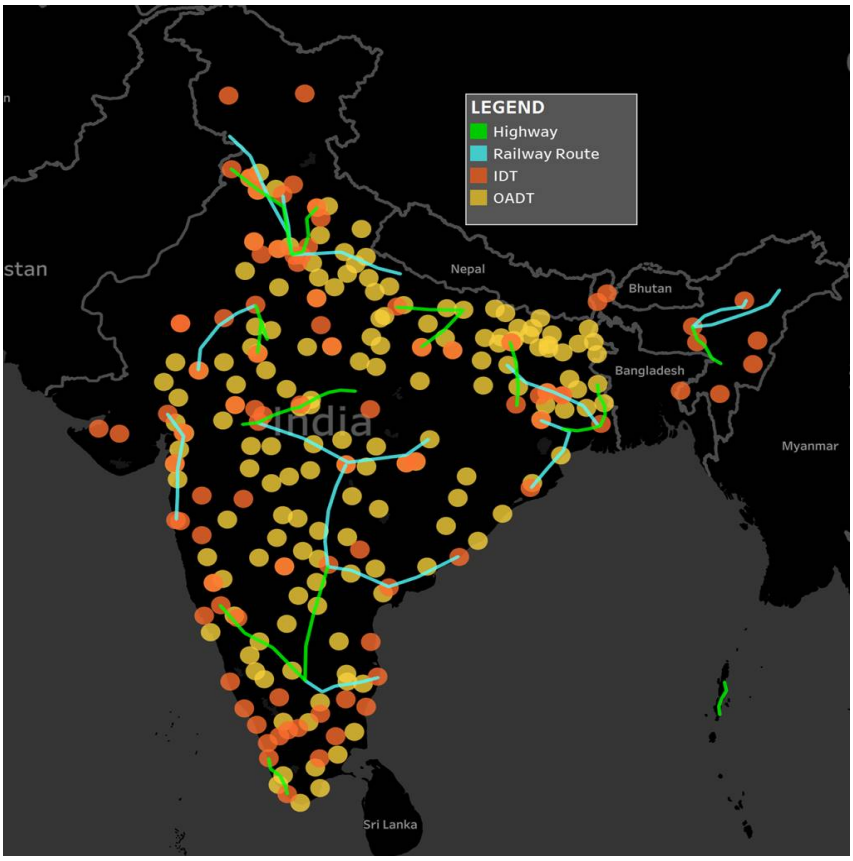
Drive tests conducted by TSPs under the supervision of the Authority are called Operator Assisted Drive Tests (OADTs). During July 2018 to June 2019 TRAI planned to conduct OADTs in one city of each Secondary Switching Area (SSA)/Long Distance Charging Area (LDCA). The country has around 321 SSAs and 712 districts (689 districts in States and 23 districts in Union Territories). Under this OADT plan, 321 cities were covered (approximately one city from every two districts), and all the cities spanned across the country.

#### 2.2.2 Performance assessment through agency appointed by the Authority

To assess the performance of the TSPs, TRAI also conducts drive tests independently known as Independent Drive Tests (IDTs). For the period of July 2017 to June 2018, TRAI conducted IDTs in 70 cities. Most of these cities were with a population of more than 10 lakhs. It also included all State capitals and satellite towns of metro towns, irrespective of the population. The published reports are available at www.analytics.trai.gov.in. In addition to the above 70 cities, IDTs were also conducted along national highways and railway routes (in-train) covering 6 Highways and 6 Railway routes.

The IDTs were again conducted for the period of July 2018 to June 2019 in 70 cities. Apart from the number of days when the testing was conducted in a particular city, there were not many changes made to the previous period's list. TRAI publishes IDTs' reports on its website, from time to time. The 70 cities (covered under IDTs' performance assessments) are in addition to the 321 cities (covered under OADTs).

*Figure 1: Locations of cities and highways where field measurements were conducted*




In addition to tier-2 towns, metros and big towns were covered by IDTs. The number of days and routes (based on kilometres) depended upon the size of the town, but, generally, the duration was between 3 to 8 days (2 to 6 days for Voice test, and 1 to 2 days for Data test). In Delhi Service Area, which includes Ghaziabad, Noida, Gurugram, and Faridabad cities, IDT was conducted for about 18 days and had a total drive route of about 2200 kms. Similarly, in Mumbai service area, IDT was conducted for 14 days, and it covered around 1800 kms drive test route. During IDT, typical Key Performance Indicators (KPIs) measured from the perspective of voice services are Network Coverage, Call Setup Success Rate, Drop Call Rate, Block Call Rate, Handover Success Rate, and Connection Quality.

In the IDTs conducted at Delhi and Mumbai, sample tests for new scenarios such as voice call mute, inter-operator congestion, combined effect of call drop from any end of the calls were also measured for the qualitative analysis purposes.

### 2.2.3 Performance assessment through customer satisfaction surveys

The most significant factor for the overall assessment of QoS is customer satisfaction. Customer satisfaction can be assessed through surveys or feedbacks. The survey can comprise questions on provision of service, the billing performance, the network performance, reliability, and availability, maintainability, supplementary, and Value-Added Services, help services including customer grievance redressal, and overall service quality. It is important to provide the information on QoS by various TSPs in public domain.

TRAI conducts surveys to assess the perception about voice call quality through TRAI MyCall App, and the results, based on a crowdsource method, are presented on TRAI's website. Earlier, TRAI used to conduct survey through an IVRS system, wherein few randomly selected thousand mobile numbers were dialled, and specific questions were asked to the recipient. Based on the responses, the report of the survey — conducted in three Licence Service Areas (LSAs), namely, Delhi, Madhya Pradesh, and Karnataka — was published on TRAI's website. Data collection via TRAI MyCall App is a continual process, while IVRS-based survey is conducted in case of a specific requirement.

## 2.3 Efficacy of methods to measure and assess quality within buildings

In measurement and assessment of QoS via PMRs, field measurements, surveys, almost all TSPs have performed fairly well except in very few cases. When the quality of experience as perceived by the users does not match the assessments, then some people might question the methodology of the assessment or sometimes also doubt the competence or integrity of the persons involved in it. Some people might argue that there are better ways to assess the performance. One of the suggested approaches could be to continue with the current methodology but assess more comprehensively or measure more aggressively. Another suggested approach can be to change the entire methodology to crowdsource-based, and automate the processes to scale up the measurements, and capture higher granularity in the time and space domain. The argument could be supported by the wider

availability of cloud-based infrastructures, APIs, Robotic Process Automations (RPAs), Big Data, AI/ML tools and techniques, etc.

However, before scaling up the efforts, one needs to ensure that what is being measured should reflect the quality as perceived by the users. The parameters monitored presently may be helpful for general assessment but are not sufficient to assess an individual's experience of quality. If the existing problems are not addressed, a more precise approach to measurements will be of no use. The root causes of poor quality can be specific to a pocket or a period of the day; without addressing the concerns, a more granular approach in the measurement may not add value.

If the areas beyond the control of TSP are ignored while assessing quality, then it is quite possible that these areas will never be focused during quality improvement initiatives of such areas. TSPs would continue to meet the regulatory benchmarks even though the assessments would not reflect the true picture. On the other hand, if such areas are included for the assessment, LSA-level assessments may not change significantly until granularity is not enhanced. Granularity up to the Base Station cell level may not be a good choice either as it doesn't capture the variations within a cell. For the moment, even if it is assumed that the desired granularity in measurements can be practically achieved somehow, and it differentiates only at a pocket level or at a given time-band level, whether it would help in improving the quality until and unless already known barriers are not removed still remains a matter of concern. Probably, investing time and efforts in improving precision in measurements would be of little help while being aware that the factors affecting the deployment and maintenance of mobile networks are not under the control of a TSP.

The need of the hour is to understand the issues involved in the deployment of network and identify the steps to resolve them rather than just focusing on the measurements and assessments. In the last few years, DoT/TRAI has implemented several measures for removing various barriers in improvement of connectivity, including within the building scenarios; all such initiatives and measures are deliberated in detail in the next chapter.

# Chapter 3

# 3 Removing barriers to improve the connectivity inside buildings

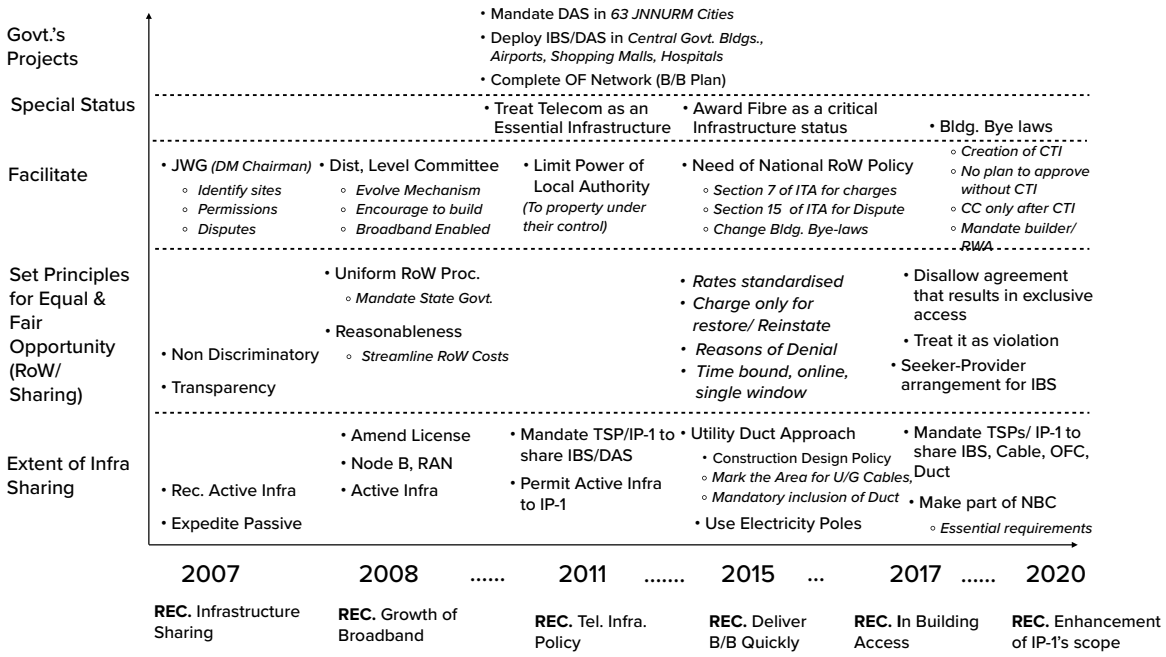
## 3.1 Barriers for a TSP in improving the connectivity

To assure seamless Quality of Services for mobile users anytime, anywhere, the network elements that radiate radio signals should be present at every nook and corner. Legal provisions of Right of Way (RoW) should support TSPs or Infrastructure Providers (IPs) to enter, install, operate, and maintain the network inside the private properties or the properties owned or managed by the public authorities. The RoW policies should also help TSPs or IPs to carry out timely deployment of networks and can eliminate any possibilities of monopolistic access to the premises.

However, one ought to have a better understanding about the support the entities, who grant permissions to deploy and run these networks, would provide. Deploying a network which meets the desired outside-in coverage of the QoS base stations, such as using outdoor macro sites, might not be good enough, as the inherent characteristics of Radio propagation make coverage probabilistic in case of wireless networks, i.e., it does not ensure the availability of a quality network inside the buildings. This may require deployment of in building solutions, and the requirements such as design or selection of specific locations might impact the outcome of good quality of service. Before identifying the actions required to improve the quality inside the building, it is important to relook at the initiatives taken by TSPs to remove barriers.

## 3.2 TRAI's initiatives for removal of barriers

The below figure depicts a synopsis of TRAI's recommendations to the Government for improving connectivity, from 2007 to 2020.




One of the suggested approaches in the recommendations was to optimize resource utilization by sharing resources that would also lead to cost optimization. Over a period, recommendations have increased its focus on the extent of sharing from passive infrastructure to active infrastructure. It was also recommended to make necessary changes to National Building Code (NBC) to incorporate the requirements to build a Common Telecom Infrastructure. It was recommended to consider telecom as an essential infrastructure and fibre as a critical infrastructure.

Sharing of infrastructure might cause a monopolistic situation since the number of players providing similar types of structure gets reduced. To address such concerns, principles were recommended for setting fair and equal opportunities to all TSPs. For this, measures such as non-discriminatory and transparency were recommended in 2007. Subsequently, uniformity in RoW procedures and reasonableness in demanding charges by streamlining RoW costs were emphasized. Later, a requirement for standard rates for the charges applied by the Authorities on TSPs/IPs was also recommended. It was also mentioned that such charges should be limited only to the costs against the restoration or reinstatements. To make RoW policies of non-discriminatory and fair opportunities more effective, recommendations were also made to grant

permissions in a time-bound manner and record the reasons in case of denial. Agreements that results in exclusive type of arrangements may be treated as violation. For IBS, agreements should be considered to represent a seeker-provider type of relationship.

Initially, institutional mechanisms to provide better coordination and management were at district/state levels, so that the broadband connectivity is improved considering the local context and requirements. It required joint working groups to identify sites, settle disputes, and evolve mechanisms to improve the broadband connectivity and should be headed by district level authorities. Later, it was recommended to limit the power of the Authority only to the property under their control.

In the last few years, emphasis was laid on the National Level Policy for RoW and to change building bye-laws. These changes required the approval of building plans and issuing of completion certificates only after it is ensured that the telecom-related requirements have been duly considered. To give a legal force to the recommendations, especially to enforce it on actors other than the TSPs, Common Telecom Infrastructure (CTI) was recommended to be included as a part of the National Building Code (NBC), and it was also recommended to amend the building bye-laws to enforce it on real-estate developers or builders. To avoid situations of monopoly, it was also recommended that practices of TSPs/IPs should be fair, transparent, and non-discriminatory.

TRAI also recommended to frame a design policy for utility ducts in deploying telecom networks, and to use electricity poles for telecom purposes. It was also recommended to formulate National Right of Way (RoW) policies under the provisions of Indian Telegraph Act (ITA), 1885. RoW policy needs to include standardized rate, charge only for restoration/reinstatement, give permissions in a time-bound manner, and have the facility of an online single window. In case of any denials, reasons should be recorded.

Recently, in March 2020, TRAI has recommended to further enhance the role of IPs in providing connectivity inside the buildings. It recommended

that IP-1s should be allowed to deploy active infrastructure and should also be allowed to import wireless equipment required to deploy in building solutions. For deploying solutions that support new generation of radio technologies, such as MIMO in case of LTE, may also require active infrastructure. New use cases are more bandwidth demanding and have high peak to average traffic ratios. In such cases, active infrastructure can provide better opportunity to TSPs/IP-1s to manage and optimize network deployed inside the building and deliver better quality of service.

## 3.3 Provisions in the existing policies and laws for removal of barriers

### 3.3.1 DoT introduced the National Right of Way (RoW) Rules

In 2016, DoT framed Indian Telegraphy Right of Way (RoW) Rules to regulate the Underground and Overground Infrastructures. It has five chapters and fourteen rules. The rules deal with the Establishment and Maintenance of Underground and Overground Telegraph Infrastructure. RoW rules also define rights of appropriate authority to seek removal of Underground or Overground Telegraph Infrastructure. Dispute Resolution mechanism has also been defined as a part of these rules.

Under RoW Rules 2016, Nodal officer is to be designated by the local authority. Nodal officers are usually appointed from local municipal corporations or development authorities responsible for approval of maps, and they are also responsible for enforcing building bye-laws. The appropriate authority is required to develop an electronic application process within a period of one year from the date of coming into force of these rules for submission.

For Dispute Resolution, the matter has to be referred to the officer designated by the Central Government. The Central Government shall, within a period of 60 days, designate notification officers for referring disputes. The officer shall resolve the dispute within 60 days, as specified by the Central Government from time to time. Mostly officers who are designated for this are Secretary/Principal Secretary of State Governments responsible for IT or Electronics related roles. In rest of the cases, profile of

such officers varies from Finance/Revenue/Commerce to Public Works, Planning, Urban Development, Disaster management, etc.

Rules define the time period within which the permissions are to be granted, and the expenses are to be charged. It also mentions that no other fee should be charged except what has been prescribed in the rules. In case of Overground Telecom Infrastructure, additional requirements such as structural safety certifications are also prescribed.

### 3.3.2 The Introduction of a sub-section in National Building Code (NBC) on Telecom requirements

National Building Code (NBC) was introduced as an outcome of a study report by a Panel of experts, who were appointed by the Planning Commission in 1965 to study the operations involved in construction. The main focus area was on to control and regulate buildings through municipal bye-laws and departmental handbooks. The panel recommended to prepare an NBC for unifying the building regulations throughout the country, and ISI (now BIS) was entrusted by the Planning Commission to prepare the NBC. In 1970s, the first version of NBC was published for its adoption, and implementation drive was launched, and an Action Committee was formed to revise and modernise local laws. Major revision, the third revision, was carried out in 2016. For this, 22 Expert Panels were formed, and about 1000 Experts participated. This revision introduced Information and Communication Enabled Installations, and there was a separate expert panel for this.

**The Purpose of NBC**

Provisions of this code are intended to serve as a Model for adoption. It lays down a set of minimum provisions (Safety, Accessibility, Environment friendly). Choice of materials and methods is left to the ingenuity of the building professionals. NBC can replace Municipal Bye-Laws/Regulatory media, or its modified version can also be used. NBC also recognized “Industrialised systems of building” for speed of construction and “Architectural control” to avoid ugliness and slum-like conditions.

**Codes/Parts of NBC**

NBC has two big volumes; the first volume has 1192 pages, and the second volume has 1018 pages. It consists of twelve parts in addition to a Part 0, which was introduced for describing Integrated approach. Part 1 to Part 11 focusses on specific aspects, but the last part on approach to sustainability is supplement to all parts/codes. Telecom/ICT related requirements were introduced in 2016 and included in Volume II Part 8: Building Services. It is important to have an overview of the entire NBC before figuring out what more might be required for good quality telecom/ICT network inside buildings. NBC has played a key role in providing good practices and acceptable standards for a variety of utility services, and essential requirements at the time of construction of building and also at subsequent stages such as operation and maintenance of the buildings. The subsequent paras summarize the various code/parts of the NBC, and at the end, compares these requirements with the requirements adopted in case of telecom/ICT.

*Summary of various code/parts of NBC*

The codes begin with an **"Integrated Approach",** which provides prerequisite for applying provisions of the Code, and covers the guidelines to be followed. The 'integrated approach' **not only takes care of the functional, aesthetic, and safety aspects but also the operational and maintenance requirements**. It also aims to achieve **cost optimization by applying value engineering**. Inter alia, it describes **major stages of a building project** and the built facility during its service life. It also lists out 23 Fields, including ICT engineers, from which professionals may be chosen to build multi-disciplinary team depending upon the nature, magnitude, and complexity of the project.

Code describes **major stages of a land development/building project** and the built facility during its service life such as Location/Siting, Conceptualization and planning, Designing and detailing, Construction/ execution, Operation and maintenance, and Decommissioning and deconstruction. It recognizes that in building projects various aspects,

including data and voice communication, and other utility service installations should **be taken into consideration from the conceptual stage itself**. A design team of professionals from the required disciplines is expected to be constituted at the appropriate stage, to consider various **design inputs**, to take care of the **complexities,** and to finalize the plan. It emphasizes **participation of the owner at all stages** and to be ensured by the design team, as design is an evolutionary and participatory process.

To achieve the accomplishment of a project in accordance with the designs and specifications in a stipulated time period and cost framework, etc., with a **degree of assurance** prior to commencement and satisfaction on completion, and commissioning, it suggests to have **Project management or construction management**. And to utilize the services of trained technicians, preferably professionals with multi-disciplinary skills, are recommended to carry out routine maintenance/repair jobs.

**The main functions of design team** constituted for planning, designing, and development are also listed with various considerations, including reference to Voice and data communication so that these can be addressed with other important issues such as specific requirements of size and type of the project. In addition to the functions of a design team, main functions of the Project Management/Construction Management for construction/execution (Actualization) such as to **specify criteria for selection of constructors**, quality control, quality audit, assist in getting **statutory approval at various stages**, ensuring availability of **operation manuals** are also listed out.

Emphasis has been made on **engagement of executing and supervising agencies**, which meet the specified norms of skills, specialization, experience, resourcefulness, etc., for the work. Finally, the responsibility of setting up a system of periodic maintenance and upkeep of constructed building has been prescribed to the operation and maintenance team. The team would be responsible for preparation/application of **operation and maintenance manual** and will draw maintenance schedule/frequencies and **guidelines for maintenance personnel**.

**Periodic validation of buildings** by competent professionals through inspection of the buildings has been specified in respect for structural safety, and safety of electrical and other installations and ensuring that all fire safety equipment/systems are functioning properly.

**The administration part** of the code covers aspects such as the applicability of the Code, organization of building department for **enforcement** of the Code, procedure for obtaining development and building **permits**, and responsibility of the owner and all **professionals** involved in the planning, design, and construction of the building. Code also defines the **"authority" that administers its codes/Parts;** it also defines the structure that is called a Building and also provides a definition for the owner of the building. The authority to administer can be given to a committee or an official or an agency to act on its behalf. Annexures A to P has details about the Guide for the qualifications and competence of professionals, Certificate for supervision of work, Certificate for completed work by Builder/Constructor, Completion Certificate, Occupancy Permit, etc.

Building/development work is required to be planned, designed, and supervised by registered professionals, which include Architect, Engineer, Supervisor, **Utility service engineer,** etc. Telecom/ICT engineers can be categorised as Engineers for Utility Services. Requirements of registration for various professionals by the Authority or by the body governing such profession as applicable to practice within the local body's jurisdiction are mainly related to Architecture, Civil Engineering, and Urban design. The **competence of such registered personnel** to carry out various activities is also indicated.

Building Services specifies the qualifications and competences of the engineers for utility services or constructors but do not specify any qualifications **for the professional experts in wireline or wireless telecom systems**. However, from the general requirements related to work of building services, including Telecom/ICT enabling requirements, it may be expected to be executed under the planning, design, and supervision of

competent personnel. Code enables to stipulate the requirements of qualification for registered professionals for building services under Building Services part of the code, or it may be decided by the Authority taking into account the practices of the national professional bodies dealing with the specialist engineering services. This approach similar to what is to be followed for association of other/multi-disciplinary professionals for taking inputs and associating with their areas of specialization may be followed in case of ICT-related requirements. For example, the minimum qualifications for an architect is as laid out in the Architects Act, 1972, is to register with the Council of Architecture.

Development control rules and general building requirements part describes various requirements such as **proper planning and design at the layout** and building level to ensure health safety, public safety, and desired quality of life. It also covers requirements for accessibility in buildings and built environment for elders and persons with disabilities.

It **classifies types of land uses** at two levels, first level is on the basis of **Use Category** such as Residential, Commercial, Industrial, Public, semi-Public, recreational, etc., and the second level is a **sub-classification** based on the use zone such as Planned Residential Zone or Unplanned/Informal Residential Zone. It also **classifies types of plots on size or types of developments** such as Detached-buildings, Semi-Detached buildings, Row Housing, etc. It also classifies buildings **based on occupancy** such as Residential, Educational, Institutional, Mercantile, Storage, etc., and also on the basis of type of construction, which is from the perspective of fire safety. **FAR** is also defined for different types of buildings.

In addition to the community open spaces, this code/part also prescribes requirements for various amenities, including telecom facilities. For Telephone and Communications, it prescribes to plan a land area (minimum) of 4.0 hectares with a Telephone exchange of 40,000 lines (1 for every 4,00,000 population Area), and land area of 300 square meters to have Remote subscriber unit (RSU) in a radius area of 1 for 3 km.

**Fire and Life Safety** part, which is referred as an essential element and many times compared with the need of similar requirements in case of telecom services, covers the requirements for fire prevention, life safety in relation to fire, and fire protection of buildings. It also specifies **occupancy-wise classification**, constructional aspects, egress requirements, and protection features that are necessary to minimise danger to life and property from fire. From the Fire Safety's perspective, buildings are classified as residential, Educational, Institutional, Assembly, Business, Mercantile, Industrial, Storage, and Hazardous in groups, and sub-divisions have also been classified under the 'Fire and Life Safety" of the Code.

Significant part of the code is covered by aspects such as Building Materials, Structural Design, and Construction Management Practices, and Safety, which are **mainly related to civil engineering works;** comprehensive requirements have been developed over the decades. These requirements have been institutionalized, and ecosystem is in place to follow the processes stipulated in the code, **unlike** in the case of the requirements for enabling Information and Communication.

**Information and Communications enabling requirements** are mentioned in one section out of six sections of the Part 8: Building Services; other Sections provide details related to utilities and also provides detailed guidance to concerned professionals/utility engineers for meeting necessary functional requirements in buildings. Main focus of this part is on activities related to Electrical Engineering such as Lighting, and Natural Ventilation, Electrical and Allied Installations, Air Conditioning, Heating and Mechanical Ventilation, Acoustics, Sound Insulation, and Noise Control, Installation of Lifts, Escalators, and Moving Walks. Section 6 of this part provides the details specific for telecom/ICT enabling requirements.

Requirements related to Information and Communication Enabled Installations are covered in 28 pages and mainly **covers the essential requirements** for ICT-enabled installations, technology systems, and

related **cabling** installations in a building. It also covers the **basic design and integration requirements** for telecommunication spaces within the building/buildings along with their cabling infrastructure, their **pathway components, and passive connectivity hardware**. Buildings meant for data centres and those for housing telecom exchanges/facilities for offering public services in such buildings may have various other considerations.

General requirements for the Telecommunication spaces and Connecting hardware describes various requirements for general considerations, size of rooms, and spaces depending upon the size of the buildings and also describes the **method for the space allocation and their layouts**. It also guides about the **maximum data transfer rate** provided by different categories of copper twisted pair cables and optical fibre cables. For optical fibre cables it also suggests that the specifications of certain types of Optical Fibre Cables are available in the Telecom Engineering Centre (TEC), Department of Telecommunications (DoT).

Requirements cover **Telecom Media and Connecting Hardware,** which apart from wireline infrastructure includes Wireless Systems, including Wireless LAN Access Points (APs), Wi-Fi Access Point with Centralized Controller, Distributed Antenna System (DAS)/ In-Building Solutions (IBS), and Wireless Repeater. **Site survey approach** is to be adopted to consider various factors impacting wireless coverage area, and at the time of installation, spacing, or frequency management is to be done.

It also includes general requirements relating to installation of different communication equipment, **cable terminations**, **power connections,** and general guidelines required for planning and providing information and communications technology (ICT) services in the building at the planning and execution stages. The provisions given herein are **basic requirements applicable to all residential** and other types of buildings.

This part also covers requirements for Backbone Cable Media Distribution and Building Pathways, which includes **inter-connection between telecom spaces** such as risers, inter-building cabling that may be underground, direct buried, aerial, or in the tunnel. Typical requirements

related to Building Backbone Pathways includes vertical pathways, conduits, ducts, trays, riser systems, vertical pathway size, access to roof for installation of antenna, powering the equipment, etc. General guidelines for installation and work safety are also included.

The **design and planning of LV systems,** namely intercom, data cabling (telecom/ ICT), CCTV, fire alarm, etc., are **part of the electrical wiring installation**. Planning involves consideration of all prevailing conditions and the need to consider type and requirements of the consumer and also for **considering anticipated future requirements**. A competent electrical design engineer is to be involved at the planning stage to provide for an installation that will prove adequate for its intended purpose and ensure safety, reliability, and energy efficiency in its use. **List of standards** for telecom/ICT enabling requirements **refers to IS** standards for electrical installations.

**Other aspects** such as Plumbing Services including Solid Waste Management, Landscape development, signs, and outdoor display structures such as Landscape planning, design, and development.

Code also defines the **approach to sustainability** and covers the parameters from the sustainability point of view, which is a supplement to all other Parts/Sections of the Code. Asset and Facility management part covers provisions relating to management of building assets and associated facilities and includes various aspects relating to maintenance of all types of facilities and fixed assets, such as buildings and building services.

Part/Section of this Code, where reference is made to **good practice** in relation to design, constructional procedures, or other related information, and where reference is made to **accepted standard** in relation to material specification, testing, or other related information, the **Indian Standards listed at the end of the Part/Section** are to be used as a guide to the interpretation.

***Comparing*** *requirements for other services with the requirements for telecom/ ICT*

NBC has incorporated enabling requirements for telecom/ICT. The Part 0 **"Integrated Approach"** takes care of the functional, aesthetic, safety aspects, and value engineering, while Part 12 "Approach to Sustainability" covers the provisions relating to management of building assets and includes aspects related to maintenance of building services, which are **technically applicable on telecom/ICT too,** and these approaches are expected to be adopted, and followed in practice, while planning telecom/ICT related requirements.

Telecom/ICT requirements have been introduced in NBC. The engagement of teams for **project management, design, supervision, and execution,** as envisaged in general for various requirements is although not specifically mentioned but is **expected to be in practice in case of telecom/ICT.** Telecom/ICT requires classification of buildings like the **classification of buildings** of "Fire and Safety".

NBC nor does any of its documents details out the activities related to major stages of the building project in case of Telecom/ICT. The documents or **guidelines** should guide on the complexities too, as the building project management teams use the guidelines to plan and engage with appropriate/concerned teams to deliver the project. Design of telecom/ICT is also evolutionary and requires the owner's **participation in the process at various stages**.

For good quality network within the building, it is important to engage **qualified professionals with appropriate knowledge and experience along** with an integrated approach, right from the conceptualization stage to the construction stages of the building project, and throughout the life cycle. However, the **professionals referred in NBC** for telecom/ICT planning and installations are electrical engineers, with the competency in LV (Low Voltage) systems, and are **not experts in Radio** Networks of 2G, 3G, 4G, or upcoming 5G mobile network systems. In wireless systems, installing antennas at buildings or boundary walls or street pole might be required, and such requirements need engagement of telecom/ICT design professionals with building project teams, and this has not been considered

in the current descriptions of the code. Designing wireless system requires in-depth knowledge of radio propagation models, capacity calculation on air interface, and hands-on experience on coverage prediction tools, drive/walk test tools, etc., **which a typical LV-system expert might not have**.

Depending on the nature, magnitude, complexity of the project, RF (Radio Frequency), and transmission network planning experts should be included as a part of multi-disciplinary teams. It is important that the **level of expertise and capabilities of tools** for planning and designing of wireless networks inside the buildings are carefully selected while forming the design team, project management/construction management team, and operation and maintenance team, **depending on the size and complexity of the project**.

The Architect should be competent to carry out functions related to building/development permits such as preparation of all plans, issuance of certificates for supervision, and completion, etc. And in case of telecom/ICT, the **Architect might need to collaborate with professionals** of Wireline and Wireless systems.

The list of standards, as referred in telecom/ICT, includes a few IS standards related to electrical installations. To design and deploy a wireline and wireless systems, which meets the desired coverage, capacity, and Quality of Service requirements, it might be essential to refer to **specific standards of telecom/ICT, best current practices (BCPs), and develop more detailed guidelines to help the designer**. Planning and Designing of these systems will need other requirements apart from technical requirements such as aesthetics, safety, value engineering, etc. The requirements can vary according to the types and size of the buildings and the service usage of the occupants; this may also impact the design and deployment of the systems. **Buildings can be Classified** on the basis of area, height, density, type of construction, purpose of use, etc.; it will be very useful to define the general requirements for different classes of buildings.

For administering the code/part of the telecom/ICT infrastructure related requirements such as enforcement, procedure for obtaining permits, responsibility of the owner, and professionals involved in its planning, design, and construction**, the administering "authority" can be designated to a special unit of professionals experienced in the telecom domain,** and such officials or agencies who can act on their behalf. Accordingly, this authority may formulate a **Guide** for the qualifications and competencies of telecom/ICT professionals, provide certificates for supervision of telecom/ICT work, provide certificates for completed telecom/ICT work by Builder/Constructor, and these can be considered while issuing Completion Certificate, Occupancy Permit, etc.

### 3.3.3 DoT endorsed TRAI's recommendations of 2011 and 2017, and conveyed it to MoHUA

In 2019, DoT endorsed TRAI's recommendations on Telecom Infrastructure Policy (TIP) made in 2011, along with the recommendations made in 2017 on In-building Access. DoT requested Ministry of Housing and Urban Affairs (MoHUA) to ask State/UT Governments to issue necessary directions/guidelines to Municipal Authorities **for existing private commercial/residential complexes** to provide access to all on a fair, transparent, and non-discriminatory manner. It is further required that in future, no Owners/RWAs should enter into an agreement resulting in exclusive access; thereby, taking away the choice and flexibility from the residents of such premises in terms of QoS, tariff, and redundancy.

DoT requested MoHUA that for **access to existing Government/PSU building/Premises,** all departments/owners should be advised to provide access to TSPs so that seamless telecom services are available to the general public. Accordingly, MoHUA may issue an advisory for allowing sharing of infrastructure. In the same communication, DoT asked MoHUA to advise all the States/UTs to share IBS in all the existing Government/public buildings.

With regards **to the new building premises,** DoT requested MoHUA to make changes in the Model Building bye-laws such as include the

requirements for creation of CTI with telecom ducts as a part of it, mechanisms to enforce the requirements stipulated in the NBC. It also mentioned that no building plan should be approved without CTI and Telecom Duct, and issue Completion Certificate only after ensuring CTI as per standards is in place.

## 3.4 Do the current provisions solve all the issues?

As seen in the detailed analysis above, relevant provisions have been made in the RoW policies with the objective of providing hassle free access to TSPs in a fair, non-discriminatory, transparent, and time-bound manner. The requirements for enabling Telecom/ICT infrastructure within the buildings have been laid down by NBC, and for their enforcement, necessary amendments in the building bye-laws have already been made or are at the planning stage. The key question that arises is whether the current provisions and their effective enforcements would ensure a good quality network or services inside the buildings or more provisions should be made?

### 3.4.1 How to build a Good quality network?

The first step is to define what good quality of service is within a building, and that it meets the expectations of the residents of that building. The next step is to ensure that such a network is already into existence and is providing its services to the residents. Designing, executing, and evaluation of the telecom/ICT network will also be done on similar lines, and with the same level of professional engagement as is seen by civil engineers in a building project.

The buildings should have the provision to offer residents the choice to choose from the services of all operating networks of that location at a reasonable price. A single system under the sole ownership will be cost optimized, it will reduce coordination efforts, and will make the availability of the network at appropriate time, but it will also lead to monopoly. This can be addressed through various measures such as setting procedures to test the reasonableness of the charges, fees, etc., to creating a platform where all stakeholders can participate in the decision making.

### 3.4.2 Business model which make services available at a competitive price

A good telecom/ICT infrastructure within the building can be developed and delivered in different ways; for example, the telecom operators may build the infrastructure while the civil and engineering job can be delivered by the builder and the remaining can be dealt by the Telecom operators or Infrastructure Providers, who can build this network and interconnect it with the TSPs, etc. It is yet to be figured out which engagement model will be successful in a multi-actor and multi-stage environment. The model should avoid winner-takes-it-all scenarios as it can lead to rent-seeking situations. Business model should be shaped by power dynamic but it should be in the interest of the residents or the users of the network.

The market can determine the engagement model, as the residents or the users of the networks in the building who are looking for good quality of service will be willing to pay for the same. Any other ways to deal with the situation are not yet formulated, and regulatory intervention might be required to define roles and responsibilities of different actors.

The business model should have attractive incentives for actors that will encourage them to build, operate, maintain a good quality network, and upgrade it from time to time, and any sub-par services can be penalised. If incentives are not properly aligned in the Business model, the Regulations might not be very useful too. Requirements can be subcategorised into binding and non-binding, where non-binding requirements are to be dealt by the market.

### 3.4.3 How to build the business model in a cost effective and timely manner?

When the business case for in building solution is efficient and effective but is delayed, it will cost dearly to all stakeholders.

Even requirements for entities to grant permissions and charge TSPs fairly and follow the processes non-discriminatorily and transparently would still not assure that services from all operators are available in the building which has telecom/ICT infrastructure, as the individual TSP might connect depending upon its own evaluation of the business case in providing

services, and may also have its own plan to roll-out networks in a particular area. To accomplish the availability objectives of a good quality network before the demand arises, it is important to synchronize the activity of building developer, telecom/ICT infrastructure developer and to connect the networks of all operators to the in-building telecom/ICT infrastructure.

To achieve this the builders should announce the project at the conception stage to the telecom operators so that they can get engaged in the process of building telecom/ICT infrastructure for the upcoming projects. This may require a systemic dialogue between a builder and the telecom operators or infrastructure solution providers for announcing the event, acknowledgement by others, and collaboratively identify a good telecom/ICT infrastructure in the building. Requirements for a building may vary depending on many factors such as type, height, size of the building.

Engagement of the professionals at an early stage may reduce the cost of implementation, and will help to achieve the desired quality by deploying of networks in accordance to the design of the building. Even little compromise may have huge impacts on QoS. Deviations from the design while deploying the network due to constraints imposed by external factors causes difficulties in achieving the desired objective and leads to poor QoS.

### 3.4.4 How to develop an ecosystem to ensure delivery of a good quality network

The availability of technical specifications and guides or manuals will help to build telecom/ICT infrastructure and different actors can work on different segments, and it will ease the effort to build a final solution as per the requirements. Such specifications and manuals also help to avoid duplication of work. Professionals may be certified against the knowledge skills required to accomplish the tasks in accordance with the specifications and manuals. This makes the task easier for competent professionals.

Description of methods to carry out work, performances of the products, and design principles help in identifying tools that can simulate the results based on design of the network and building project scheme. Such tools

may also be certified for evaluation of the design and approval based on simulated results conforming to the intended quality of service. To make assessment of quality of service at the subsequent stages of network deployment and accord approvals, tools which also consider actual field measurements while generating output may be useful.

To consider the quality experienced by the residents, purpose specific surveys with participation limited to the residents or visitors to the society will be useful for the evaluation of quality of service. However, in case of mobile networks, difficulties faced in identifying actionable items is that participants to surveys grant score on a given scale, and it is given on the basis of general experience spread over a number of locations and various time bands. If simulated results or actual measurements cannot be correlated to the customer's experience, then it may not lead to any specific action to be taken to improve the quality. Time and efforts required to address the concerns at individual level may be disproportionate to the return or capacity available at the end of service provider. Surveys which enables customer to convey real issue and provide feedback becomes important to bring efficiency and effectiveness. Digital 3D maps of the building interactive interactions with the residents and the view customized to the participant of the survey might be able to capture the essence.

## 3.5 Review of International practices to improve connectivity inside the buildings

### 3.5.1 United States of America (USA)

In the last few years, U.S. Federal Communications Commission (FCC) has introduced three orders, which are Small Cell Order, the Moratoria Order, and the One Touch Make-Ready Order, to accelerate 5G or broadband deployments in the country. Federal Act Sections 253 or 332(c)(7) may treat a state or local government to be in violation unless few conditions are met such as the fees are a reasonable approximation of the state or local government's costs; only objectively reasonable costs are factored into those fees, and; the fees are no higher than the fees charged to similarly situated competitors in similar situations.

Small Cell Order dated 26th September 2018, explains when a state or local regulation of wireless infrastructure deployment constitutes an effective prohibition of service prohibited by the Sections 253 or 332(c)(7) of the Communications Act; it also removes uncertainty by identifying specific fee levels for small wireless facility deployments that presumably comply with the relevant standard; and it also provides guidance on when certain state and local non-fee requirements that are allowed under the Act—such as aesthetic and undergrounding requirements—may constitute an effective prohibition of the service.

To address the issue of deployment of small cells, FCC is adopting a "one-touch, make-ready approach", removing the multi-step make-ready process. New regime "in which the new attacher performs all make-ready work," may help in fast, more streamlined, and more cost-effective processes surrounding network buildout of 5G networks.

The rule change does take away a level of control from local authorities as FCC considers it as a violation of federal law for states or localities to impose moratoria on broadband deployment. It seems to be intended to enable the presence of more TSPs in the area for better services.

### 3.5.2 United Kingdom (U.K.)

Ofcom, the telecom regulator of U.K., commissioned the research in response to the increasing data demand consumption indoors and the ongoing developments in construction, notably the increasing use of metal film on windows, reinforced concrete block building structures, and external cladding which together acts to attenuate mobile signal propagation. It is estimated that such techniques can contribute over 20dB of loss where older building types might normally be between 5 to 10dB.

Ofcom published a Report[1] on 9th January, 2014, this report was submitted to Ofcom by Real wireless, an independent wireless consultancy, and the report provide options for improving In-building Mobile Coverage. It

[1] https://www.ofcom.org.uk/research-and-data/telecoms-research/mobile-smartphones/improving-building-coverage

mentions that over 90% of mobile usage is inside buildings. The report highlights that despite having coverage to 99.7% of the population, 19% of users regularly encounter coverage problems in their home.

The study highlights the potential benefits and challenges associated with deployment of dedicated indoor solutions including:

- Self and carrier provided Wi-Fi
- Repeaters
- Femtocells
- Picocells
- Distributed Antenna Systems
- Distributed Base stations (CoMP, CPRI, X2)

Key points highlighted in this report are:

- Outdoor-in solutions are hassle free for the consumer but do not work for all. Approaches to improving in-building service levels fall largely into two categories: Outside-in solutions and Dedicated in-building solutions.
- The main drawback of outdoor-in solutions is that due to variations in construction materials and building geometries, there is no guarantee that the cellular signal from outdoors will be able to penetrate all buildings. If service being targeted is 2 Mbps (service expectations) for all parts of the U.K. (Deployment level), then 14 million users could require in-building solutions.
- The most appropriate dedicated in-building solution to indoor mobile service issues is complicated by the range of buildings and users to be covered. The range of in-building solutions included Wi-Fi, Carrier Wi-Fi, Femto Cells, Pico Cells, Distributed Antenna System (DAS), and Distributed Base stations.
- Best-fit solutions may depend upon different combinations of users and type of buildings as it may be influenced by the cause of poor service outside, and also influenced by factors in that particular building including the wish of the user to have a fixed broadband line or the service of other family members. Solutions would also be

influenced by the capacity requirements, deployment challenges, and cost involved.

- Common area concerns found in this study, inter alia, included availability, openness, security, upgradability, etc. It also suggested the Regulator to monitor full integration of solutions into existing operator networks, addressing security aspects in case of openness, barriers for multi-operator support. It recommended the Regulator to provide information and assistance to consumers to identify appropriate solutions, consider monitoring and reporting of in-building coverage levels, consider if operators need extra encouragement to collaborate, and assist in formation of best practice guidelines for the implementation of security standards.

The report seeks to demystify and also helps to understand that Indoor service is of an increasing importance to the consumers, but cellular service from macro cells alone fall short. It recognizes that Indoor coverage could worsen if not planned appropriately. It also discusses technical options to understand the range of these options for addressing indoor not-spots and the merits of each. It also mentions that many solutions to indoor not-spots lead to confusion on the most appropriate solution. It also highlights potential regulatory and policy implications such as:

- The consumer needs assistance to navigate the choice of In-building solutions
- Spectrum is not a fundamental barrier to in-building technologies being deployed but could help accelerate adoption of some solutions
- Ofcom could consider providing updates on in-building coverage levels in their market reports
- Ofcom should monitor appropriate openness of solutions to ensure that consumers have a choice of suppliers for their preferred in-building solution
- Ofcom could assist in forming best practice implementation guidelines on security in in-building solutions and raising consumer roles in this

- Ofcom should analyse the FCC position on repeaters and consider why this does not fit the U.K. Market? These devices can be purchased by consumers in the U.K., and their deployment is limited by the fact that consumers must get their permission from their operator before deploying them in the licenced spectrum. In contrast to this, the FCC, in the U.S., allows repeater products to be deployed by consumers, and they are widely deployed in this way. Given the emergence of intelligent repeaters to serve as a potential gap in the in-building market of home users with no broadband connections, it is recommended to analyse and consider this or alternative approach.

### 3.5.3 Singapore

IMDA Singapore has released the Code of Practice for Infocom Facilities (COPIF)-2018 under Telecommunications Act[2] 1999 3(1), which provides Authority to have exclusive privilege for operation and provision of Telecom system and services in Singapore. Section 12 of this Act provides the Power to enter on and examine Land other than state land; Section 13 provides Power to enter on state land; Section 14 provides Power to enter on other land, or Building for the purpose of installation of plant and Section 22 Prohibits against exclusive agreements or arrangements.

Section 19: Provision of space or facility under CoP requires the developer or owner of any land or building to provide, maintain, or give access at the developer's or owner's expense, such space or facility as IDA may publish, within or on the land or building, for the installation, operation, or maintenance of any installation, plant, or system as may be necessary for operation of any installation or plant to be used in providing Telecommunication service. And Section 21 is related to Provision of space or facility or installation, plant or system by direction of Authority.

COPIF-2018 requires that Mobile Installation Space and Deployment Space should be provided without any charges. Further, it requires 4 Fibres in each Flat; CAT 6 and RJ 45 outlet in each Room. COPIF 2018 also specifies

[2] https://sso.agc.gov.sg/Act/TA1999

responsibilities of Builder/Developer and it also provides technical details to guide the design. Builders submit the plan of the building to CORENET, which is forwarded to TFCC (committee). The plan along with other things carry mobile coverage area as well.

Telecommunication Facility Co-ordination Committees (TFCC):

- Developer or owner completes the construction of the space and facilities (6 months before TOP)
- Developer or owner requests TFCC for inspection
- Developer or owner and TFCC conduct joint inspection on inspection items
- Developer or owner and TFCC record the results of the joint inspection
- Developer or owner to submit the inspection checklist to IMDA
- Are the inspection items compliant?
- Developer or owner to rectify defects in space and facilities, and submit declaration to TFCC after completion of rectification work

A set of as-built installation drawings for any telecommunication cable system shall be prepared by the developer or owner for each building type as specified in the COPIF, in the format (e.g., BIM) required by the relevant authority. COPIF serves to inform the developer or owner of any development of the procedures and requirements to facilitate the timely provision of mobile service coverage within the development. The developer or owner may make a written request to any licensee for the provision of mobile service coverage within the development and shall include written request relevant to the information relating to the development (e.g., type and size of the development).

### 3.5.4 Hong Kong

OFCA Hong Kong has released Code of Practice (CoP)-2012 to provide Access facilities for telecom and broadcasting. In Hong Kong, Telecom Ordinance authorises TSPs to enter building and install IBS. Network

operators are not required to pay any charges. As per CoP-2012, Network operator submits the proposal to the OFCA. Sample inspection is also done by OFCA from time to time. CoP also refers to TIA/ ITU standards.

### 3.5.5 Australia

To work as a cabler in Australia, one must be registered. This also protects the safety of cablers and customers and the telecommunications network. ACMA encourages people to file a complaint if they find out that someone is working unregistered and without proper supervision.


List of Cabling Registrars with ACMA are:

- Australian Cabler Registrar Services (ACRS)
- Australian Security Industry Association Limited (ASIAL)
- BICSI Registered Cablers Australia Pty. Limited (BRCA)
- Fire Protection Association Australia (FPA Australia)
- TITAB Australia Cabler Registry Services (TITAB)

Registrar requests the applicants to register for evidence about appropriate training and have the required skills (competencies). For Certified Professionals, there are Registered Training Organizations (RTOs) that deliver various Telecommunications Certificates such as Open Registration Pathway, Restricted Registration Pathway, Lift Registration Pathway, etc.

ACMA has Cabling Provider Rules (CPR) 2014 made under Telecommunications Act 1997, and its parts are:

- Cabling Work: Open, Restricted, and Lift
- Registration: Arrangements for Registration
- Performance of Cabling Work: Compliance and Certification
- Relationship with ACMA: ACMA can inspect cabling work
- Schedules

- Competency Requirements
- Accreditation Procedures for Cabling Provider Registrars

## 3.6 Practice Standards and Certifications

To a large extent, it is within buildings where the 'rubber hits the road', and the expectations of user experience and quality are determined. It is within this environment where there is a high level of dynamism; movement, change, shifts, and multiplicity of devices are concentrated. It is, therefore, critical to develop a structured practice standard while deploying communication systems within the buildings. There are two parts to this viz., Design and Implementation. The design capabilities must take into account the needs of today and future proof it against the changing scenarios so that the adoption of new technologies, and effecting adds, moves, and changes are done with least or no interruption to the service.

To install, configure, manage, and troubleshoot, telecom/ICT networks inside the buildings, the professional building networks, and those managing it, should know technicalities beyond the usual basics of drawing wires and terminating them. In case of wireless technologies and broadband services, professionals need to have technology and service-specific competencies. From the practices followed by the organizations and industry in the developed countries, it is observed that at the time of getting engaged with the solution providers to build out telecom/ICT networks, they are asking to engage certified professionals with a specific level of competencies to carry out the work. These certified professionals carry out work in accordance with the detailed guidelines and manuals, which they have practiced during the certification.

A number of agencies are providing telecom certification in the networking area, some of these are:

*Certified Telecommunications Network Specialist (CTNS[3])*

[3] https://www.certify-tco.org/

The Certified Telecommunications Network Specialist (CTNS) certification is offered by the Telecommunications Certification Organization (TCO) and is aimed at project team members, managers, analysts, planners, and developers who need to understand telecom networking fundamentals, including services and infrastructure requirements. A CTNS usually works for a telecommunications services provider, reseller, or telecom equipment manufacturer.

TCO offers the Certified IP Telecom Network Specialist (CIPTS) the certification, which focuses on IP networking and not on telephony or wireless. The organization also offers the Certified Wireless Analyst (CWA) and Certified Telecommunications Analyst (CTA) certifications.

*iNARTE[4] International Association for Radio, Telecommunications, and Electromagnetics*

iNARTE is the International Association for Radio, Telecommunications and Electromagnetics; it is an industry group to develop and implement a certification program for telecommunications' engineers and technicians. iNARTE has certifications for wireless system installers and product safety engineers, and technicians, among others.

The iNARTE Telecommunications certification program includes the Telecommunications Technician and Telecommunications Engineer credentials, geared toward many facets of the industry, including networking (LAN and WAN), cellular, and satellite. Both constitute of Junior, Senior, and Master credential levels.

*Internet Protocol Engineering Professional (IPEP[5]) certification*

The Society of Cable Telecommunications Engineers (SCTE) offers several professional certifications for installers, technicians, designers, and engineers who support residential and commercial projects as well as access networks.

[4] http://www.inarte.org/certifications/inarte-telecommunications-certification/

[5] http://www.scte.org/ipep

The Internet Protocol Engineering Professional (IPEP) certification recognizes a professional's expertise in designing, deploying, testing, integrating, and troubleshooting various IP systems. It also covers performance analysis, IP network deployment, operation and testing, and multimedia over IP. It has multiple levels of certifications.

*NCTI[6] Master Technician Certification*

The Master Technician certification is a professional-level, vendor-neutral credential offered by NCTI. NCTI offers College degree programs, College-level certificate programs, and NCTI Certifications. NCTI certifies in Master Technician, Master Representative, Master Dispatcher, and Emerging Leader. The Master Technician credential is available in five solution tracks:

- Master Installer (MI): Targets professionals well-versed in broadband cable installation, best practices, and new technologies.
- Master Technician (MT): The Master Technician credential is focused on professionals, who are experts in drop installations, and broadband networks.
- Master Technician, HFC Networks (MTH): This credential focuses on HFC network maintenance, fiber optic systems, and maintenance of two-way analog and digital services.
- Master Technician, Customer Premises (MTC): This credential is geared to professionals who manage all aspects of digital services from distribution to customer devices. Candidates should also possess the ability to perform installations, troubleshoot issues, and maintain systems.
- Senior Master Technician (SMT): is the highest level of master technician certification available. To earn the designation, candidates must be well-versed in HFC networks, drop installation, and complete the Understanding Voice and Data Networks course and possess the MTH and MTC credentials.

[6] https://www.ncti.com/certificates-degrees/ncti-certifications

*Registered Communications Distribution Designer (RCDD[7]) certification offered by BICSI*

The Registered Communications Distribution Designer (RCDD) certification offered by Building Industry Consulting Service International (BICSI) is one of several engineering-oriented IT communications credentials from this design and implementation engineering-oriented organization.

Under the Unified Facilities Criteria, the RCDD is required for individuals who work for or with the U.S. Department of Defense (DoD) on telecom-related design projects.

The RCDD focuses on the design, integration, and implementation of information and communications technology (ICT) systems and related infrastructure components. Other BISCI credentials include the following:

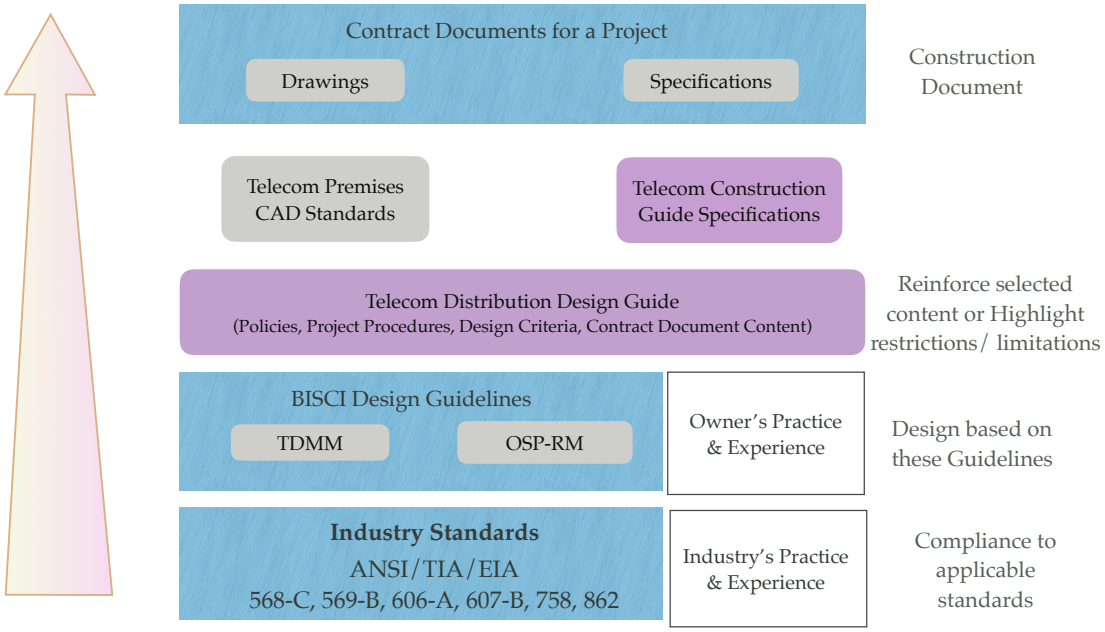
- Registered Telecommunications Project Manager (RTPM)
- Data Center Design Consultant (DCDC)
- Outside Plant Designer (OSP)
- Installer 1 (INST1)
- Installer 2, Copper (INSTC)
- Installer 2, Optical Fiber (INSTF)
- Technician (TECH)

BICSI is also involved in helping with the development and design for information of transport systems (ITS) such as the ANSI/EIA/TIA 568B structured cabling system standard. A number of Universities in USA are referring to manuals issued by BICSI and professionals certified by BICSI. Few of the manuals from BICSI are:

- BICSI CO-OSP: BICSI Customer-Owned Outside Plant Design Manual
- BICSI TDMM: BICSI Telecommunications Distribution Methods Manual
- BICSI TCIM: BICSI Telecommunications Cabling Installation Manual

[7] www.bicsi.org/rcdd

The schematic diagram indicates the role of guidelines and manuals over the basic standards when a specific project is being realized.




The robustness and reliability of the design is an important criterion, and this is a vocational skill that requires to be properly institutionalized and developed nationwide. The NBC is a first step in this direction. The New Education Policy, 2020, which has been recently announced, gives ample scope for institutionalizing such design skills as a vocation and creating new job opportunities.

Last but not the least is the actual deployment of the design. This ranges from right installation practices, proper cable termination, and adherence to fire and safety standards. It is one thing to deliberate and announce well thought out policies and codes, but yet another thing to ensure that the intended results are achieved. This cannot be done unless the following is resorted to:

- Extensive engagement of certified professionals, builders, and TSPs/ IPs
- Qualitative and quantitative assessment of implementation

- Continual up-gradation of skill sets required to ensure a comprehensive high-quality network

Cost may be more important than Quality. But Quality is the best way to reduce cost.

## 3.7 What more should be studied?

Ecosystem, which builds in-building networks, operates and manages it, can be country specific. Barriers faced by the stakeholders may be due to legal framework. If opportunities were seen by real-estate developers in other countries in providing good quality network, then why similar opportunities are not available in India?

Considering the fast changes in the mobile network technology and demands from the users, in-building network needs to be seen from an entire life cycle perspective rather than just from the beginning.

# Chapter-IV

# 4 Case studies taken up by TRAI

## 4.1 Selection of Residential Apartments

The scope of analysis for this study is limited to Multi-storey Apartments. And to cover different scenarios, multiple residential societies were selected from different cities such as Delhi, Gurugram, Bengaluru, Hyderabad, Kolkata, Jaipur, Indore, and Jabalpur.

*Figure 2: Cities in which case studies were taken up*

| City | Apartment Buildings | Remarks | Other Buildings | Remarks |
|---|---|---|---|---|
| **Bengaluru** | **2** | Two societies of 13/ 16 storied buildings in Bangaluru | **4** | Bengaluru Metro, Govt. Buildings, Software Technology Park (**9-storey**), Mall, |
| **Bhopal** | **3** | Two societies of 14 storied buildings in Indore, One **cantonment area** of Jabalpur | **4** | Lucknow Metro, Bhopal Airport & **6 floors:** Parking, Mall |
| **Hyderababd** | **4** | Four societies of 13/ 16 storied buildings in Hyderabad | **0** | ———- |
| **Jaipur** | **2** | Two societies of (5-13) / 14 storied buildings in Jaipur | **3** | Jaipur Metro, Police HQ (**8 floors**) , Mall, |
| **Kolkata** | **5** | Five societies of (16-19)/ (10-14, 24-27, 43 )/ 35/ 62/ 64 storied buildings in Kolkata | **6** | Government Buildings (**4-12 storey**), Market, Malls, Hospitals, Medical College |
| **Delhi NCR** | **6** | Six societies of (8-10)/ (10-14, 24-27) storied buildings in Delhi | **2** | Delhi Airport, Delhi Metro, Hospital |

The selected apartments were those buildings where telecom infrastructure was already deployed. TSPs were also asked to propose apartments where best solutions for in-building networks are deployed. Such buildings were expected to have good quality of network as these are equipped with telecom infrastructure. If this is true, deployment models may become standard specifications for other buildings. If actual situations differ from the expectations, then there is a need to find reasons of such gaps and to identify what more is required to be done. Quality of network in the buildings which are not equipped with telecom infrastructure would be poorer than such buildings.

Few high-end apartments were also selected to understand whether cost is a major factor for unsatisfactory quality of services inside the buildings. If builders are ready to invest in the deployment of networks whether it would assure good quality network. Or without adequate measures taken at the stage of design and subsequent stages may lead that investment not to yield desired results. For this reason, societies where maintenance charges are relatively high, infrastructure is modern and being managed in a more professional manner were also chosen to find out whether good management of building assures good maintenance of telecom infrastructure.

The purpose of such a selection was to understand whether granting permissions to TSPs to enter the building is the only issue to be resolved for having a good network or it is essential but not a sufficient requirement. If there are other factors, then there is a need to know such factors affecting a good quality of service inside the buildings. Considering varieties of apartment buildings was also required to get insight whether compliance of general specifications to all kinds of buildings would lead to a good quality network or there is a need to have different solutions for different types or classes of buildings. For this purpose, various types of buildings were chosen for the study. Study covered apartments ranging from 8–10 stories to up to 64 stories. This range covered apartments which can be covered by Ground-Based Towers (GBTs)/Roof Top Towers (RTTs), and also the apartments which would require special solutions to reach to the entire height of the towers.

Buildings with old infrastructure where general poor maintenance of the systems might impact quality of network were avoided to include as a part of the current studies to keep it focused on telecom specific issues. Few isolated buildings were also chosen, which were not getting incidental coverage to see the strength of in-building solutions.

This monograph is prepared to be a useful guide for those who want a network that meets their needs and also those who have a role to play in delivering it. On some of the issues further consultations might be required

with the stakeholders before finalizing exact steps or approaches which may be taken to improve the connectivity.

## 4.2 Methods and approaches for conducting the study

General outdoor inspections were conducted of the apartment buildings and associated areas to know where telecom infrastructures are deployed to serve the area, and which are the areas where good coverage is expected and the areas where network might be poorer. For this, the factors which affects the propagations of the radio signals such as clutter of the obstacles, their heights, etc., were considered.

General inside building inspections were also conducted to know the cable pathways, housing enclosures, equipment area, connectivity arrangements with backhaul, etc. While doing this, it was compared with the specifications laid out in the National Building Code (NBC) to know whether something more was required to be done to comply with the requirements. It included the differing requirements for different kinds of buildings.

The assessment of the quality of the network in the area under study was carried out by conducting measurements at the ground level on streets, park areas, parking areas, common areas, etc. Area was walked around the apartments, measuring signals and quality at various locations. This was to get an idea of where the biggest dead zones may be. This is a typical way which is adopted for the assessment of quality in a geographical area.

As users are not only distributed horizontally in the area but also vertically, to estimate the variations in the network quality with height, field measurements were also carried out on each floor of the buildings. The variations were expected to be dependent upon the kind of solutions deployed in the area and the kind of buildings to be served. Floor measurements were made outside lift areas and in front of the entry points of the apartments on the floor.

Through interactions with the resident associations or the field staff managing the building services, feedback was taken about the quality of experience. Interactions also helped to understand how the telecom

infrastructure was planned and deployed in that building, and also to know the procedure followed by them in giving access to TSPs for installing the infrastructure and maintaining the infrastructures.

Feedback from the managerial staff was also useful to understand the QoS issues residents of the buildings face inside the dwelling units. Interactions with various kinds of persons in the buildings was made to know the difference in quality of experience of a visitor, e.g., guest to the apartment, operational staff on duty, drivers associated with the residents, etc. Apartments which are on rent and changes in the tenant of the apartment might also change the telecom requirements in a particular apartment at different point in time. Interactions were also required to know variety of use cases.

The issues and factors which were observed to be impacting the quality of service inside the buildings were examined with respect to current regulatory, licensing, legal provisions, and also from the perspective of functioning of the market to respond to it. Whether regulatory interventions or introduction of new business models may help to address the issues were also deliberated as a part of the study.

Other factors than readiness of in-building networks which may affect the overall readiness of offering of services to the users were also studied. This included confluence of efforts to build network inside the buildings and availability of supporting backbone infrastructure outside of the buildings. Roles and approaches of the public authorities to participate in building telecom infrastructure, which may help in improving the quality of network, its availability in a timely manner and offering of services in a competitive manner were also deliberated. Initiatives taken so far by TRAI, DoT, MoHUA, state governments were also studied.

International practices were also studied, and key approaches adopted by them to improve the connectivity are also captured as a part of these studies. Certification of professionals, availability of guidelines, and manuals in addition to technical specifications, which help in building a good quality network were also studied.

Studies included participation of TSPs and IPs. Before concluding studies, various interactions were held with town planners, builders, architects, etc. A virtual conference was also held where experts presented and deliberated on the issues. Experts from BIS, TRAI, various service providers, international experts from manufacturers such as M/s Ericsson and M/s Nokia, and from telecom regulators such as IMDA Singapore, International professional bodies who are involved in developing manuals and guidelines such as BICSI, International Experts from solution providers such as CBRE, etc., participated in the event. The joint conference by TRAI and MoHUA was organised to understand the gap between the customer's expectation and what he is served. And to discover the right approach for making the markets do what they do best.

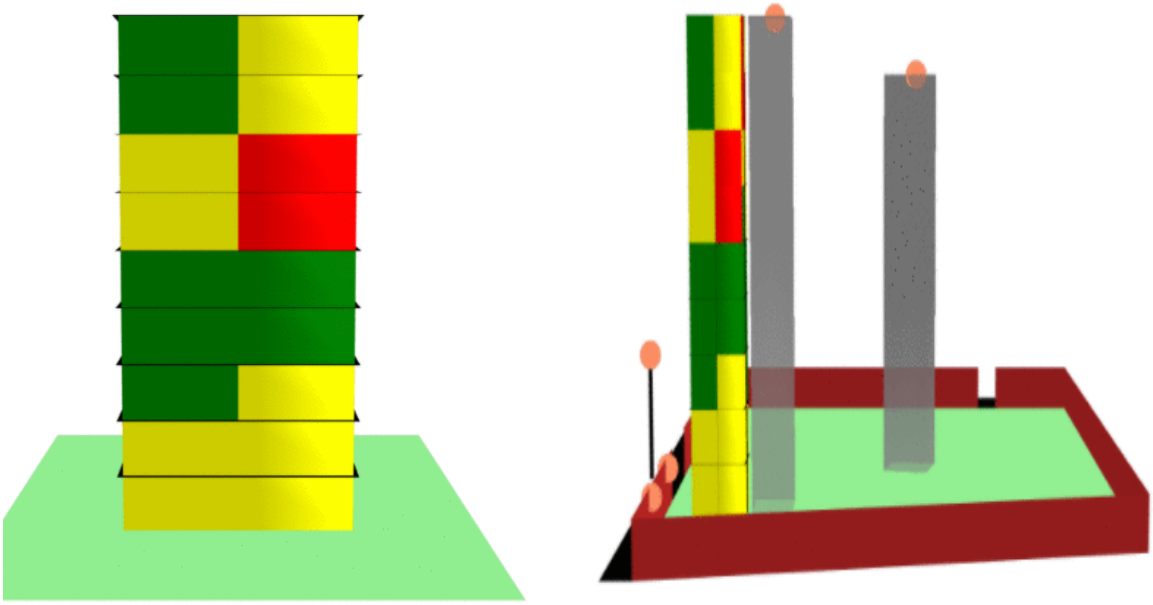
## 4.3 Analysis of the observations

### 4.3.1 Quality of Service and its measurements

TRAI has prescribed benchmarks for Quality of Service for mobile networks. The operators measure their field performance against these standards and TRAI does supervisory checks of similar nature; TRAI collects and analyses data from the network equipment (such as data about call-drops); and even collects information from the users' handsets, such as data-speed measurements through MySpeed App. There are also third-party services, like Ookla, and OpenSignal, who publish their own reports.

The information collected by TRAI is published on our website. TRAI even brought out a whitepaper in 2018 on the different methodologies in measuring data speeds, their pros and cons, and how to interpret the results.

*Figure 3: Network signal variations across floor and face of the building*



The paradoxical fact, however, is that while measurements indicate that the networks meet the carefully devised QoS benchmarks, the experience of most users from inside the buildings is still unsatisfactory!

### 4.3.2 Quality of Experience

There are many reasons why the QoE and QoS could be different:

The measurement of QoS is done outdoors at the street level, whereas the experience of the network is largely indoors.

The radio waves can penetrate walls and, therefore, we do get the mobile service inside our homes. But there is a loss of strength in the signal while going through walls or other structures.

If you have a clear line of sight to a mobile tower in your neighbourhood, you may get an experience that corresponds with the measured QoS in your area. Otherwise, you may have to hangout in the balcony where the network is usually available.

### 4.3.3 The experience during pandemic

All of us have become dependent on the mobile network, and this dependence has been greater during the pandemic.

Work from home, school from home, and even grocery shopping from home have become the new normal, all of which require a good network, whether cellular or fixed line.

Add to that Netflix, Prime Video, Spotify or WhatsApp video calls with friends. We now need a good high-speed network, not only in the balcony but in every bedroom, even when all doors and windows shut.

### 4.3.4 Good network must be designed and delivered, with the surroundings in mind

If there are powerful sodium vapour lamps in the street outside, some of that light filters through to your home.

It is so because light is electromagnetic radiation in a certain frequency range, which can pass through glass without much loss. It is the windows, as you know, that let the light in.

Radio waves used for mobile communication are also electromagnetic waves, but in a different frequency range. These waves can pass through walls too. That is why the mobile network is able to enter your home more easily than light, but it does suffer attenuation every time it goes through the walls. Therefore, it may not be good deep inside the home.

Ideally, good lighting and a good network should be designed by an expert, and the radiating elements, whether bulbs or the antenna, should be inside the building.

### 4.3.5 Indoor solutions

Most of the time we use mobile phones from within buildings. And if we are not indoors the person, we call is likely to be indoors because that's where we spend most of the time.

If 60% of the time a call happens while we are inside, only 40%x40% or 16% calls are between two persons who are both outside in the open. If we have to improve the experience for the balance 84% calls, improving indoor coverage is crucial.

Indoor solutions instead of outside-in coverage solutions are required for the network to really (1) reach a building and (2) get inside. And efforts in terms of policy initiatives, introducing provisions under building bye-laws have indeed already been made to tackle both these problems but require more initiatives to really get good quality network inside the buildings.

Ballpark figures mentioned by many solution providers to have good network inside the buildings were of the order of Rs. 20 to Rs. 50 per square feet depending upon the type of infrastructure required and the kind of quality is expected inside the apartments. This cost may come down if this work is carried out at an early stage of the building project. This cost may come further down with the scale of demand of the solutions and more availability of products, solutions, and professionals to deliver it. There are solutions to create a first-rate network indoors and they aren't so expensive as one might assume at first. But one may not be aware of what they are and where they are to be found. Solutions which are useful for a given cost may also need to be determined by the end users. Different business models may divide the responsibility to bear the cost in building these networks and maintaining it. Business models may also offer to end users to have spectrum of solutions and decide themselves which best suits them.

### 4.3.6 Right of Way

The first problem is that of the Right of Way. That is, the right to lay a cable or to install a tower. This may be through or in a municipal area, or it may be on a private property. There are rules and procedures already laid down, but these rules haven't totally solved the problem. And, therefore, we need to have fresh ideas on how to improve this situation.

When the current rules were made, the experts obviously thought that they were adequate and effective. If weaknesses in the rules or in the manner of their implementation is being felt, then it is because we have learnt what a tough issue this is. Any simple solutions may be there which would work like a magic bullet. To have a workable strategy for different situations, there is a need to have a platform where relevant stakeholders regularly meet and evolve it. Such platforms need to include local actors and devise

a mechanism to engage stakeholders right from the design level to deployment, and at subsequent stages whenever performances of the networks are not up to the mark.

Currently, TSPs approach public authorities as and when they plan to provide coverage in a particular area and for that purpose, they need permissions to install the infrastructures. Different TSPs have different plans and execute it at different point in time. The public authorities do see it as granting permissions for the requests made and charge TSPs. There is no coherent plan which reduces the cost of deployment and makes available network of different service providers in a timely manner.

The reason of this approach of public authorities seems to be recovering the cost incurred in restoration and rehabilitation from the service providers who are private parties and commercially benefits by providing services. However, it is observed that market penetration of the service providers may vary from one geography to other and business interests may also vary. Pre-planned sub-structures and super-structures required for telecom as a part of the city planning would not only help in reduction of cost of deployment of infrastructure but also make networks available in a timely manner and from all of the service providers operating in that area.

Telecom planning as a part of plan of utility infrastructure of city would change the approach from granting permissions or acceding to the demands of TSPs to offerings from the city or state authorities to TSPs to deliver a good quality network. Approach of TSPs to evaluate viability of business case to deploy network in an area considers time and cost factors viz-a-viz return in terms of increase in revenue. External factors not under the control of TSPs and from business perspective not appealing enough to invest in leads to poor quality networks. Returns from good telecom networks are not only in terms of revenue generated from the offering of voice and data services but larger benefit it provides in terms of opportunities to different stakeholders to take care of the citizens. To factor in these benefits that accrue to other stakeholders than the TSPs, it is

required to have collaborative participation of all relevant stakeholders in building of the telecom infrastructures.

For example, residential apartments with smart building infrastructures may offer efficient and effective management of the building services, taking care of senior citizens, persons with different abilities, safety and security of kids, smarter gate entry solutions, better management of operational staff, etc. Parking and street areas enabled to provide IoT services offer support to have advantages from features of next-generation vehicles. In terms of volume of the usage of data, these services may not give return on the investments made but these services create great value for the society being served through these networks. There might not be a business case in deploying a good telecom network infrastructure in the basement parking area if returns are just on the basis of the revenue generated from the increased volume of traffic from these specific areas.

In cases of public infrastructure buildings, cantonment areas, Metros, premises given to concessionaires, e.g., Airports, providing a good telecom network, and keeping it latest depends upon a number of actors other than TSPs. The entities who are controlling and managing these properties are awarding contracts to the parties selected via a competitive bid. These entities presume that the bidding process gives them maximum return, and this is the best way to provide rights to install the telecom infrastructures and commercially operate it. However, if this assumption is tested in terms of overall benefits to the users who visits these buildings, then they will fall flat. Providing exclusive rights to operate one agency leads to some kind of monopoly, prescribing practices which should be fair, non-discriminatory and transparent while charging TSPs may not act in a desired manner in the absence of arrangements which forces to correct the actions. Such entities decide who will deploy the solutions and when they will deploy it, upgrade it, and expand it without any responsibilities to act in a timely manner and maintain a good telecom network.

Instead of such entities being authorities to award the contract and grant permissions to TSPs to enter, they need to take ownership of the building

and operating a good telecom network inside the buildings, or in an area under their control. DoT may have to consider introduction of relevant provisions in the regulations for RWAs, public infrastructure managers, concessionaires, etc., to build and maintain such networks.

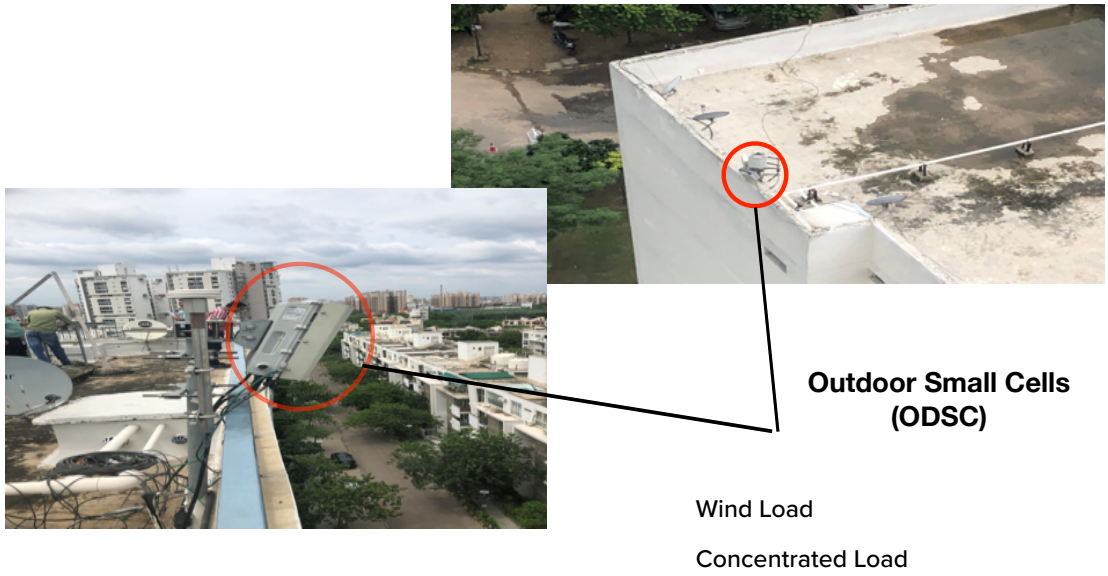
### 4.3.7 National Building Code

An attempt has also been made to solve the other problem of getting the network inside the building. For this, provisions were introduced in the National Building Code, 2016, and also provisions in the building bye-laws to enforce the NBC requirements. There is a need to understand "how things are", and then imagining "how things could be."

During studies it was revealed that many buildings studied were meeting the requirements stipulated in the NBC for enabling telecom/ICT but services were not up to the satisfaction of the residents of the buildings. For example, buildings were having enclosures, pathways, and housings for termination of the fibres, and antennas on each floor of the building, close to the entry point of the apartment were also provided but all rooms in the apartment were not having good coverage. Each Apartment was priced of multi-crore, and monthly maintenance charges were in several thousand rupees, so bearing cost to build a good telecom infrastructure was not an issue. In fact, builders have invested in building telecom infrastructure, but it has not yielded the desired results.

In another case, one of the service providers installed almost double number of outdoor small cells than the number of towers in that building area. It was expected that it would give good coverage inside the apartments. In fact, it helped to provide better coverage but not hundred percent satisfaction despite these efforts. In the basement area where cars are parked, drivers wait, operational staff is present, coverage was poor. Improvement in coverage happened for a particular TSP and not for all TSPs. Management of the apartment building was uninterested to permit other TSPs to do disruptions again to put their infrastructure, and number of antennas which would be installed would become multiple times. Good solutions did not ensure availability of network of all service providers in that building.

*Figure 4: Coverage provided using Outdoor Small Cells*




Major cause of this seems to be not validating the design and delivery of the telecom networks. Certain assumptions were made at the time of design and deployments, such as presence of wireless network at entry point of the apartment guarantees good coverage inside the apartment. Another assumption was that if high speed broadband is provided at the entry point of the apartment, flat owner or tenant can build its own network as per the requirements. Assumptions were not true as the flat owner or tenant cannot hire services from the open market for building a customized telecom network. Another assumption made is that if Wi-Fi signals are available in the entry hall or room of the apartment then the problem is solved. After introduction of voice over Wi-Fi by some of the TSPs it is assumed that voice services related issues are also resolved once Wi-Fi is there.

During studies it was found that the strength of Wi-Fi signal, despite having Wi-Fi Access Points (APs) inside the apartment varies significantly. People purchase Wi-Fi extenders, routers to get good quality signals in different rooms. Number of such extenders and their efficacy depends upon the lay

out plans of the apartments. Sometimes, such networks do not offer seamless connectivity to the users if they move within the apartment during established communication. For this, people invest in the latest meshed networked Wi-Fi solutions, which are relatively costlier. In result, people end up paying several thousands of rupees in getting a solution which does not provide mobile connectivity. Building such a network may address many concerns of the residents of the apartments but not the issues faced by the visitors or support staffs, which might not use that network.

More efficient and cost-optimal solution may be to design networks considering all these aspects at the time building is conceptualized. Design may be validated against the requirements of the end user, with the help of tools and experts. Validation may be required at multiple stages, such as after deployment of networks, when it is commissioned to offer the services, it starts handling significant amount of traffic and at regular intervals.

Current specifications in the NBC and approval process may not ensure all such aspects. One solution may not fit to all, buildings would be required to be classified for different requirements in different cases. Even different TSPs may adopt different solutions as they may be having different spectrum bands, different technologies. Keeping in mind that technologies, services, and demands of the users are changing every few years, and unlike other utilities, general compliances may not work. For specific building project, design would be specific. In view of this, technical specification part of NBC related to enabling telecom/ICT requirements may be decoupled and may be notified by DoT. However, NBC may give legal backing to get such specifications enforced. For administration of this part of code of NBC, DoT field units present in the corresponding states may be authorized. This arrangement would keep requirements abreast of latest developments in the sector and also involve experts who are better placed to handle it.

## 4.4 Outcome of studies

### 4.4.1 Code requirements for telecom/ICT in the NBC are to be linked to DoT's requirements

Building Services such as electricity or water are different from Telecom. These services have established standards that do not change much, whereas Telecom technology is always evolving. The requirement of Telecom services may be different in different households. How many connections each dwelling unit wants will be different depending on the occupants. Also, single agencies provide electricity and water, and these are government agencies. However, telecom services are provided by multiple operators and the occupants have to be in a position to exercise his choice when availing the service. The builder will need to provision the infrastructure for different TSPs, but how many TSPs are required needs to be decided. Detailed guidelines in this regard will have to be issued by the Authority/ DoT.

Detailed technical specifications for in building telecom/ICT requirements may be prepared and published by TEC unit of the DoT and it has to be updated from time to time. Buildings may be classified, and different solutions or guidelines may be suggested for different scenarios. NBC code may refer to the latest specifications published by DoT.

Platform is also required to be developed to know specific details required for designing the in-building networks such as Nos. of Operators, Nos. of Users, Types of Networks, Types of Services, Traffic Demand, etc.

As per the current practice, TSPs make a bare minimum arrangement once a demand arises from such buildings for provisioning the services. TSPs are not keen to plan a solution if number of users are less than 1000. If the responsibility of establishment of Common Telecom Infrastructure is given to the builder, CapEx investment by TSP for the solution automatically comes down. Now the builder may have to design the solution for the residents. The guidelines for setting up the same may need to be issued by the Authority/DoT.

### 4.4.2 NBC need to include specific requirements for the professionals who can carry out telecom-related tasks

Establishment and maintenance of telecom infrastructure, which has hitherto been the domain of TSP will now be the responsibility of builders,

RWAs, and local authorities. Hence, the required expertise will need to be build up in all these players. Also, the tools necessary for auditing the Quality of Service need to be suggested. This work may have to be done through guidelines/certification/empanelment by Authority/DoT.

Professionals who may carry out telecom/ ICT related works need to be certified as good design requires good understanding of the subject and tools. In previous chapter, number of certification courses are listed. India may have to develop its own requirements or adopt one out of the listed ones.

National Skill Development may consider these requirements and may like to develop requisite training courses for the same. NBC code may specify the requirements of professionals as a part of the code. Certified professionals may also be registered on a platform where their availability in specific geographical regions to hire services may also be known to other stakeholders.

### 4.4.3 DoT's units may be defined as Authority to administer part of NBC code related to telecom requirements

Approvals might be required at multiple stages, such as at the design level, which may be sought at the time of approval of Map of building project. Prediction tools together with CAD of proposed building structure may be used to confirm whether design is good, and likely to meet the requirements of end users. Capacity of the network for which it is designed for may also be checked from the network design level details.

Next approval may be required at the time of issuance of completion certificate to the project and it may be a combination of the proposed design and filed inspections. Tools need to take care of inputs which differ from the proposed design.

Further, approval may be introduced at the time of giving possession/handover to maintenance agency, and in-building network may be live to offer the services. In this case, field measurements may also be conducted to ensure availability of a good quality network.

To define responsibilities of different stakeholders and for legal backing, relevant provisions in the bye-laws would be required to be introduced.

To carry out different tasks, DoT may be required to empanel Certified Design Professionals, Certified implementation professionals, and Certified auditors. DoT may also specify the requirements of tools which may be used for making predictions and carrying out audits.

Being a technical work and requiring telecom professionals for issuance of such approvals, it would be better if DoT's field units present in corresponding states are defined as the Authority to administer this part of the code of NBC.

#### 4.4.4 City's master plan should consider planning of sub-structures and super-structures for telecom-related requirements

NBC has provision to plan space requirements for telephone exchanges and is depended upon the population of the city. After privatization of the telecom sector and introduction of mobile technologies, such planning is not being done by the city or state authorities which takes care of the telecom-related requirements.

Considering the value that a good telecom network creates and how useful it will be for the welfare of the society, there is a need to pre-plan telecom requirements in a coherent manner, and collaboratively participate in creation of the telecom infrastructure. DoT, MoHUA, City/State Governments, and other stakeholders need to work out on a plan for each city in advance and build it together.

#### 4.4.5 Policies need to cast responsibilities on RWAs, Concessionaires, public infrastructure managers or developers to build and operate good telecom network

As per the current practice, the work of laying telecom infrastructure does not normally happen along with the other utilities. The telecom infrastructure is laid once the buildings are occupied by the residents. The same is carried out by the TSPs depending on the likely revenue which they

will earn. The infrastructure laid is bare minimum, and the TSP is not interested in providing In-Building Solutions required for better mobile coverage due to high CapEx cost and without tangible increase in the revenue. The approach will have to be changed whereby the infrastructure is made ready along with the other utilities.

With no expertise available in laying the communication infrastructure, the builders currently approach the TSP. First mover TSP has the advantage of capturing the market. However, this may lead to monopoly and lack of choice for the customer.

The installation work can also be given to an Infrastructure Provider, who can then onboard the TSPs or IPs. Here also it is to be ensured that the customer should not suffer from a lack of choice. Also, the monetization by IPs has to be fair and reasonable.

It is, however, clear that to achieve the desirable Quality of Service, the essential telecom infrastructure has to be ready by the builder well before occupancy. Guidelines/Regulations may be needed to share the common telecom infrastructure created by TSP/IP.

Once the builder transfers the ownership of the dwelling unit, the general maintenance of the common infrastructure, specifically, in case of Multi-Storey Apartments, lies with the Resident Welfare Units as per Apartment Ownership Act or Housing Societies Act. The common facilities, as defined in these Acts, include central services power, light, etc. There may be a need to include the maintenance of the common telecom infrastructure by these Associations. Currently, the work associated with the maintenance of telecom infrastructure is with respect to TSP, and necessary capacity creation may have to be done for Common Telecom Infrastructure maintenance.

There are various actors other than TSPs and IPs which are required to be brought under regulations to follow the guidelines and instructions issued by DoT/TRAI from time to time to improve the connectivity inside the buildings. Such actors may be builders, architects, RWAs, maintenance

agencies for telecom infrastructure, Audit agencies for validating the implementation as per the requirements or assessing the performance from time to time. NBC and Building bye-laws need to give legal backing to have such institutional mechanisms for assuring a good telecom network.

The responsibilities for setting up and maintaining the infrastructure may include:

- Establishing a Civil, Electrical, Telecom infrastructure, which can be entrusted to the builder with his team of professionals
- Interconnecting in-building networks with TSPs' backhaul, and process of integration in a timely manner need to be defined and developed
- Operating and maintaining the system to have provisioning of new requests in a timely manner, achieving minimum performance of the networks, carrying out repair and maintenance works within stipulated timelines. This responsibility may be of the infrastructure agency/professionals appointed by the RWAs, concessionaires, public infrastructure managers.
- Upgradation and expansion of the deployed system to meet requirements introduced by new technologies, services or networks. This responsibility to perform within a stipulated time may also be of Agencies/professionals appointed by the RWAs, concessionaires, public infrastructure managers.

Due to the involvement of multiple stakeholders in providing the solution, it is necessary that each entity carries out the mandated task, which will need to be specified through contractual obligations. Bound by the Service-Level Agreements with in-building networks, TSP may also be required to meet the benchmarks for in-building networks.

Owner/Tenant and RWA (Apartment ownership Act, Society Act) need amendment whereby the common facility may include the communication infrastructure. Also, repair and maintenance of the Common Telecom Infrastructure needs to be carried out by the Society at its own cost.

Owner and Builder (Housing Act/Bye-laws) may require changes for identifying telecom as an essential service, and the necessary references to NBC for installation of the infrastructure. The bye-laws may have provisions for certifying the work carried out by the builder.

The maintenance of the telecom infrastructure may be the responsibility of the RWA for which it may take the help of an Infrastructure Provider or carry out the task on its own. However, the RWA might require an IP license in that case.

### 4.4.6 New business models to be supported for market to respond in a better way

The responsibility for Quality of Service to be provided to a resident lies solely with the Service Provider today, while the other agencies, i.e., Builder and RWAs see telecom as a monetization tool, whereby TSPs/ISPs pay to them, as there are multiple players in the market. However, the Quality of the Services, specifically, mobile coverage continues to be poor as the entire burden for providing the same is with the TSP, who is not interested in incurring huge CapEx for establishing the In-building solutions needed to provide the coverage. It is a known fact that the mobile coverage cannot be improved to desired extent merely by macro sites or Roof Top Towers. In Building Solution may need to be provided, and CapEx and Opex required for the same have to be shared between the stakeholders.

If residents of the building owns the network and pay for it, they may influence the decision at every stage of building of network, its maintenance, its upgradation or expansion. If the agency entrusted with the work to maintain a good telecom network fails to deliver at any stage, it may be changed. Business incentives need to be aligned in a manner that principals and agents work in a non-conflicting manner.

There should be an option available with the end users to get built customized network for their apartment by ordering or hiring services from the open market. This may help in offering innovative solutions by new players in the market to end users, and also enables to pay higher for having

a premium quality network. It may open up the market for more competition to provide a good quality network. However, TSPs may have to provide necessary backhaul network to get good services.

# Chapter-V

## 5 Way forward

Providing ubiquitous good quality telecom networks is a challenge. People have started demanding more from their networks (more bandwidth, greater reliability, lower latency, etc.) because we are dependent on it for work, education, entertainment, shopping, and access to services. This was experienced especially acutely during the ongoing pandemic. Even when the immediate threats posed by the COVID-19 pandemic gets subsided; networks of all types will need to keep up with the growing demand of telecom inside the buildings.

*Initiatives required to deliver good quality networks*

Current specifications of NBC provide certain details about telecom requirements along with associated civil and electrical requirements. Building bye-laws give it a legal backing. RoW policies are ways to resolve issues in getting permissions to install infrastructure in public and private spaces. Whether the current provisions of NBC, Building Bye-Laws and RoW policies will be good enough to address all issues related to good quality network? These were examined as a part of the case studies undertaken by TRAI. Study reveals that to have quality of experience up to the satisfaction of residents, more initiatives are required in the functioning of the market; as the way returns from a good network are seen by the stakeholders as an opportunity to demand fees and charges for permitting creation of such infrastructures.

While technology has evolved rapidly to meet these requirements, operators struggle to provide the connectivity as per their customers need, even when the capacity and willingness to pay for it are not in question. We need to identify and remove the obstacles for the market to respond to it and solve it for the benefit of the customers. Wherever required, processes are to be institutionalized and backed by regulatory provisions.

*Engage with end users and empower them to influence the decisions*

Customers are to be empowered to play an important role in influencing and deciding the shape and form of a good quality network being built to serve them. Customer as an individual needs to be given an option to get customized or premium type of network build for themselves. In case networks built for the residential apartment buildings or enterprise buildings are not being managed well then customers must have mechanisms to set it right. Business models with incentives, aligned in a manner, which encourage installation, operation, and management of a good quality network need to get evolved.

*Value lies in co-designing and co-creation of the networks*

Authorities and entities used to grant permissions or rights to TSPs to install telecom infrastructures have to appreciate the value a good network brings in by improving operational efficiencies and offering innovative ways to improve the quality of life of the citizens. They need to become collaborative partners to build the network, and reap benefits from it rather than taxing it. All relevant stakeholders have to co-design and co-create telecom networks inside the buildings.

*Coherence in planning of networks inside the building with the TSPs' backhaul*

Telecom authorities need to play a key role in assuring that a good quality network is available inside the building as envisaged at the design and deployment level. Such authorities need to create mechanisms that assure that inside the building network is plugged with appropriate backhaul connectivity from all TSPs present in that area. The alignment is not only in terms of technical match of the components but also in terms of time when services should be available.

## 5.1 Building a good network requires collaborative partnerships

### *5.1.1 Confluence and congruency of efforts to build the network*

It's apparent that building a network inside buildings is a complex, multi-dimensional problem can be effectively resolved only by a coordinated effort between a multitude of agencies such as TSPs, Infrastructure Providers, Real-Estate Developers, RWAs, Authorities granting permissions or

facilitating utility infrastructures. This collaborative engagement at early stage of the building project would enable co-designing and co-creation of the networks. On the other hand, if engagement happens at a later stage, which is commonly observed, imposes many constraints on the design aspect of the network, which would not have been there in case of planning at an earlier stage.

### *5.1.2 Pre-planned design and early stage involvement of stakeholders delivers good quality network*

In wireless networks, compromise in the placement of antennas by a few meters leads to compromise in the quality of the service experienced by the residents. Such compromises are taken for granted by the TSPs and builders on the reasoning that the best has been done while the same is not true. Constraints imposed on designing networks might be in terms of availability of technical supporting infrastructure at a particular point, or it may be from an aesthetic or safety perspective, or there may be a cost or disruption factor that may matter to the authority granting permissions.

### *5.1.3 Platform may help in collaboration and symbiotic relationship*

For early engagement of relevant stakeholders, a platform to interact and orchestrate the processes to deliver a good quality network at an appropriate time may be helpful. Such platforms may offer city or area specific coordination as local actors would have a key role to get it realized. However, reusability of the platform components and access to common repository, which is the same for larger area, may help in better management of the platform. This kind of platform may be developed by TSPs as they are very few in numbers while real-estate developers may be many and might vary from area to area. DoT together with the city governments can supervise and facilitate to bring up this platform. This platform should provide at least the following facilities:

- Marketplace where Real-Estate Developers can meet with telecom solution providers and certified professionals to get telecom network designed and deployed.

- Registration of Real-Estate Developers with facility to update project specific details
- Registration of solution providers and professionals, who can help real estate developers to get telecom/ ICT work designed and deployed
- Repository of details of the service providers along with technologies and spectrum bands, who are offering services in the area, and also providing details of prospective technologies and spectrum bands, which are being actively considered by the DoT in the coming few years
- Repository of Building related information, CAD files along with relevant details required to design the wireless networks and convey back to real-estate developers to consider as part of their building design
- Processes to orchestrate among stakeholders from start of the engagement process, then navigate through the requirements at the subsequent stages of the building project to deliver a good quality network

In USA[8], Standards' organizations like Building Industry Consulting Service International (BICSI) and Underwriters Laboratories (UL) require standards to be observed. For public safety, the local jurisdictions specify and enforce the communications infrastructure required in buildings. In-building communications (IBC) certifications include WiredScore, TIA (coming in the Fall as part of a Smart Buildings Certification), and the Smart Buildings Alliance program.

## 5.2 Prospective and existing users need to be kept in loop while building the network

### 5.2.1 Capacity creation needs context specific and reasonable values

To design a good network, requirements of coverage, capacity, and quality of service are the key inputs. Usually, TSPs, or Solution providers, or

[8] As per the inputs provided by M/s Limor Schafman, Keystone Tech Group via email in response to the discussions held with them on the subject

builders takes a call on what are these requirements, and on the basis of their experiences and assumptions they build the network. Prospective or existing users are offered services from the network they have built. If services are not satisfactory, than the usual argument that is given is that in wireless environment nothing is guaranteed. Concentration ratios at various aggregation points are also based on certain assumptions, which may go wrong in a particular context for which it was designed.

### 5.2.2 Business models in which customer can pay and get customized network built

When discussions are held to build a network which guarantees good quality network in every apartment or part of the building, and every nook and corner of an apartment, then the usual defense provided is cost-optimal design and returns on investment, in a case of residential apartment, justifies not only the planning coverage of hundred percent and also ensures excellent signal strength everywhere. If argument continues that the customer is willing to pay and bear that cost, then why such a high availability and reliable networks should not be built then it is countered with the argument that such business models are not prevalent in India.

To appropriately assess the requirements of network coverage, capacity, and quality in a given building, inputs are required from the prospective and existing users of the area. Formal ways need to be formulated to capture such requirements and give adequate opportunities to such users to participate in the process. One way might be to convey their requirements as a part of the services offered along with the offering of dwelling units. Other way might be to offer services with basic minimum configurations, and also options to have premium networks. Another way may be to have options available with the customers to get a customized network, or premium quality network built for them from the professional services available in open market. Operation of wireless networks might require authorization to radiate license spectrum and for that purpose, building a network, and operationalization might be required to be delinked.

Below is a synopsis[9] of the "State of In-building business models" in USA that are in place to improve In-Building Connectivity (IBC) and that are beyond the traditional MNO single and shared IBC solution approach with their enterprise customers.

Large Neutral Host (NH) operators such as Boingo, ExteNet, and Mobilite, have historically focused on larger venues that all MNO seek to enhance in building network performance but are best suited to do so via a 3rd party operator (3PO). The 3PO is also preferred by venue owner for two primary reasons 1) One vendor to manage design, procurement, deployment, and operations under a SLA (typically limited to availability) under a long-term agreement, typically 10+ years), and 2) Revenue share (typically 10%–15%) provided by Neutral Host as a percentage of what the NH receives from monthly lease and management fees from the MNOs. CapEx funding can include primarily MNO supplemented by venue owners and also funded by NH, especially those that have access to capital markets. The classic example is Boingo, the first NH in USA to launch business focused on airports 15 years ago.

The recent Boingo investor presentation is a public document[10]. It describes how a mature NH has built its business initially focused on venue MNO, which was considered critical, and then to leverage the building owner or enterprise relationship, add value beyond those funded by MNOs was provided.

The presentation also mentions the different levels of penetration and addressable market for venues (airports, Stadiums, and Arenas) and the targeted industry segments Hospitals, Universities, Hospitality, etc. This may give an idea about how DAS and Small Cell solutions are to be targeted, and how much is still in play, "seeking a solution" in the USA. Over the last 5 years, Boingo has focused on Multi-family, Student Housing, and Military bases. The Multi-Family and Student Living markets have grown by

[9] As per inputs provided by M/s Limor Schafman, Keystone Tech Group via email in response to the discussions held with them on the subject

[10] August-2020-Boingo-IR-Deck_vFinal.pdf

acquiring small operators, who are focused on specific segments and geographic areas.

ExteNet Systems is expanding its business model to cover the traditional IBC use-cases but is extending the value proposition to essentially lease (long term 10+ years) from the building owner the “right of way” of the riser closets, and manage the Meet Me Rooms that offers broadband providers as a single point of contact to gain access to building and it’s tenants.

The above-mentioned Neutral Hosts make IBC their core business model.

TowerCos also offers NH solutions for IBC. They view this as an extension of their tower business, and the fiber networks they have built and/or acquired to support MNO backhaul.

Crown Castle, American Towers, and Vertical Bridge are clear leaders in TowerCo business in USA that offer NH IBC offerings to venue owners and enterprises. These TowerCos are looking to extend their last mile infrastructure indoors and outdoors to help drive the demand for edge data centers, which then can leverage their on-premise and metro fiber networks.

Vertical Bridge and ExteNet share a common ownership.

Entities are focused to deliver in-building IP connectivity (non-MNO) as a managed service but provided if it is a service tied back to their proprietary solution. These smaller entities are targeting multi-family residential and multi-use (retail, office, hospitality, and residential) complexes. Their value is to simplify the provisioning of connectivity for the venue owners and enable the venue owners to bundle the services provided as part of their monthly billing to their residents and tenants. This ubiquitous coverage and adequate capacity provided via an SLA through the venue owner operator via wireless services delivered as Wi-Fi, LPWAN, and IPTV solutions has helped the traditional MNO and broadband providers to not focus on these marginal venue types.

Examples of these type of managed service provides are as follows:

https://redbison.us/

https://www.gigamonster.net/

Adding MNO as well as private LTE or IoT focused solutions to enhance in-building connectivity is also delivered as a managed service by companies such as:

https://connectivitywireless.com/services/neutralconnect/

Customer Owned and MNO Managed Enterprise RAN programs are offered by large MNOs in USA to enable a broader IBC, which is more focused at private (SME) and public enterprises (local and state governments) market segments. The Tier-1 MNOs over the last 2 years introduced this program to improve the MNO connectivity in building without their need to fund the CapEX and manage the programs through activation. The MNO's willingness to enable non-MNO owned RAN infrastructure to access their core network is unheard of historically and is a breakthrough to enable IBC to scale.

The key aspects of this newly launched program are as follows:

1) Enterprise funds and owns IBC solution includes the traditionally owned and provisioned RAN infrastructure. But the solution must be purchased from MNO approved vendors such as Nokia, Corning, and Ericsson as typical examples).

2) The IBC solution must be designed (with MNO approval) as well as installed and tested by an MNO approved System Integrator (SI).

3) If 1) and 2) are met, the MNO will enable the enterprise to connect the RAN directly to their core network via an enterprise provisioned internet backhaul circuit.

4) MNO will complete 911 call testing, support SI to activate RAN to provide signal to DAS network, review and store the close out package and provide network monitoring trouble shooting.

5) Enterprise is responsible for hardware fixes to RAN.

The above approach enables MNOs and enterprises to jointly improve the IBC mobile network performance and at a scale. The enterprises' willingness

to fund CapEx and procure infrastructure creates opportunity for more IBC deployments is no longer limited to annual MNO budgets. The MNO's willingness to take on performance monitoring and troubleshooting roles reduces enterprise risks to negative outcomes as they typically lack mobile network domain knowledge and Network Ops Centers that can manage the RAN infrastructure, which is a core competency of MNOs.

### 5.2.3 Engagement and involvement of users in decision making process helps to develop good network meeting the requirements

Current NBC specifications suggests one fiber per apartment, while other countries have proposed to have 4 fibers for each apartment. But how many are good enough, and what type of fiber infrastructure would appropriately meet the requirements may be project and user specific. In fact, actual requirement of a user is quality of experience and not the particular number of fibers or a particular type of fiber. Users would be willing to see that services are delivered to meet their expectations. In summary, users need to be kept in loop from beginning of the project when they convey their requirements to the point of time when services start getting delivered.

In a telecom world that continues to become more and more dynamic, the consequences of poor implementation choices will become increasingly severe. With participation and involvement of the end users and their representatives in some aspect of the design, and implementation of the in-building networks and listening to their advices may lead to their commitment, not merely compliance.

### 5.2.4 Congruence of networks at juncture point of inbuilding and backhaul required to have good quality

Capacity and quality of service requirements cannot be fulfilled by just building a good network inside the building, but it requires adequate capacity and reliability of backhaul networks. TSPs need to keep backhaul network ready to meet the requirements of a building or cluster of building. Requirements may vary from TSP to TSP, and same would be required to be estimated in advance.

### 5.2.5 Sub-structure and super-structure planning for telecom need to be part of

#### City planning

Backhaul network requires laying of underground and overground telecom infrastructure by the TSPs. Currently, it is governed under RoW policies under which TSPs have to approach authorities to provide permissions and pay requisite fees or charges. A number of initiatives are taken to make process simple, reasonable, fair, and non-discriminatory. However, every TSP plans as per its own plan and timelines. Proactive plans to design civil, electrical support infrastructure and requisite spaces at suitable places while drawing the master plan of the city may be very helpful to connect to the networks of the buildings.

Sometimes, optimal network designs may suggest having common connectivity terminations for a group or a cluster of buildings instead of having dedicated arrangements for every individual building. However, such initiatives are likely to see demand of compensation by the property owner whose space is being used to serve the neighborhood. City master plan with provisions of common space to cater to the requirements of telecom/ ICT could avoid such situations.

### 5.2.6 Value creation by a good quality network to improve quality of citizen's life is the return to the city or state

A good telecom connectivity is helpful for any city or state governments to offer citizen-centric services in a more effective and efficient ways. In this way, it reduces the public expenditure incurred in offering such services. Better health facilities, efficient transport facilities, safe travels, energy efficient solutions, etc., are enabled by a good telecom network. The value created by a good telecom network cannot be comparable with the revenue earned by charging TSPs and having a sub-optimal network. The Authorities, builders, maintenance agencies, cantonment area managers, concessionaires of public infrastructures, etc., need to see the value telecom brings in, and invest in building this value for the citizens rather than considering it as a direct source of revenue from TSPs.

## 5.3 Assurance of a good quality network requires validation

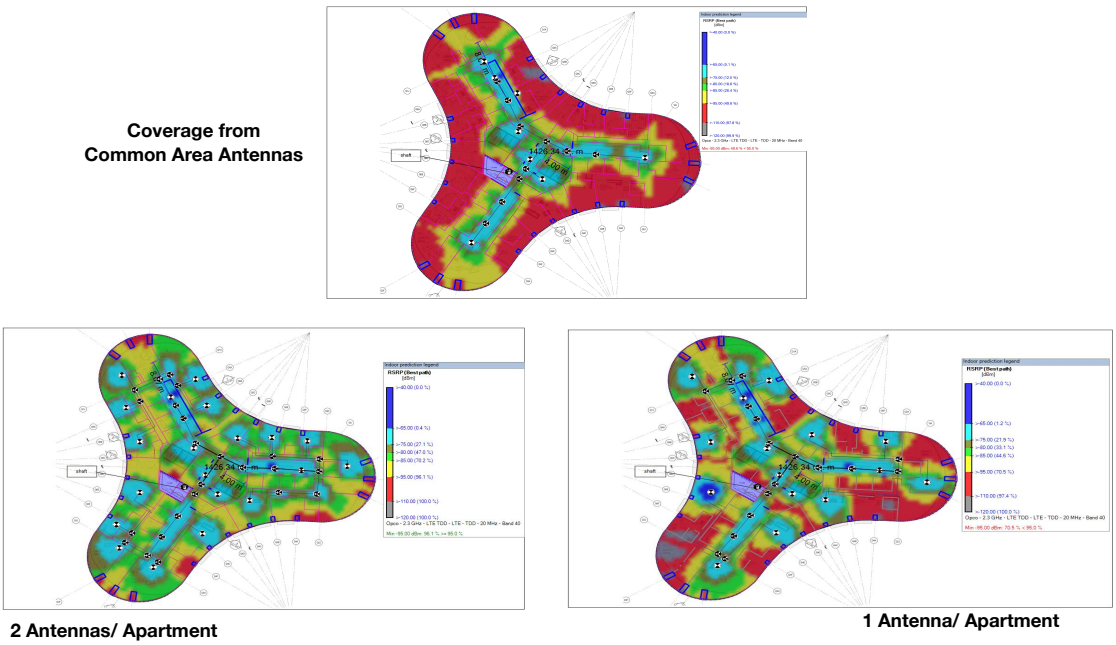
### 5.3.1 Design are project specific and need to assess the end effect of the design

Consideration of the requirements of the end users while designing the network may indicate that network being built would satisfy them. However, assurance of a good quality network may require validation of the claims at various stages. Current NBC specifications and building bye-laws may require certain approvals of the designated authorities to confirm meeting the specified requirements.

### 5.3.2 It is not only last mile but also last feet which impacts quality of experience

Case studies revealed that the installation of multiple antennas on each floor of the residential apartment has not assured good network in all the rooms of the apartments on that floor. As far as prescribed specifications to lay out the telecom infrastructure are concerned, all are met, but it has not satisfied the end users. This has happened on two accounts; one is where and how many antennas are to be put, and second is the assumption that the designed network would fulfill the requirements.

*Figure 5: Quality of Coverage inside apartments depending upon number of antennas*




Studies also reveal that just presence of high-speed internet at the doorstep of the apartments would not assure good quality inside. It is presumed in

most of the cases, that end users would manage the apartment-specific requirements. By installation of Wi-Fi access points inside the apartments it is expected that it will illuminate the entire apartment. It may be noted that Wi-Fi network private access points do not solve network availability issues of visitors to the building, and of a resident for other parts of the building. It has been found that without entering inside the apartments and putting antenna infrastructure over sufficient number of places, e.g., 2 antennas for the size of an apartment of 2500 sq. feet may be required. Actual requirements may vary on the basis of layout of the apartment, constriction material, location of antenna, etc. It may require individual apartment to be considered at the design level and make adequate provisions to make it ready for a good network.

### 5.3.3 Design are not only project specific but also may be different for different apartments

For most of the requirements, NBC specifications are suggestive and advisory, and wherever requirements are hard coded, it takes away the flexibility to change the requirements in context of latest developments in the technology domain. For example, rooms with specific dimensions and in specific numbers for the purpose of telecom infrastructure may not well fit in the requirements to accommodate the different needs of the equipment of different service providers. Prescriptive approach may ensure compliance but not best fit and cost-optimal solutions.

### 5.3.4 Digital information exchange and modelling may help in better assessment

Telecom infrastructure design considerations may vary with the type or class of buildings, compliance to general principle applicable to all may not assure desired quality. Currently, there is no mechanism to validate the design of the network against the requirements. Telecom, especially wireless networks, have complicated characteristics to be considered for validating the claims, in-building infrastructures adds to this complexity. In addition to domain experts, there would be requirement to use professional tools that simulates the environment and predicts the quality of services. Such tools may require building related information in digital forms and with adequate

details about the kind of structure, characteristics of materials impacting propagation of the radio waves.

#### 5.3.5 Define DoT as the Authority to administer part of NBC code related to telecom/ ICT requirements

NBC has provisions to define the Authority for administration of part of the code; considering the technical expertise required to validate the claims, it is recommended that NBC part of the code Telecom/ICT enabling requirements may be administered by DoT's field units present the at state level. Requirements for different classes or types of the buildings may be dealt by DoT's standardization and policy making units such as TEC or NTIPRIT. Legal backing to such specifications for getting it implemented by real-estate developers may be provided by NBC, and corresponding building by bye-laws. Such delinking of technical specifications from NBC would help to keep the pace with changes in technologies, services, and new spectrum bands used to deliver the services.

#### 5.3.6 Designing of radio networks to consider non-telecom aspects

Designing of networks need to consider various spectrum bands, advanced antenna systems, technology aspects, and service aspects. Once radio networks are designed by the solution provider, same is conveyed back to the builder for making relevant civil and electrical support infrastructures. Mounting and housing infrastructure required for antennas also need to be communicated for having requisite provisions for readiness. Electrical infrastructure which can account for energy consumptions of individual telecom components, may help in the introduction of energy-saving solutions. Aesthetic aspects in terms of protruding antennas, color, and quality of exteriors of antenna blended with facets of the building may reduce friction encountered during the installation of antennas. To address aesthetic aspects, more specific information may be required to be exchanged considered among builder and telecom solution providers.

### 5.4 Agents should respond in the interests of the Principals

#### 5.4.1 Bidding process to award the contract does not serve the interests of the end

users

Resident Welfare Associations (RWAs) or entities controlling and managing the property supposedly represents the interests of the residents or users of that premises. Such agents act on behalf of the principals and may be paid for this. Currently, TSPs are charging from the end users for the services they are offering. TSPs are paying RWAs or agencies who have built the inbuilding network or maintaining it. Discovery of charges to be paid are either determined in a unilateral manner or discovered through a bidding process where the highest bidder is awarded the contract.

### 5.4.2 Poor quality network may cost more than a good quality network without any direct revenue to the Authorities

It is presumed by RWAs or property managers that they are acting in the interests of their residents or building or premises' users, while in fact, it may be just the opposite of it. Higher charges or cost translates into a quality compromised network. For poor quality, one may accuse TSPs but real reasons behind it may be the processes adopted to award the contract. Poor quality network is an indirect cost to the users in terms of poor work efficiencies and inefficient operations and management of the services offered through telecom networks.

RWAs and property or premises managers need to see the bigger picture, and appreciate the value good telecom networks brings in. Rather such entities need to make confluence of forces that would deliver a good network and make them congruent in terms of applications and actions.

### 5.4.3 In-building operators may lose opportunity to continue in case not performing

Studies have revealed that building a good network and assigning work to a good agency may not ensure that it will remain a good network in its lifetime. Agencies having a good technical expertise and financial background may go bad over a period of time, and it may be due to a number of reasons. If such entities own the in-building network, and runs into financial crisis then it leads to the transition of good network into a poor network. Reasons may be the reduction in operational and maintenance

staff, impact on the investments required from time to time for upgradation and expansion of the deployed networks. Key issue becomes how to transfer the ownership or foreclosure of contracts. Currently, award of contracts and ownership of in-building networks do not take care of such situations. What may be required is to have ownership in the hands of end users in a similar way a co-operative arrangement works in other sectors. Performance requirements might be required to be defined at a building level and need monitoring on a regular basis.

### 5.4.4 Rating of buildings on their telecom's performance may encourage competition among buildings

Baseline performance requirements may be part of the contracts. To continually improve the performance of networks, building may be rated on the basis of quality of experience and information may be available in public. Such assessments may be combination of field measurements, surveys from the users of that building or premises. Surveys may be exhaustive and created for participation of the users to provide detailed feedback of experience specific to their apartments, parking areas, and common areas. Presentation of building with 3D visuals and only relevant part of the buildings for a particular resident or building user may help in getting more appropriate and quality feedback.

### 5.4.5 Regulatory provisions needed for RWAs to maintain a good quality network

RWAs or property/premises managers might resist change if they think they will lose something of value as a result. In such cases, because agents or representative of residents tend to focus on their own best interests and not on those of the residents, resistance often might result in confllict. Political behavior sometimes emerges before and during change efforts when what is in the best interests of one individual or group is not in the best interests of the representatives of the end users. To deal with such situations in a timely manner and in the interests of end users, DoT may have to modify Telegraph act to cast responsibilities on RWAs, and also modify necessary changes in the Registration of the Societies Act to introduce relevant

provisions to address issues when RWAs fail to deliver responsibilities related to in-building telecom networks.

### 5.4.6 Regulatory provisions needed for the concessionaires and public property managers to maintain a good quality network

Similarly, a company which is given the right to operate a specific premise within a government's jurisdiction should be subjected to particular terms related to keeping building ready with in-building telecom networks and upgrading or expanding it from time to time. Such provisions are to be monitored in an institutional manner, and concessionaires need to honour the instructions issued in this regard within a stipulated time frame otherwise liable to consequences. Studies revealed that concessionaires are not taking interests to keep their building equipped with the latest technologies and upgrade with the telecom requirements of the users in a timely manner. There is a need to cast specific responsibilities on such concessionaires to design, develop, upgrade, and expand good quality networks from time to time. DoT's field units may keep watch and conduct meetings at regular intervals to ensure that buildings continue to evolve to serve the telecom requirements.

Public departments and companies such as CPWD, NBCC, etc., dealing with government-related building infrastructures may also be required to get their in-building networks designed as per the requirements of the end users. Such agencies also need to be subjected to validation of their claims of meeting the requirements as per the laid-out processes. Entities responsible for managing the Government buildings should also be responsible for keeping inside building network upgraded and get it expanded from time to time meet the requirements.

There is an immediate need for resident building property managers such as RWAs, public property managers such as Airport authorities, CPWD, NBCC, city governments, state governments, and concessionaires such as GMR, to own the responsibility of building a good quality network and keep it up to date to meet the requirements of the end users.

## 5.5 Bidding process to award the contract of building or maintenance

### of telecom networks may result in poorer services

During studies it was revealed that most of the entities who have to select the agency for building the network or maintaining it are inviting competitive bids. The highest bidder is chosen to award the work. This agency, in turn, charges TSPs to get connected with their networks. This creates monopoly for providing services in that building or area. Depending upon the importance of area, TSPs may or may not be willing to pay the charges demanded by these entities. There are provisions to have fair, non-discriminatory, and transparency during this process, but it is difficult to enforce it in a monopolistic environment where corrective forces are absent.

Bidding process is presumed to discover competitive price in granting permissions, or rights to a particular agency, but it may defeat the very purpose for which it was awarded. One may continue to blame TSPs for providing poor services in that area but, in fact, they may be not responsible for this. Poor quality network may introduce inefficiencies in the operations of the systems who have awarded the contract or loose the opportunity to take benefits of latest technologies, which improves efficiencies or offers new innovative services.

There is a need to make fundamental changes in assigning roles and responsibilities for the in-building networks. Entities who are property managers should be responsible to build a good quality telecom network. The cost borne on this part may be distributed or recovered from the relevant stakeholders. These entities should also be responsible to upgrade and expand the telecom systems to meet the requirements of the end users.

This would change the current interaction level among stakeholders; as of now, it is interaction between commercial space selling units and business units eyeing the opportunity to monetize from the exclusive rights. If entities, ask bids to construct the best quality network at lowest price and recovers this cost from others then the dynamics of the market changes. If these entities also consider opportunities to take advantage of these networks for their own purposes, then they start co-designing and co-creating the networks.

For example, smarter management in the pickup area for passengers saves cost for the property managers. During long-haul train journeys, good telecom network may improve efficiency in ordering foods, offering entertainment facilities, booking cab services in advance and in a time aligned with the arrival of the train. Airports can introduce autonomous vehicles in the premises, baggage management systems using technologies which are interoperable and do not result into vendor lock-ins. Good telecom network well integrated with the other stakeholders' system may offer personified experiences to the passengers without the requirements to install a number of apps specific for one purpose.

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## List of Acronyms or Abbreviations

| S. N. | Acronym/ Abbreviation | Description |
|---|---|---|
| 1 | 2G | 2nd Generation |
| 2 | 3D | 3-Dimension |
| 3 | 3G | 3rd Generation |
| 4 | 4G | 4th Generation |
| 5 | 5G | 5th Generation |
| 6 | ACMA | Australian Communications and Media Authority |
| 7 | ACRS | Australian Cabler Registrar Services |
| 8 | ANSI | American National Standards Institute |
| 9 | AP | Access Points |
| 10 | ASIAL | Australian Security Industry Association Limited |
| 11 | BCP | best current practices |
| 12 | BICSI | Building Industry Consulting Service International |
| 13 | BICSI CO-OSP | BICSI Customer-Owned Outside Plant Design Manual |
| 14 | BICSI TCIM | BICSI Telecommunications Cabling Installation Manual |
| 15 | BICSI TDMM | BICSI Telecommunications Distribution Methods Manual |
| 16 | BIM | Building Information Modelling |

| | | |
|---|---|---|
| 17 | BIS | Bureau of Indian Standards |
| 18 | BRCA | BICSI Registered Cablers Australia Pty. Limited |
| 19 | CAD | Computer Aided Desgin |
| 20 | CapEx | Capital Expenditure |
| 21 | CAT 6 | Category 6 |
| 22 | CBRE | Coldwell Banker Richard Ellis |
| 23 | CCTV | Closed-circuit television |
| 24 | CIPTS | Certified IP Telecom Network Specialist |
| 25 | CoMP | coordinated multipoint |
| 26 | CoP | Code of Practice |
| 27 | COPIF | Code of Practice for Info. communication Facilities |
| 28 | CORENET | COnstruction and Real Estate NETwork |
| 29 | COVID-19 | novel coronavirus disease of 2019 |
| 30 | CPR | Cabling provider rules |
| 31 | CPRI | Common Public Radio Interface |
| 32 | CPWD | Central Public Works Department |
| 33 | CTA | Certified Telecommunications Analyst |
| 34 | CTI | Common Telecom Infrastructure |
| 35 | CTNS | Certified Telecommunications Network Specialist |
| 36 | CWA | Certified Wireless Analyst |

| | | |
|---|---|---|
| 37 | DAS | Distributed Antenna System |
| 38 | dB | Deci Bel |
| 39 | DCDC | Data Center Design Consultant |
| 40 | DCR | Drop Call Rate |
| 41 | DoD | Department of Defense |
| 42 | DoT | Department of Telecommunication |
| 43 | EIA | Electronic Industries Alliance |
| 44 | FAR | Floor Area Ratio |
| 45 | FCC | Federal Communications Commission |
| 46 | FD | Financial Disincentives |
| 47 | FPA | Fire Protection Association |
| 48 | GBT | Ground-Based Towers |
| 49 | GMR | GMR Group |
| 50 | HFC | Hybrid Fibre Coaxial |
| 51 | HQ | Head Quarter |
| 52 | IBS | Indoor Building Solution |
| 53 | ICT | Information and Communications Technologies |
| 54 | IDT | Independent Drive Tests |
| 55 | IMDA | Infocomm Media Development Authority |
| 56 | iNARTE | International Association for Radio, Telecommunications, and Electromagnetics |

| | | |
|---|---|---|
| 57 | INST1 | Installer 1 |
| 58 | INSTC | Installer 2, Copper |
| 59 | INSTF | Installer 2, Optical Fiber |
| 60 | IoT | Internet of Things |
| 61 | IP | Internet protocol |
| 62 | IPEP | Internet Protocol Engineering Professional |
| 63 | IS | India Standard |
| 64 | ISI | Indian Standards Institution |
| 65 | IT | Information Technology |
| 66 | ITA | Indian Telegraph Act |
| 67 | ITS | information of transport systems |
| 68 | ITU | International Telecommunication Union |
| 69 | IVRS | Interactive Voice Response System |
| 70 | KPI | Key Performance Indicators |
| 71 | LAN | Local Area Network |
| 72 | LDCA | Long Distance Charging Area |
| 73 | LSA | License Service Area |
| 74 | LTE | Long Term Evolution |
| 75 | MI | Master Installer |
| 76 | MIMO | Multiple Input Multiple Output |

| | | |
|---|---|---|
| 77 | MoHUA | Ministry of Housing and Urban Affairs |
| 78 | MT | Master Technician |
| 79 | MTC | Master Technician, Customer Premises |
| 80 | MTH | Master Technician, HFC Networks |
| 81 | MTNL | Mahanagar Telephone Nigam Limited |
| 82 | NBC | National Building Code |
| 83 | NBCC | National Buildings Construction Corporation Limited |
| 84 | NCTI | National Center for Technology Innovation |
| 85 | NTIPRIT | National Telecommunications Institute for Policy Research Innovation and Training |
| 86 | OADT | Operator Assisted Drive Tests |
| 87 | OFCA | Office of the Communications Authority |
| 88 | Opex | Operation Expenditure |
| 89 | OSP | Outside Plant Designer |
| 90 | PMR | Performance Monitoring Reports |
| 91 | PSU | Public Sector Undertaking |
| 92 | QoE | Quality of Experience |
| 93 | QoS | Quality of Service |
| 94 | RCDD | Registered Communications Distribution Designer |
| 95 | RF | Radio Frequency |

| | | |
|---|---|---|
| 96 | RJ 45 | Registered Jack 45 |
| 97 | RoW | Right of Way |
| 98 | RSU | Remote subscriber unit |
| 99 | RTOs | Registered Training Ogranisations |
| 100 | RTPM | Registered Telecommunications Project Manager |
| 101 | RTT | Roof Top Towers |
| 102 | RWA | Resident Welfare Association |
| 103 | SCTE | Society of Cable Telecommunications Engineers |
| 104 | SMT | Senior Master Technician |
| 105 | SSA | Secondary Switching Area |
| 106 | TAIPA | Towers and Infrastructure Providers Association |
| 107 | TCO | Telecommunications Certification Organization |
| 108 | TEC | Telecom Engineering Center |
| 109 | TECH | Technician |
| 110 | TFCC | Telecommunication Facility Coordination Committee |
| 111 | TIA | Telecommunications Industry Association |
| 112 | TIP | Telecom Infrastructure Policy |
| 113 | TITAB | Telecommunications Industry Training Advisory Board Australia Cabler Registry Services |
| 114 | TOP | Temporary Occupation Permit |

| | | |
|---|---|---|
| 115 | TRAI | Telecom Regulatory Authority of India |
| 116 | TSP | Telecom Service Provider |
| 117 | USA | United States of America |
| 118 | UT | Union Territory |
| 119 | WAN | Wide Area Network |
| 120 | X2 | X2 protocol |