# Smart Cities in India: Framework for ICT Infrastructure

ICT

IoT

Smart City

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# TELECOM REGULATORY AUTHORITY OF INDIA

## A White Paper on

## Smart Cities in India:
## Framework for ICT Infrastructure

New Delhi, India

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# PREFACE

The telecom sector is one of the most dynamic sectors of the economy. With the advent of new technologies and technological advancements, things keep on changing, and to be more precise, they keep on getting better, may it be the consumer experience, spectrum utilization, development of new services, etc. The telecom sector has grown rapidly in the past two decades and has brought with it many innovations in other allied sectors of the economy as a whole.

India is witnessing a wave of migration from the rural to urban areas. Therefore, comprehensive development of physical, institutional, social, and economic infrastructure is the need of the hour. All these developments are important in improving the quality of life and attracting people and investments to the city, setting in motion a sustainable cycle of growth and development.

In order to manage the ever-increasing population in the cities, it is important that infrastructure in the cities are upgraded and managed by using Information and Communication Technologies (ICT) to make them sustainable in the long run. That is the context of this White Paper.

The White Paper highlights the Role of digital technologies for smart cities, discusses the key smart solutions, deliberates the need of Global Standardization and connectivity related aspects specific to smart cities, and tries to identify the framework for ICT Infrastructure for the success of Smart Cities Mission in India.

I am sure that this White Paper will open the gates for the industry and the technocrats to kindle their thought process and bring about transformation through identification of key enablers in order to accelerate the development of Smart Cities in India.

**(R. S. Sharma)**
**CHAIRMAN, TRAI**

New Delhi
Date:  22nd September 2020

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# CHAPTER 1
## BACKGROUND

1.1    Rapid urbanization over the past two decades has led to the mushrooming of megacities (accepted as those with a population in excess of ten million) around the world. The sheer size and scale of these cities place huge pressure on infrastructure development, public services provision, and environmental sustainability. If we add economic, social, and ethnic stratification, as well as health, safety, and security risks to the list of challenges, the task facing the leader of any megacity seems overwhelming and is certainly one that cannot be solved by technology alone.

1.2    As the global population continues to grow at a steady pace, more and more people are moving to cities every day. As per World Health Organization report[1] the urban population in 2018 accounted for 55.2% of the total global population, up from 34% in 1960, and continues to grow.

1.3    Cities have historically been the centers of economic power of a nation and the megacities of today continue with this trend, becoming economic powerhouses, both at a national and international level, primarily due to the economies of scale that they command. These megacities are able to attract foreign investment, global businesses, and top-notch talent from around the world. Ultimately, the virtuous cycle of prosperity and progress leads to microeconomic resilience and improves the ability of the megacity to cope with, recover from, and reconstruct itself after external and internal shocks such as financial downturns, social unrest, natural disasters, and epidemics.

1.4    Cities nationally and internationally are main drivers of economic activity and growth, but this output depends on a comprehensive infrastructure to deliver physical and social resources – the fuel of a

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[1]http://www.who.int/gho/urban_health/situation_trends/urban_population_growth_text/en/

city's 'economic engine'. The economic performance of a city is inextricably linked to its physical and communications infrastructures and the delivery of resources through these infrastructures.

1.5 According to United Nations data booklet 'The World Cities in 2018'[2], the populations of the world's cities with 5,00,000 inhabitants or more grew at an average annual rate of 2.4 percent between 2000 and 2018. However, 36 of these cities grew more than twice as fast, with average growth in excess of 6 per cent per year. Of these cities, 7 are in Africa, 28 in Asia (17 in China alone), and 1 in Northern America. Among the 36 fastest growing cities, 25 have a long history of rapid population growth, with average annual growth rates above 6 per cent for the period 1980–2000. The report also mentioned that at the turn of the century in 2000, there were 371 cities with 1 million inhabitants or more worldwide. By 2018, the number of cities with at least 1 million inhabitants had grown to 548, and in 2030, a projected 706 cities will have at least 1 million residents. In respect of future trends of urban population with respect to the rural population, it has been mentioned that between 2018 and 2030, the urban population is projected to increase in all size classes, while the rural population is projected to decline slightly. Rural areas are home to 45 per cent of the world's population in 2018, a proportion that is expected to fall to 40 per cent by 2030.

1.6 According to 2011 census, in India[3], the urban population was about 37 crores, accounting for 31% of total population and generating about 63% of the nation's economic activity. The urban population is rapidly increasing, with almost half of India's population is projected to live in its cities by 2050.

1.7 The strain on traditional delivery mechanisms and supply of resources due to increasing populations poses a significant challenge to the

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[2]https://www.un.org/en/events/citiesday/assets/pdf/the_worlds_cities_in_2018_data_booklet.pdf
[3]https://censusindia.gov.in/2011-prov-results/paper2/data_files/India2/1.%20Data%20Highlight.pdf

sustainable growth of cities. This applies not only to physical resources, such as energy, water, or waste management, but also to social and economic resources, such as healthcare, traffic management, and city logistics. As traditional resource delivery systems approach the limits of their capability, there is an urgent need for innovative delivery systems to effectively manage and control resource use in cities.

1.8 To handle this large-scale urbanization, we need to find new ways to manage complexities, increase efficiencies, reduce expenses, and improve quality of life. This will lead to manage cities in a smarter way. With the emerging technologies using ultra-low power sensors, wireless networks, and web- and mobile-based applications, smart cities are becoming a reality. The smart cities will be able to provide live status updates on traffic patterns, pollution, parking spaces, water, power, and light, etc. This kind of information helps in improving economic and environmental health of the city for residents and visitors. This will also improve working conditions and productivity for the people who maintain the city. Smart Cities focus on the most pressing needs and on the greatest opportunities to improve quality of life for residents today and in the future.

1.9 Due to the mounting pressure of urbanization, the cities are changing their nature, creating even a greater divide between the expectations of the citizens and the ability of the city to deliver the critical infrastructure. Population growth, ageing infrastructure, limited resources, changing needs, and expectations of the city create new challenges for the cities to tackle. As cities become more attractive places to live, work, and visit, there are intended consequences and impacts as a result of increased demand on their infrastructure.

1.10 There are plenty of reasons which could be attributed to transform a city to Smart city. To cope up with the present scenarios, and to create an environment which is sustainable and livable, the cities have to:
- drive further efficiency through reduced cost of service delivery
- cope with the increased demand on city infrastructures

- reduce demand on scarce resources by identifying actual needs, and eliminating waste
- add network capacity with minimal investment
- reduce cost to the citizens, businesses
- deliver better, more reliable and connected services to citizens
- empower people with information and choice
- provide healthier environment and reduce pollution
- drive innovation and provide business opportunity
- enhance quality of life, attracting human capital, business investment and economic growth

1.11 A smart city needs smart governance, smart businesses, and smart citizens. A smart city is one that can effectively leverage technology, infrastructure, public policy, and citizens' engagement to create an urban environment that fosters economic growth and productivity, innovation, social mobility, inclusiveness, and sustainability. ICT-enabled smart infrastructure will surely help a city to become smart and sustainable.

# CHAPTER 2
## SMART CITIES PARADIGM

### A.    Elements of a Smart City

2.1    All the nations are going through an urban transition; rather, some might say urban transformation. Without doubt, modern technologies provide opportunities to deliver game-changing outcomes, that will deliver a more sustainable and resilient society, and must be built intelligently into the fabric of that transformation process. In many ways, the opportunity is to re-invent the model for urban living; a model that ensures responsible resource consumption; and one that ensures prosperity, equality, societal cohesion, and happiness.

2.2    Innovation and technology development are accelerating. Strategic plans and roadmaps are needed to help ensure that the market is suitably served with best practices that is pertinent to the goals and context of this very large market.

2.3    The 21st century is of rapid urbanization. Ensuring that the world's cities offer citizens a rich and rewarding lifestyle requires that cities exploit technology to enrich people's lives, deliver services, and ensure sustainable growth. Over the recent years, there has been a major worldwide push towards smart cities with many major world cities rolling out initiatives and new services aimed at improving cities and the lives of citizens. Governments worldwide are driving smart cities' initiatives in order to achieve their policies on energy efficiency, sustainable development, and reliable, resilient, and cost-effective infrastructure and citizen services for the whole community.

2.4    The society, the business, the infrastructure, the services, and all other aspects of the civilization on the planet Earth are going through a paradigm shift in the wake of technological advancements being taking place, especially in the field of ICT. All the ecosystems, Smart Cities, Smart Grid, Smart Buildings, or Smart Factories, are now going through three classes of transformations:

- Improvement of infrastructure – to make it resilient and sustainable,
- Addition of the digital layer – which is the essence of the *smart paradigm,* and
- Business process transformation – necessary to capitalize on the investments in smart technology.

2.5 After reviewing numerous definitions of Smart Cities by various different stakeholders and the genesis of Smart City, it can be summed up that – In a Smart City – Sustainability is the True Destination; Resilience is the Core Characteristics; Smart is merely an Accelerator, and Standards are the Chromosomes of its Smart infrastructure[4].All Smart City programmes and projects pursue many common goals, including sustainable development, better efficiency, resilience, safety, and wider support for citizens' engagement and participation. However, each individual city tends to follow its own approach in smart cities programme and projects.

2.6 Sustainable development of any nation depends on the development of sustainable cities, which can only be achieved through the wide-reaching roll out of integrated, scalable, Smart/sustainable city/community solutions.

2.7 Considering the various definitions of smart cities as mentioned above, it is evident that the Information and Communication Technologies (ICT) has been identified as a common thread in improving the quality of lives of the citizens in a smart city.

## B. Drivers for "Smart" Paradigm

2.8 In general, the objectives expected from Smart Cities, and, therefore, the objectives of implementation of ICT in Smart Cities are:
- Optimization: Looking at all data coming in from various input

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[4]https://narnix.com/standards-chromosomes-smart-infrastructure/

sources – resources, utilities, devices, and services, and putting in systems such that they can improve their operations and make it more efficient.

- Predictive failure information: Forecasting the probability or knowing when a system or public machinery might breakdown. And as the next steps, taking measures to address it.

- Improved usage information: Understand how citizens are using different services and the consumption of essentials. Enhance what is falling short and de-emphasize what is excess.

- Improved failure and diagnostic information: Make sure services are operating and generating revenue.

- Transparency: Facilitated by making the information, processes, costs, consequences more open and democratic.

- New services packages: With more information about citizens' behavior and consumption patterns, the government will be able to offer more tailored services in the future.

2.9     From a sector specific view, the objectives expected by the public that ICT can significantly aid in are:

- City administration: to streamline management and deliver new services in an efficient way

- Education: to increase access, improve quality, and reduce costs

- Healthcare: to increase availability, provide more rapid, accurate diagnosis, provide wellness and preventive care, and create more cost efficiencies

- Public safety: to use real-time information to anticipate and respond rapidly to emergencies and threats

- Real estate: to reduce operating costs, use energy more efficiently, increase value, and improve occupancy rates

- Transportation: to reduce traffic congestion while encouraging the use of public transportation by improving the customer experience and making travel more efficient, secure, and safe

- Utilities: to manage outages, control costs, and deliver only as much energy or water as is required while reducing waste

### C.    Make Cities and Human Settlements Inclusive, Safe, Resilient and Sustainable

2.10    More than half of humanity – 4.2 billion people – live in cities today, and by 2030, it is estimated that six out of ten people will be city dwellers. By 2030, the world is projected to have 43 megacities[5] with more than 10 million inhabitants each, most of them in developing regions. However, some of the fastest-growing urban agglomerations are cities with fewer than 1 million inhabitants, many of them located in Asia and Africa. While one in eight people live in 33 megacities worldwide, close to half of the world's urban dwellers reside in much smaller settlements with fewer than 5,00,000 inhabitants.

2.11    The world's cities occupy just 3% of the planet's land[6] but account for 60%–80% of all energy consumption and 75% of the planet's carbon emissions. Rapid urbanization is exerting pressure on freshwater supplies, sewage, the living environment, and public health. Our rapidly growing urban world is experiencing congestion, a lack of basic services, a shortage of adequate housing, and declining infrastructure. More than 30% of the world's urban population lives in slums, and in Sub-Saharan Africa, over half of all city dwellers are slum dwellers.

2.12    The United Nations (UN) under the theme 'Transforming Our World: The 2030 Agenda For Sustainable Development'[7] has set 17 Sustainable Development Goals (SDGs). Digital development and use of Information and Communications Technologies (ICT) have been recognized as an important tool for achieving the new SDGs set by UN for the welfare of mankind. The 17 goals are very ambitious, aiming to end poverty, extreme hunger, ensure quality education for everyone, improve

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[5]https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html#:~:text=By%202030%2C%20the%20world%20is,of%20them%20in%20developing%20regions.&text=While%20one%20in%20eight%20people,with%20fewer%20than%20500%2C000%20inhabitants.

[6]https://www.un.org/sustainabledevelopment/cities/#:~:text=The%20world's%20cities%20occupy%20just,living%20environment%2C%20and%20public%20health.

[7]https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf

healthcare, end gender inequality, protect, restore and promote sustainable use of ecosystems, etc., to improve social and economic development, and end inequality. These SDGs have been adopted by UN since 1st January 2016 and with aims and objectives to be fulfilled by 2030.

2.13 Information and Communications Technologies (ICT) has been recognized as an essential tool for achieving the new Sustainable Development Goals (SDGs) set by United Nations for the welfare of mankind. Digital development is a key in achieving all 17 Sustainable Development Goals (SDGs).

2.14 One of the SDGs 'Goal 11: Make cities and human settlements, inclusive, safe, resilient and sustainable' has outlined the targets as mentioned below:

- By 2030, ensure access for all to adequate, safe, and affordable housing, and basic services, and upgrade slums.
- By 2030, provide access to safe, affordable, accessible, and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention given to the needs of those in vulnerable situations, women, children, persons with disabilities, and older persons.
- By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning, and management in all countries.
- Strengthen efforts to protect and safeguard the world's cultural and natural heritage.
- By 2030, significantly reduce the number of deaths and the number of people affected, and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations.
- By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management.

- By 2030, provide universal access to safe, inclusive, and accessible, green, and public spaces, in particular, for women and children, older persons, and persons with disabilities.

- Support positive economic, social, and environmental links between urban, peri-urban, and rural areas by strengthening national and regional development planning.

- By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015–2030, holistic disaster risk management at all levels.

- Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials.



*Figure 2.1: Sustainable Development Goals*

### i. India's efforts vis-à-vis UN Sustainable Development Goal 11

2.15 India is urbanizing rapidly. Between 2001 and 2011, the country's urban population had increased by 91 million. India is projected to add 416 million urban dwellers between 2018 and 2050[8]. By 2030, India is expected to be home to seven megacities with populations above 10 million. 68% of the country's total population lives in rural areas, while 17% of the country's urban population lives in slums.

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[8]https://population.un.org/wup/Publications/Files/WUP2018-KeyFacts.pdf

2.16 To address the various issues in urban areas, Jawaharlal Nehru National Urban Renewal Mission (JNNURM)[9] was launched in 2005 as the first flagship scheme of MoHUA. The program was implemented by Ministry of Housing, Urban Affairs and Poverty Alleviation (MoHUPA) under two components, which are Basic Services for Urban Poor (BSUP) and Integrated Housing and Slum Development Programme (IHSDP), which aimed at integrated development of slums through projects for providing shelter, basic services, and other related civic amenities with a view to providing utilities to the urban poor. Later in 2015, the Central Government came up with a newer version of the program known as Atal Mission for Rejuvenation and Urban Transformation (AMRUT).

2.17 The Government of India's Smart Cities Mission and the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) are working to address the challenge of improving urban spaces. Further, the Prime Minister's Pradhan Mantri Awas Yojana aims to achieve housing for all by 2022.

### ii. Sustainable cities

2.18 Sustainable cities, urban sustainability, or eco-city is a city designed with consideration for social, economic, environmental impact (commonly referred to as the triple bottom line), and resilient habitat for existing populations, without compromising the ability of future generations to experience the same.

2.19 Many people are working towards making cities more sustainable. A sustainable city offers a good quality of life to current residents but doesn't reduce the opportunities for future residents to enjoy.

2.20 Key features of a sustainable city:
- Resources and services in the city are accessible to all.
- Public transport is seen as a viable alternative to cars.
- Public transport is safe and reliable.
- Walking and cycling are safe.

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[9] http://mohua.gov.in/upload/uploadfiles/files/1Mission%20Overview%20English(1).pdf

- Areas of open space are safe, accessible, and enjoyable.
- Wherever possible, renewable resources are used instead of non-renewable resources.
- Waste is seen as a resource and is recycled wherever possible.
- New homes are energy efficient.
- There is access to affordable housing.
- Community links are strong, and communities work together to deal with issues such as crime and security.
- Cultural and social amenities are accessible to all.
- Inward investment is made to the CBD (Convention on Biological Diversity) city.

A sustainable city will grow at a sustainable rate and use resources in a sustainable way.

### iii. Connect 2030: ICTs for the Sustainable Development Goals (SDGs)[10]

2.21 World Telecommunication and Information Society Day, which marks the founding of ITU on 17th May 1865 when the first International Telegraph Convention was signed in Paris, is celebrated every year on 17th May. This celebration is targeted towards creating awareness of various advancements in the field of ICT and how it helps in the development of society.

2.22 This year's theme "Connect 2030: ICTs for the Sustainable Development Goals (SDGs)" is showing the way forward for the next 10 years to reflect on ICT advances for transition to smart and sustainable development with five strategic goals such as Growth, Inclusiveness, Sustainability, Innovation, and Partnership.

2.23 The 2030 Agenda[11] for Sustainable Development recognizes that "The spread of information and communication technology and global interconnectedness has a great potential to accelerate human progress,

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[10]https://www.itu.int/en/wtisd/2020/Pages/default.aspx
[11]https://www.itu.int/en/wtisd/2020/Documents/WTISD2020-Toolkit-en.pdf

to bridge the digital divide and to develop knowledge societies". ITU has made a concerted effort in this regard to highlight the role that ICTs will play in achieving the SDGs.

2.24    India has adopted the National Digital Communications Policy (NDCP) in the year 2018 with specified strategic objectives to be achieved by the year 2022. These objectives of NDCP will promote the usage of ICT, which will directly result in achieving Sustainable Development Goals. One of the important objectives of the NDCP is to create a robust digital communication infrastructure, which can be used for development in various sectors, including Education, Healthcare, Energy, Employment, Innovation, etc. These policies will help in many ways to achieve the overall socio-economic development envisaged in Sustainable Development Goals (SDGs).

### iv.  Resilience

2.25    Cities worldwide are placing increasing importance on building up resilience to natural disasters, such as extreme weather, flooding, heat, and water stress, caused by climate change. Confronted by a natural disaster, smart cities can use sophisticated ICT infrastructure and analytical capabilities to enhance and coordinate the information flow between multiple public agencies, such as transport authorities, emergency services, and energy providers, and citizens. With the help of mobile networks, a city municipality can reach most of its citizens at a short notice.

2.26    The UN Office for Disaster Risk Reduction (UNDRR) and its partners launched the 'Making Cities Resilient' (MCR) Campaign in 2010. The Campaign was intended to raise awareness on urban risk reduction with city leaders and local governments to work along with local partners, grassroots networks, and national authorities. According to the Rockefeller Foundation[12],"Urban Resilience is the capacity of individuals, communities, institutions, businesses, and systems within

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[12]https://www.rockefellerfoundation.org/wp-content/uploads/City-Resilience-Framework-2015.pdf

a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience." A resilient city is one that has developed capacities to help absorb future shocks and stresses to maintain the same functions, structures, systems, and identity. Further, utilizing climate information (of past and future) to identify climate stressing activities typical to their cities/regions.

2.27 Resilience not only means preparing cities to better respond to natural disasters, perhaps even more importantly, it also means taking steps to prevent disasters. Urban resilience can also refer to building a diverse economy that can weather economic downturns.

2.28 Four Ways Cities Can Build More Climate-Resilient Neighborhoods:
- Tailor early warning systems to meet the needs of vulnerable people.
- Map city services and access to amenities.
- Build Long-Term resilience into infrastructure and planning.
- Promote an inclusive culture.

2.29 Resilient Cities and neighborhoods will need to embrace density, diversity, and mix of uses, users, building types, and public spaces. Ensuring that infrastructure is climate resilient will help to reduce direct losses and reduce the indirect costs of disruption. New infrastructure assets should be prioritized, planned, designed, built, and operated to account for the climate changes that may occur over their lifetimes.

2.30 Making a city more resilient also requires building regulations and land use planning; training, education and public awareness; environmental protection, and strengthening of the city's ecosystem; effective preparedness, early warning and response; and recovery and rebuilding plans.

2.31 A city's ability to respond effectively to natural disasters heavily depends on its uses of ICT infrastructure, including mobile networks

and satellite communications, to efficiently receive, process, analyse, and re-distribute data, and mobilise various city services.

### v.  Critical Infrastructure

2.32  Critical infrastructure is the body of systems, networks, and assets that are so essential that their continued operation is required to ensure the security of a given nation, its economy, and the public's health and/or safety. Critical infrastructure includes the vast network of highways, connecting bridges and tunnels, railways, utilities, and buildings necessary to maintain normalcy in daily life. Transportation, commerce, clean water, and electricity all rely on these vital systems. Critical Infrastructure Protection (CIP) is the need to protect a nation's vital infrastructures such as food and agriculture, transportation systems, communication networks,  sewage, water,  and  electric systems. Government in every nation has a responsibility to protect these essential critical infrastructures against natural disasters, terrorist activities, and now cyber threats.

### vi.  Critical Information Infrastructure

2.33  Information infrastructure technologies enable organizations to define, organize, share, integrate, and govern data and content to create business value.

2.34  The critical Information Infrastructure is the backbone and foundation of any modern society/community today. Those ICT infrastructures upon which the core functionality of Critical Infrastructure is dependent. The critical information infrastructure (CII) is any physical or virtual information system that controls, processes, transmits, receives, or stores electronic information, in any form, including data, voice, or video, that is so vital to the functioning of the critical Infrastructure that the incapacity or destruction of such systems would have a debilitating impact on national security, national economic security, or national public health and safety. A few essential components of the Critical Information infrastructure are: Smart City,

Smart Health, Smart Water, Smart Surveillance, Smart Grid, and Smart Street Lighting, etc. They all need highly reliable Communication Backbone.

2.35 In India, NCIIPC (National Critical Information Infrastructure Protection Centre) is responsible to facilitate safe, secure, and resilient Information Infrastructure for Critical Sectors of the Nation. It continuously endeavours to take all necessary measures to facilitate protection of Critical Information Infrastructure, from unauthorized access, modification, use, disclosure, disruption, incapacitation, or distraction through coherent coordination, synergy, and raising information security awareness among all stakeholders.

2.36 NCIIPC has broadly identified the following as 'Critical Sectors':
- Power and Energy
- Banking, Financial Services and Insurance
- Telecom
- Transport
- Government
- Strategic and Public Enterprises

### vii. Digital Transformation

2.37 The imperatives of building a sustainable and secure planet have given rise to new paradigms like the green movement, DC power, renewables, microgrids, sustainable transportation, networking devices, network, and cyber security, smart homes, smart buildings, smart grids, and smart cities. All these shifting and rising paradigms are ultimately converging into the new and much larger paradigm of 'Sustainable and Trustworthy' Digital Infrastructure.

2.38 Digital Transformation is the use of new, fast, and frequently changing digital technology to solve problems. It is about re-engineering and transforming processes that were earlier non-digital or manual. Digital transformation can be defined as the acceleration of business activities, processes, competencies, and models to fully leverage the changes and

opportunities of digital technologies and their impact in a strategic and prioritized way.

2.39   Technologies such as Big Data; Internet of Things; Data Analytics; Artificial Intelligence; Digital Twinning; Cloud Computing; 5G; Virtual, Augmented and Mixed reality, etc., are being used in cities to enable the development of smart policies, smart governance, and smart citizenship. The technology platforms used by cities need to be designed to enable government efficiency and public access to useful data. This can include cloud computing services, sensor networks, and data centers, and traffic management systems for both road congestion management as well as public transportation systems such as subways and light rail. Policies built on top of these platforms include e-government portals and e-government services that allow citizens access to data on shared Application Programming Interfaces, leveraging the information for community benefits.

2.40   Smart City technologies based on digital infrastructure and digital services offer a potential way of monitoring and managing physical and social resources in the city. Digital technologies can collect sufficiently large amounts of data to support very close matching of supply availability against demand requirements.

2.41   It is also increasingly realized that the so-called smart infrastructure implementations today tend to be vertical-centric siloed infrastructures that are proprietary solutions, wherein a single vendor owns the vertical application, platform, services, and data (and in certain cases the communication infrastructure as well). This approach inhibits interoperability, data sharing, optimal use of resources, and, therefore, is detrimental to the growth of the industry. The focus now is, therefore, increasingly on how all the different city systems need to be integrated and work together effectively for that city to become smart. This is not just integration at a technical level, but also about integration of business processes, management, and strategic and regulatory integration.

### viii. Cyber Security and Cyber Resiliency

2.42 Challenges that all economies are facing today in safeguarding the security and privacy of their ecosystem including citizens are – Transnational Nature of Cyber Crime, Cultural Vulnerabilities, Internet Resilience, and Threat Landscape.

2.43 International law defines Four Global Commons (natural assets outside national jurisdiction), which are the earth's natural resources, i.e., the High Seas, the Atmosphere, Antarctica, and Outer Space. Cyberspace is the 5th Global Common[13]. It is also considered as the 5th Dimension beyond the three dimensions of Space, and the 4th dimension, i.e., Time.

2.44 The new paradigm of Smart Grid, Smart Building, Smart Home, Smart City, Smart Manufacturing, already complicated by the 'Internet of Things' and Internet of 'Everything', made further complex by the Artificial Intelligence, Machine Learning, Blockchain, and Quantum Computing, which make it truly complex to develop and embed comprehensive Security, Privacy, and Trustworthiness attributes in the products, systems, and solutions for any use case or application - be it consumer, commercial, industrial, automotive, or strategic domains like critical infrastructure, defense, and aerospace.
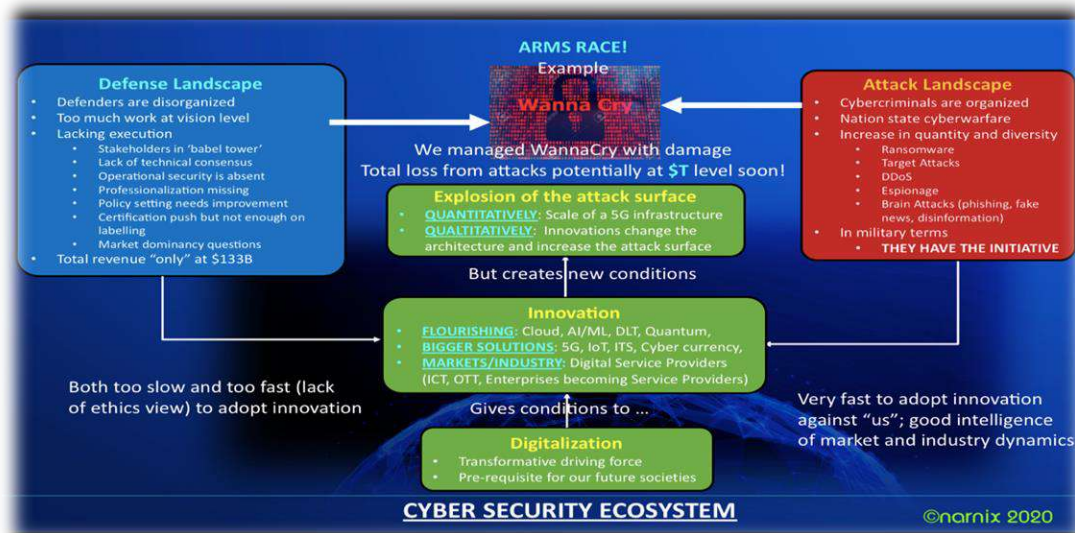
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[13]https://www.dqindia.com/cyberspace-global-commons-the-challenges-1/

*Figure 2.2: Cyber Security Ecosystem*

2.45    On the one hand, we have the highly protected Networks for the 'Critical Information Infrastructures'; on the other hand, these very 'highly protected networks' need to give access to the consumers for Consumer Engagement and Participation in these Smart (Digital) Infrastructures to meet the true drivers of setting them up. These large Smart Networks are actually highly complex 'Systems of Systems' and 'Networks of Networks', and thus create fresh challenges in the Security Paradigm and development of Protection Profiles.

2.46    It is evident that cyber security is a very complex paradigm, and with evolving new technologies, requirements, and ever-increasing Attack Surface, the vulnerabilities are rising many folds with time. In such a dynamic scenario, it is important as how do we develop a Cyber Security Strategy to make our Cities, Civic, and Critical Infrastructure comprehensively Safe, Secure, Resilient, and Trustworthy.
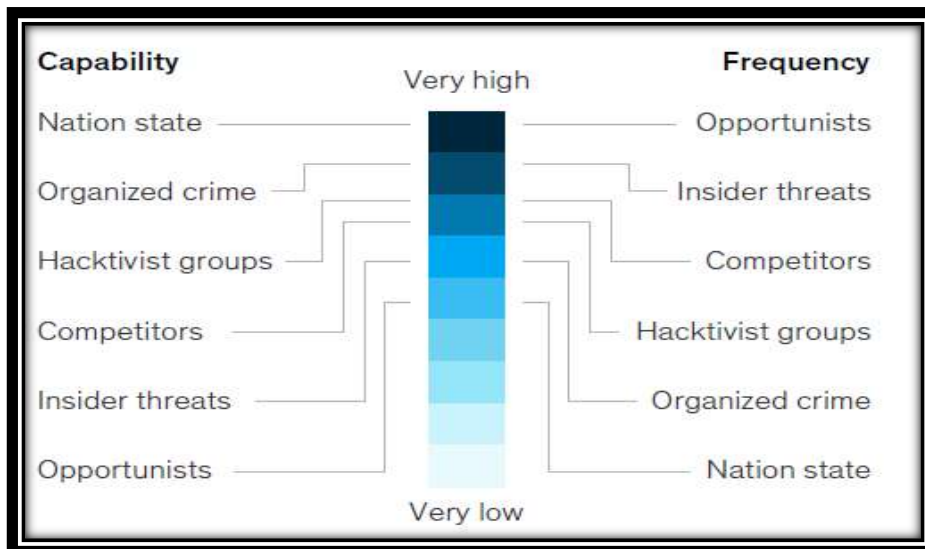
*Figure 2.3: McKinsey on Risk, November 2019[14]*

### ix. Smart City as a System of Systems

2.47 All Smart City programmes and projects pursue many common goals, including sustainable development, better efficiency, resilience, safety and wider support for citizen's engagement and participation. However, each individual city tends to follow its own approach in smart cities' programmes and projects. It is not surprising that the numerous technology activists are very vocal on various Smart Cities forums even though cities cannot be reduced to cluster of just "Big Data" and "IoT".

2.48 The current implementation practices of smart cities are rather disjointed, namely:

- Smart Cities programmes and projects are, primarily, local initiatives;
- Smart Cities programmes and projects are considered as technology projects;
- Numerous Smart Cities interest groups are operating;
- Efforts for the development of a common vision are insufficient, and;
- Typical financing patterns do not promote a common vision.

2.49 As a result, there is no agreed basis for efficient and effective cooperation and coordination between different Smart Cities

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[14]https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/Risk/Our%20Insights/McKinsey%20on%20Risk%20Issue%208%20Winter%202019/McKinsey_on_Risk_Issue_8.pdf

programmes and projects. There is a lot of duplication of work, developed solutions are not reusable, and the same mistakes are repeated.

2.50 ICT has been recognized as a true enabler of the smartness in every aspect of the smart city paradigm. But there is a need of consensus among city administration, consulting companies, service companies, and technology companies on which ICT components are necessary and how cities should approach this agenda.

2.51 Smart Technologies and city scale ICT are part of a new and emerging market where many of the products – both hardware and software, in a multi-vendor environment, and across sectors and services are still being developed. But almost nascent smart technologies market suffers from many barriers – interoperability, technical, and institutional, that need to be overcome if the market is to grow and mature.

2.52 Smart City technologies based on digital infrastructure and digital services offer a potential way of monitoring and managing physical and social resources in the city. Digital technologies can collect sufficiently large amounts of data to support very close matching of supply availability against demand requirements. The use of historic information to correlate with actual events can also inform immediate reaction where the data sets match those of a previous historic event. The new communications potential from sensors on buildings, roads, and other elements of the city, and the sharing of data between service delivery channels, if integrated, will enable the city to improve services, monitor, and control resource usage, and react to real-time information.

2.53 A defining feature of Smart Cities is the ability of the component systems to interoperate. The optimal use of resources across a complex urban environment depends on the interaction between different city services and systems. To identify the most effective use of resources, therefore, requires communication between the different component systems (e.g., energy consumption monitored by Smart Metering

combined with external temperature and sunlight monitoring on the building to reduce the energy consumption).

2.54   A city is a complex system of systems, involving many different domains and infrastructures and organizations and activities. All these need to be integrated and work together effectively for a city to become smart, and there are many levels at which integration needs to take place. This is not just integration at a technical level, but also about integration of business processes, management, and strategic, and regulatory integration.

### x.    The Interplay – Smart Cities and Smart Infrastructure

2.55   The relationship between Smart Cities and Smart (Digital) Infrastructure needs to be understood in this context: "In a smart city, energy, water, transportation, public health and safety, and other key services are managed in concert to support smooth operation of critical infrastructure while providing for a clean, economic and safe environment in which to live, work and play".

2.56   Hence, the perspective in Infrastructure Design for any city has under gone a paradigm shift with advent of convergence and networking technologies, solutions for information, communication, entertainment, security, and surveillance; which are beginning to have a profound impact on the way we look at the Buildings' Design (be it residential or commercial) and Town Planning.

2.57   Cities are intricate composite environments and the way they are operated, financed, regulated, and planned, are extremely complex, to say the least. City operations are multidimensional and comprise of multiple stakeholders whose dependencies and interdependencies affect and ultimately determine the built environment.

2.58   The various departments mostly overlook these dependencies and interdependencies in their efforts, and focus on providing their services and on being answerable only for the services they provide. Part of the answer to making cities 'smarter' is a more all-embracing coordinated

management of resources and infrastructure, a collaborative approach to a cleaner, greener environment, and harmonized governance that results in a better quality of living of its citizens.

2.59    It is true, however, that convergence is still eluding the evolved citizens of today's global village because of a lack of harmonized standards in the respective ecosystems of the Smart Homes, Smart Buildings, and Smart Cities. The smart nodes of one network cannot talk to smart nodes of the other networks. A wide array of proprietary systems/solutions, or systems/solutions with very limited interoperability are being deployed in each application area for today's home automation, building automation, industrial automation, or even the infrastructure automation needs of the society.

2.60    The multiplicity of technologies and their convergence in many new and emerging markets, however, particularly, those involving large-scale infrastructure demand a top-down approach to standardization starting at the system or system-architecture rather than at the product level. Therefore, the systemic approach in standardization work can define and strengthen the systems approach throughout the technical community to ensure that highly complex market sectors can be properly addressed and supported. It promotes an increased co-operation with many other standards-developing organizations and relevant non-standards bodies needed on an international level. Further standardization needs to be inclusive top down, and bottom up a new hybrid model with comprehensive approach is needed.

2.61    To achieve comprehensive interoperability, it is imperative to work on the finest granularity of each component and layer for standardization as well as harmonization, and ensuring the interoperability among various similar components addressing different applications at semantic as well as syntactic levels. Further, the standards being adopted for the smart homes or smart buildings deployments must be harmonized with standards in all other relevant ecosystems like smart grids and smart cities and integrated digital infrastructure paradigms.

2.62 By laying a common replicable framework, there is an opportunity for the different Smart Cities to leverage State level or National ICT Infrastructure instead of replicating ICT infrastructure, solutions, and service across multiple instances. The hugely complex nature of a smart infrastructure project creates a very real risk that oversights in the planning phase can cause the sub-optimization of sub-systems, which can severely impair the overall success of the project. Organizations can mitigate this risk by taking a far-reaching, structured, and detailed approach to project planning. By encapsulating the requirements of all stakeholders (both within and outside an organization), modeling the impacts of change, and tracing requirements throughout the project, it is possible to quantify the impact of different decisions in the planning stages, rather than realize mistakes once the project has been completed.

2.63 All sectors in the infrastructure framework are influenced by the unified ICT backbone paradigm. However, a common infrastructure pool enables the creation of an interconnected and truly homogenous system with seamless communication between services. Coordination, collaboration, and harmonization can be better implemented by the effective use of standards based open, common, and shareable, information, and communication technologies. The disconnect amongst technological trends being pursued by the stakeholders of the now homogenous smart infrastructure needs to be bridged without any further delay to maintain the Lifecycle Cost/TCO (total cost of ownership) of these individual components within viable economic thresholds.

# CHAPTER 3
## SMART CITIES ECOSYSTEM, STAKEHOLDERS AND MARKET DYNAMICS

3.1 A smart city is one that can effectively leverage technology, infrastructure, public policy, and citizen engagement to create an urban environment that fosters economic growth, productivity, innovation, social mobility, inclusiveness, and sustainability. Disruptive Technologies such as the Internet of Things, Big Data, Artificial Intelligence, 5G, and Virtual/ Augmented/ Mixed Reality have given rise to an entirely new aspect of the way human, machines, and things are going to communicate with each other in the very near future. In addition, due to climate change and other environmental pressures, cities are increasingly required to become "smart" and take substantial measures to meet stringent targets imposed by commitments and legal obligations.

3.2 Furthermore, the increased mobility of our societies has created intense competition between cities to attract skilled residents, companies, and organizations. To promote a thriving culture, cities must achieve economic, social, and environmental sustainability. This will only be made possible by improving a city's efficiency, and this requires the integration of infrastructure and services. While the availability of smart solutions for cities has risen rapidly, the transformations will require radical changes in the way cities are run today.

## A. Smart Cities' Stakeholders

3.3 In Smart Cities' paradigm, stakeholders can be categorized into one or more of the following typologies based on their personal or organizational interest in the development of a smart city. As smart city stakeholders, one can have direct or indirect influence(s) in the decision-making process, which plays a significant role in the transformation of a city into smart city.

*Figure 3.1: City Planners Arch Blueprint Maps[15]*

3.4   A high-level mapping of Stakeholders of the smart cities' ecosystem enumerates a comprehensive list including but not limited to the following:

- Citizens
- Local Business Owners
- Temporary Inhabitants of the City
- Municipal Authorities
- Urban/City Planners
- Utility and Public Services Providers
- Telecommunication Services Providers
- Industries
- Academic and Research Institutions
- Regional and National Agencies
- Financial Organizations
- Public Interest Groups
- Specialized Consulting Firms

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[15]BIS Pre-Standardization Study Report - Unified, Secure & Resilient ICT Framework for Smart Infrastructure, Page 66.

- Local Professional Associations, or branches of National or International Associations.

## B.    Stakeholders' Concerns

3.5    Looking at the major groupings of stakeholders, their key concerns can be described as follows:

**Citizens** are the primary beneficiaries of a Smart City. However, they will profit from the "set of standards for city systems" indirectly. It will be for each city to collect the citizens' concerns and treat them systematically in accordance with this "set of standards for city systems", along with the related tools and guiding materials. Citizens' concerns include[16]:

- Adequate Water Supply.
- Assured Electricity Supply.
- Sanitation, including Solid Waste Management.
- Efficient Urban Mobility and Public Transport.
- Affordable Housing, especially for the poor.
- Widespread and transformative use of Data and Technology.
- Good Governance and Citizen participation.
- Sustainable Environment.
- Safety and Security of Citizens, particularly women, children, and the elderly. Affordable Healthcare for everyone.
- Modern Education for children and adults.
- Attractive for Business.

3.6    **Standards Development Groups and Industry Standards Development Groups** are responsible for formal definition of functional elements and their interfaces that are to be used as part of the sets of standards needed to deliver smart cities. They need guidance to help them address 'by-design' city system quality characteristics as required by Municipal Authorities, Service Providers, and Industry, such as:

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[16]http://smartcities.gov.in/upload/uploadfiles/files/SmartCityGuidelines(1).pdf (Page 5)

- Interoperability,

- Safety,

- Security (including Confidentiality, Integrity, and Availability),

- Privacy,

- Resilience,

- Simplicity,

- Low cost of Operation,

- Short time-to-value,

- Combining diversity and uniformity,

- Self-referential and that covers the whole life cycle of city systems.

3.7 **Smart City architecture teams** are responsible for understanding smart cities and describing them in a common structure by adopting and tailoring a Smart City Reference Architecture to the unique needs of the particular city.

3.8 Investors are responsible for taking informed decisions about their investments in city systems Infrastructure. Cities are missing out on significant investments coming from the growing popularity of sustainable investments, which pushes many investment and pension funds to leave the fossil-fuel industry and to look for another investment-safe industry; on the one hand, and the high risks of existing city bonds on the other.

3.9 Their concerns are, therefore, how to benchmark Smart Cities related initiatives, and, therefore, provide evidence as to the potential of smart technologies to mitigate potential economic losses from disasters, their value in building a sustainable future, and the commercial return on smart solutions to city needs.

## C.    The City Imperatives

3.10    As proposed by ISO TC 268 "Sustainable development in Communities"[17], the 6 purposes of sustainability and smartness for cities and communities is to strengthen:

- Social cohesion, population consensus, inclusivity (participation of all)
- Well-being, creativity, and innovation
- Preservation and improvement of environment
- Responsible resource use
- Attractiveness, supporting Indian businesses, and providing a level playing field
- Resilience

3.11    The 12 major relevant issues for Smart Sustainable Cities and Communities identified by ISO TC 268[18]:

- Governance
- Education
- Innovation
- Health and care
- Culture
- Living together
- Economy
- Living and working environment
- Safety and security
- Smart community infrastructures
- Biodiversity
- Mobility

3.12    The collaboration between a set of key stakeholders and interested parties is a key component of the achievement of a sustainable and smart city. These may belong to one or several specific categories:

- Public authorities: national, regional, local government, and municipalities
- Developers and Investors: Public or private, promoters, trades
- Industry and operators of public or private services

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[17] https://www.iso.org/committee/656906/x/catalogue/
[18] https://www.iso.org/committee/656906/x/catalogue/

- Public interests' groups, and associations
- Permanent or temporary residents, inhabitants, businesses, consumers
- Banks, insurers
- Consumers/citizens
- Prosumers, i.e., consumers who also produce

3.13 Within this, the key perspective to focus on is that of the "citizen", this term being taken, in the context, broadly to mean individual citizen and their families.

### The Citizen Perspective

3.14 In the smart/sustainable city/community context, the term "consumer" is to be taken broadly to mean individual citizens and their families. The smart community offers considerable opportunity not only for citizens to have an improved living environment in which they can benefit from effective services but also for them to have an additional say in matters affecting their daily lives. At the same time, equal treatment for all citizens needs to be ensured, and account needs to be taken of "big data" risks to their personal information.

3.15 Against this background, citizens need:
- Transparent information about the public, and commercial services being provided in a smart/sustainable-city/community, what is their cost, what are their rights and the redress procedures when they go wrong, etc.;
- Mechanisms to ensure their individual voice is heard;
- Assurances that the security of their personal information is properly protected, and that this data will not be misused for commercial purposes;
- Support and education for those unable to take immediate, and full advantage of smart community living;
- A physical environment that ensures accessibility for older people, and those with disabilities.

## D. ICT Requirement for various Elements of Smart City

3.16 ICT infrastructure is the core of a smart city. ICT integrates all the verticals of a smart city. Smooth rollout and transition to smart, robust, technology neutral, and dynamic ICT resource could be a prerequisite for any upcoming smart city. ICT resources for smart cities, in the form of hardware and software, consists of millions of connected devices, sensors, Internet of Things (IoT), M2M communications, Cloud computing, Big data, etc., which certainly require robust standards and conformity. The entire ecosystem of ICT components viz., devices, networks, platforms, applications, cloud storage, requires protocols, standards, security features for proper functioning and providing the desired output.

3.17 ICT plays an important role in connecting the resources, securely managing the massive amounts of data generated, and providing the relevant services that are required. A smart city uses digital technologies to:
- engage more effectively and actively with its citizens,
- enhance the city performance and the wellbeing of the citizens,
- reduce operational costs and the city resource consumption,
- generate new business opportunities and increase the attractiveness of the city,
- and much more.

3.18 The real benefits of the Smart Cities come when installed infrastructure provides multiple benefits across sectors and across services. There must be interdependencies of infrastructure and information collected through ICT infrastructure.

3.19 Global movement of transforming the cities into smart cities has generated ample opportunities for the device manufacturers, platform/application developers, solution providers and infrastructure providers. However, in absence of any regulation or standards, non-

standardized proprietary devices and solutions have come up in the market.

3.20 Such proprietary or non-standardized solutions have been created in silos and pose problems of interoperability and prevent sharing of data amongst divergent applications. Due to non-standardization of security related aspects – Device Security, Authentication, Communication Security, Data Integrity, Data Privacy, Lawful Interception remain the challenges to be addressed.

3.21 The purport of the creation of smart cities will only be achieved with a holistic approach, supported by globally acceptable standards that enable fully interoperable solutions that can be deployed and replicated at scale. Due to non-standardized proprietary implementations, the devices and applications do not interoperate, giving rise to higher costs and preventing sharing of data amongst divergent applications.

## E. ICT and Complementary Technologies – IoT, Big Data, Cloud, 5G

### i. Internet of Things

3.22 The Internet of Things is an ecosystem of ever-increasing complexity, and the vocabulary of its language is dynamic. At this relatively nascent stage, the IoT ecosystem is fragmented and disorganized. Over time, the IoT ecosystem should undergo a streamlining and organizing process and a "knitting together" of its individual pieces, because the IoT will play an increasingly important role in how we live and run our businesses.

3.23 Various programs launched by Govt. of India, such as "Smart Cities", "Digital India", "Make in India", "AMRUT", and "Startup India" are the key drivers of IoT industry's growth in the country. Further, many mega projects undertaken by the Government of India will help in the effective, and sustainable utilization of resources by the application of IoT solutions deployments.

3.24 However, because of pervasive-wide spectrum of communication technologies, diverse heterogeneous standards resulting in lack of interoperability and harmonization, the ecosystem is likely to stay fragmented in near future, if not addressed immediately.

3.25 As reiterated earlier, Internet of Things is all about "heterogeneous" and "aware" devices interacting to simplify people's life in some way or the other. Hence, the heterogeneity of the IoT paradigm has made it imperative to have a fresh look at the prevalent architectures and frameworks of the IoT and ICT Infrastructures being developed or being deployed.

3.26 The IoT value chain is perhaps the most diverse and complicated value chain of any industry or consortium that exists in the world. In fact, the gold rush to IoT is so pervasive that if one combines much of the value chain of most industry trade associations, standards bodies, the ecosystem partners of trade associations and standards bodies, and then add in the different technology providers feeding those industries, one gets close to understanding the scope of the task. In this absolutely heterogeneous scenario, coming up with common harmonized standards is a major hurdle.

3.27 Bringing the "Internet of Things" to life requires a Comprehensive Systems Approach – inclusive of intelligent processing and sensing technology, connectivity, software, and services, along with a leading ecosystem of partners. Harmonization in the Communication and Application Protocols, Messaging Middleware, Cloud, Big Data, and Data Analytics, Artificial Intelligence shall bring some semblance in this diverse ecosystem.
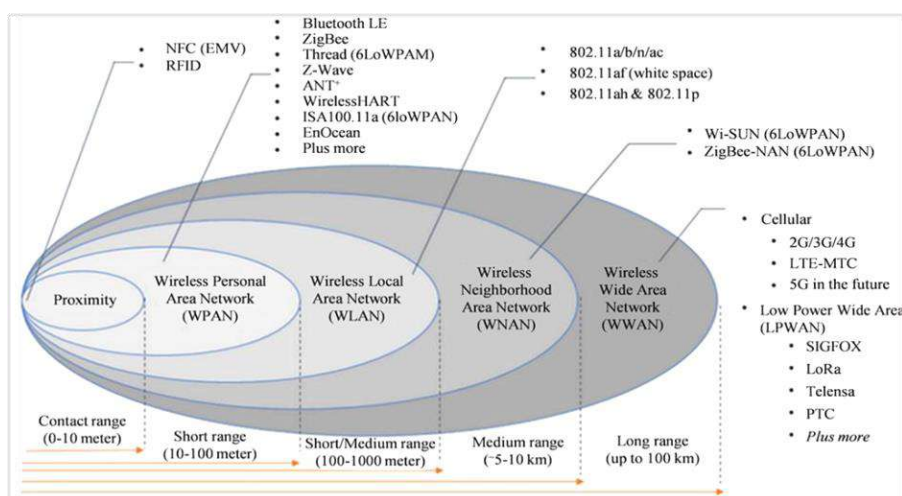
## ii. Connectivity for M2M/IoT

3.28 Connectivity is the key to any digitalization approach. It is the enabler for IoT, cloud, and data analytics as it provides the connection between the things and the control, operations, analytics, and business applications. While connectivity is one of its major components, IoT is much more about providing the services and semantic extensions to

enrich data to valuable information that can be interpreted and understood by all applications allowing to build up own knowledge.

3.29 Based on the specific requirements of the various application areas concerning, for example, bandwidth, reach, quality of service, latency, and available resources different protocols, will be used at the different layers of the communication stacks developed for the multitude of communication technologies and network architectures.

3.30 The wide variety of communication technologies, protocols, and standards developed in the last few decades, be it wired or wireless, address all kind of use cases in communication requirements with appropriate architectures and network topologies required for M2M/IoT applications. In wireless communication Wi-Fi, ZigBee, 6LoWPAN, Bluetooth technologies may be used for short-range connectivity among device(s) to the gateway; while Cellular technologies like 2G, 3G, LTE, and wireline technologies like Fibre, Fibre to the Home (FTTH), etc., may be used depending on the deployment for connecting the M2M/IoT gateway to the desired server.

3.31 Within the IoT paradigm, we have multiple categories of stakeholders Consumers, Enterprise, Industrial, Infrastructure. Each category's constraints and requirements are quite diverse and different from others, which make the IoT paradigm as one of the most complex and heterogeneous.



*Figure 3.2 M2M/IoT connectivity options*

3.32 In general, we have the trend to use commercially widely available, off-the-shelf technologies like Ethernet and Wireless LAN also for industrial applications. In the latter context, care shall be taken to ensure that the specific requirements of the industrial applications concerning, for example, latency and availability are supported.

### iii. Big Data and Analytics

3.33 Data analytics, smart or big data, is concerned with handling and analysis of large sets of data. This includes efficient storage, search, and visualization. Predictive maintenance, process optimization, supply planning, and product quality control are examples for the use of data analytics. The input will be the data from the process and supply chains, product lifecycle information, and simulation data from the development and engineering processes.

3.34 The IoT ecosystem is heavily dependent on data collection and transmission. Connected sensors collect large amounts of data through the Internet, enabling M2M interaction and processing of the data for particular services. Different types of data are transmitted and processed within the IoT ecosystem. The data primarily includes personal data and sensitive personal data such as financial information, location, health-related information, etc., that is attributed to an individual.

### iv. Edge Computing - Cloud Computing Paradox for IoT

3.35 Transition of IoT data processing to the network edge was expected to happen in the early IoT development lifecycle stage. However, decreasing connectivity costs and rising communication networks throughput led to a slow pace of this trend, which resulted in a shift toward centralized cloud processing. Now falling prices and the increasing processing power of edge devices have kickstarted the transition towards network edge. The change to edge computing may have a significant impact on an organization's IT and Operational Technology (OT) systems, and how the foundation of new age digital products is laid.

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### v. 5G Services

3.37 The dawn of the 5G era will reshape current wireless communication methods used for IoT-based applications. IoT cannot thrive without effective and affordable wireless connectivity, interoperability, and common standards. Hence, 5G has the potential to make a ground-breaking impact on the way in which future IoT ecosystems are designed, especially in the areas of scalability, latency, reliability, security, and the level of individual control on connectivity parameters. With a promise of 20Gbps peak data rate, less than 1ms latency and 90% reduction in network energy utilization, 5G will spur the next round of telecom infrastructure investments across the globe.

3.38 The sharp hike in consumer data and the proliferation of IoT devices will fuel the growth of 5G. A key requirement for 5G-network roll-out is availability of a strong reliable backhaul, which is non-existent in India, at present. As 5G networks will have to support large volume of data from emerging applications like IoT, smart cities, requirement of a strong and reliable backhaul (from cell tower to network operators Point of Presence) becomes a critical concern. Further to support 5G requirement for latency reduction (from 50ms to 1ms) and speed from 100 Mbps to 20Gbps, the Fibre deployment in India needs to be increased from current market of 16–18 million Fibre km per year to at least 50 million Fibre km per year. 5G will also require a multifold

increase in small cells deployment, with each small cell having backhaul on Fibre. The percentage of tower backhaul on Fibre for the operators will need to increase significantly from 20% to 70%–80% levels. Further, for high capacity microwave backhaul, use of E-Band (71–76 GHz paired with 81–86 GHz) and V-Band (57–64 GHz) needs to be initiated.

### vi.    Wi-Fi Offload

3.39   Wi-Fi has proved to be immensely popular with smartphone users as a low-cost solution for improved localized coverage, and mobile broadband experience, at venue specific locations, especially indoors. Substantial traffic on a smartphone today is carried over Wi-Fi. If we can achieve high traffic volumes on Wi-Fi, it would be easy to attain a high proportion of traffic offloading from the cellular networks to Wi-Fi networks, thus, freeing up cellular spectrum for enhancing outdoor mobile network capacity.

3.40   The capacity to carry large volumes of traffic over radio waves is the most challenging aspect. In a smart city environment, large number of mobile cells would be required to provide the connectivity and carry traffic. However, cost, environmental aspects, and especially radio interference issues are to be addressed. For this reason, the operators are introducing very small radio cells to deliver the required capacity and coverage. These cells are characterized by transferring large volumes of data over a very short distance. Mobile operators worldwide have started to implement a mobile data offloading strategy. In other words, they will have to find complementary technologies for delivering data originally targeted for 3G/4G networks. Two technologies, Wi-Fi and Femtocells, have emerged as the preferred offloading technologies. A third technology, WiMAX, is also in existence.

### vii.   Common Service Layer

3.41   In the heterogeneous world of M2M/IoT, Common Service Layer brings interoperability by creating a distributed software layer – like operating

system – which facilitates the unification by providing a framework for interworking with different technologies to enable re-use of what is already available as much as possible.
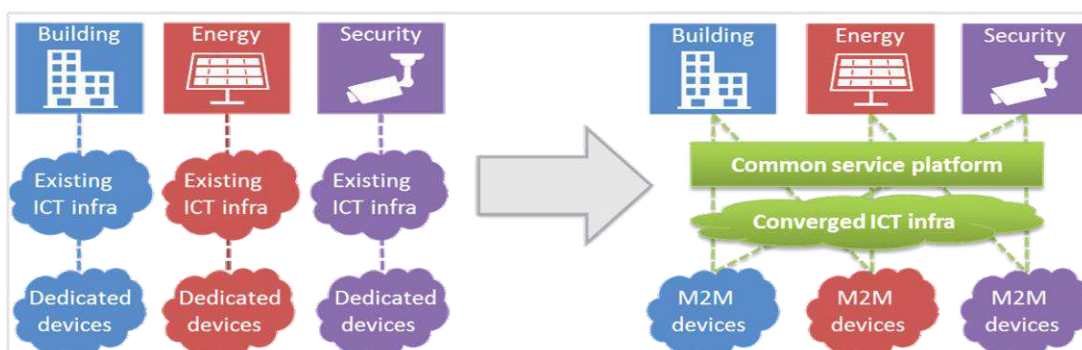


*Figure 3.3: M2M Evolution: OneM2M Architecture Approach*

**viii.  Application Protocols and Messaging Middleware**

3.42  Application protocols and messaging middleware are responsible for the information exchange above the transport layer. Several protocols like Simple Object Access Protocol (SOAP), Representational State Transfer (REST), and Extensible Messaging and Presence Protocol (XMPP) already exist. They were developed for specific Internet applications (e.g., XMPP for chat message exchange) but the same are now also used in various industrial application areas. Specifically, for communication with constrained devices and in constrained networks, new protocols like Constrained Application Protocol (COAP) and Message Queuing Telemetry Transport (MQTT) have been developed.

3.43  It must be ensured that the protocols can cope with the requirements of the different industrial application areas like scalability, processing efficiency, high reliability, and low latency.

**ix.  M2M/IoT Networks – Security**

3.44  In this next generation technology world, the virtual will have control over the physical world. Take the example of key utility infrastructure, such as power and water. Getting security right in the age of IoT could mean the difference between chaos and order, not just in cyberspace but in the physical world. The digital world is unique as there is a "fine

line" between productivity and chaos, and that "trust" is the issue that will determine success and failure in the digital future.

3.45   The M2M devices will be generating huge amounts of data, at times, data that are personal in nature, during its life cycle. One of the points where data security can be compromised is at the device layer itself. Hence to ensure data protection, "Security by design" principle should be implemented, or, at the very least, "Integrity by design", within the limits of physics. M2M device manufacturer should also be regulated by rules of product safety where applicable.

3.46   While security considerations are not new in the context of information technology, the attributes of many IoT implementations present new and unique security challenges. Addressing these challenges and ensuring security in IoT products and services must be a fundamental priority. Users need to trust that IoT devices and related data services are secure from vulnerabilities, especially as this technology becomes more pervasive and integrated into our daily lives. Poorly secured IoT devices and services can serve as potential entry points for cyber-attack and expose user data to theft by leaving data streams inadequately protected. The interconnected nature of IoT devices means that every poorly secured device that is connected online potentially affects the security and resilience of the Internet globally. This challenge is amplified by other considerations like the mass-scale deployment of homogenous IoT devices, the ability of some devices to automatically connect to other devices, and the likelihood of fielding these devices in unsecure environments.

3.47   Data must not be changed in transit, and steps must be taken to ensure that data cannot be altered by unauthorized people. From a user safety standpoint, integrity is critical, and privacy of user data and fraud prevention may require confidentiality and additional mechanisms.

3.48   Hence, as a matter of principle, developers and users of IoT devices and systems have a collective obligation to ensure they do not expose users and the Internet itself to potential harm. Accordingly, a collaborative approach to security will be needed to develop effective and appropriate

solutions to IoT security challenges that are well suited to the scale and complexity of the issues.

3.49 Fortunately, IoT security can be covered with four cornerstones:
- Protecting Communications
- Protecting Devices,
- Managing Devices, and
- Understanding Your System

3.50 These cornerstones can be combined to form powerful and easy-to-deploy foundations of security architectures to mitigate the vast majority of security threats to the Internet of Things, including advanced and sophisticated threats.
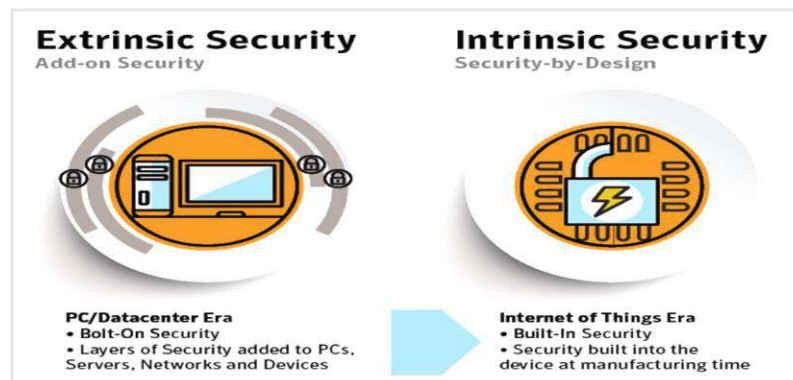


*Figure 3.4 Extrinsic Vs Intrinsic Security*

## F.    M2M/IoT in Smart Cities and Smart Infrastructure

3.51 Smart cities being the convergence of IT, communication, and diverse engineering technologies designed to cater to a nation's integrated critical infrastructure requirements comprehensively, is a mission critical deployment needing the highest possible grade of security. Different agencies have projected huge growth (albeit different numbers in different time scales) for the M2M/IoT devices, deployments, and business in the next decade. The sheer wide spectrum of applications of this paradigm, be it consumer, enterprise, industrial, commercial, infrastructure, somehow ensure that the buzz does not die down, in spite of non (or very slow) proliferation of the paradigm on ground.

3.52 However, beyond leveraging M2M/IoT, and ICT in the digitization of Institutional, Economic, Social, and Governance Infrastructures of a city, the physical infrastructure regarding IoT devices are expected to grow exponentially in India. For example, in next five years, more than 250 million Smart Electricity Meters are going to be procured and deployed under the NSGM (National Smart Grid Mission)[19]. All these 250 million Smart Meters are going to use Communication Modules and Gateways/DCUs (Data Concentrator Units). At a conservative figure of one DCU/Gateway to 500 Smart Meters, 250 million Communication Modules, and 0.5 million DCUs/Gateways shall be needed for the last mile communication in the Smart Metering (AMI) Deployments alone.

3.53 Even if the unified Communication Infrastructure is deployed, the number of sensor Communication modules is not going to reduce; only the DCUs/Gateways needed shall reduce but shall need enhanced features and design complexities.

## G. Communication and Network Infrastructure

3.54 The spectrum requirement for M2M/IoT services will be based on the technology through which the particular service is extended. A wide range of existing and emerging technologies can be used to provide M2M services. M2M/IoT can be deployed using a wide range of different protocols based on their connectivity requirements and resource constraints. It can use both wireline and wireless networks. Many of the devices and the services offered through them will require flexibility and mobility, and, hence, would prefer wireless network.

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[19] https://smartutilities.net.in/2020/06/28/energy-transition/

the devices and the services offered through them will require flexibility and mobility, and, hence, would prefer wireless network. These can include short-range radio protocols such as ZigBee, Bluetooth, and Wi-Fi, cellular networks, or bespoke networks for M2M like Sigfox, LoRa, etc.

### i.  Licensed Access Spectrum

3.56  Considering the Indian scenario as well as the global deliberations on the spectrum for International Mobile Telecommunications, much more spectrum is expected to come under the ambit of IMT usage. The cellular mobile technologies are growing and developing at fast pace encompassing various use cases including IoT, M2M, and other communication needs of a Smart City.

3.57  The telecom network infrastructure is ready to be leveraged for providing connectivity and services in M2M. Further, the telecom access technologies are rapidly evolving to meet the requirements of M2M communication/ IoT. For example, narrowband IoT (NB-IoT), EC-GSM, and LTE-M are new cellular access technologies, specifically tailored to form an attractive solution for emerging low power wide area (LPWA) applications. Operation in licensed spectrum also provides predictable and controlled environment, which enables efficient use of the spectrum to support massive volumes of devices. The incumbent telecom operators are natural candidates for providing connectivity and services in M2M sector.

3.58  The TSPs should harness the ready availability of their networks, all over India to provide M2M connectivity and services. The telecom operators (ISPs/TSPs) viz. CMTS, UASL, and UL holders can either offer customized M2M services on their own or they can lease their resources to resellers. The resellers of telecom services in the country are covered under UL (VNO) licensing regime.

### ii. Unlicensed Access Spectrum

3.59   In India, two bands, 2.4 GHz (2.400–2.4835 GHz) and 5.8 GHz (5.8255.875 GHz), have earlier been defined as License-exempt bands for indoor and outdoor applications. In addition, now 5.15–5.35 GHz, 5.470–5.725 GHz, and 5.725–5.875 GHz are also available for indoor and outdoor uses in unlicensed bands. The Telecom Regulatory Authority of India has recommended to DoT to de-license the V-band (57–64 GHz band) for indoor and outdoor access applications like Wi-Fi hotspots, etc. In sub-GHz band 433–434 MHz and 865–867 MHz are license exempt for indoor applications. TRAI, while making recommendations on M2M dated 5th September 2017, has already recommended to de-license additional 1 MHZ frequency band at 867–868 MHz and a chunk of 6MHz in 915–935 MHz band.

### iii. BharatNet

3.60   The BharatNet initiative has been rolled out to realize major objectives of the Digital India vision. It aims at establishing a highly scalable network infrastructure accessible on a non-discriminatory basis, to provide on-demand, affordable broadband connectivity for all households, and on demand capacity to all institutions. It is a three-phased initiative to provide broadband access to 2,50,000 Gram Panchayats (the rural/village Local Bodies) through a network of Optical Fibre Cable (OFC). As per August 2020 data[20], total OFC laid so far under the scheme is 4,49,400 kilometers. Connectivity to approximately 1,55,738 Gram Panchayats has already been provided. The government is also working extensively on providing public Wi-Fi hotspots for affordable access and offloading data from cellular networks. As of now, Wi-Fi hotspots have been installed in 68,044 Gram Panchayats. Approximately, 1,96,436 Fibre to the Home (FTTH) connections have been provided on BharatNet infrastructure.

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[20]http://bbnl.nic.in/

## CHAPTER 4
## SMART CITIES MISSION – INDIA

### A. Background –The India Perspective

4.1 In the approach to the Smart Cities Mission, the objective is to promote cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment and application of 'Smart' Solutions.

4.2 The Biggest Challenge: Livelihoods:

- India will have about 400 million additional persons in the labour force by the year 2050.
- Agriculture and related activities that provide subsistence to about 220 million of the current workforces of 500 million cannot absorb this additional labor without further reducing levels of earnings.
- There has to be a massive transfer of people from primary to secondary and tertiary sectors, and from rural to urban areas.
- Industries and businesses are moving away from megacities into lower order cities or rural locations, while the informal sector is moving into the megacities.
- It is the non-polluting tertiary activity and growth of select informal sector that are driving the limited urbanization in million plus cities.
- Informal livelihoods must be integrated into urban plans and zoning regulations: unorganized workforce gains access to markets and basic amenities.

4.3 Other challenges:

- Holistic Thinking
- Selecting appropriate role models
- Promoting Innovation
- Energy:
  - o Integrate Energy and Waste Management
  - o Promote Low Carbon Mobility
- Building Construction:

- o Integrate Building Systems and City Networks/Systems
- o Advance Materials Sciences
- o **T**otal **Q**uality **M**anagement
- Urban Management:
  - o Use (hygienic) Big and Open data for simulation and modeling
  - o Revamp curricula in architecture, planning, engineering
  - o Study Urban Networks and Systems
  - o Converge networks and technologies through IoT, M2M, and standardization
  - o Command and Control Centers

4.4 India: Areas of concern–Housing, Slums, Overcrowding, Public Safety, Garbage, Pollution, Infrastructure, Transportation, Disaster Management, Education, Healthcare, Governance, Accountability, Transparency.

4.5 Leveraging India's uniqueness: Socio-Economic Disparity, Religion, Co-existence, Interdependence, Non-demanding Citizens, Collective Voice, Tolerance, Coping Mechanism, Youth, Growth, Entrepreneurial Spirit. Can Technology help leapfrog?
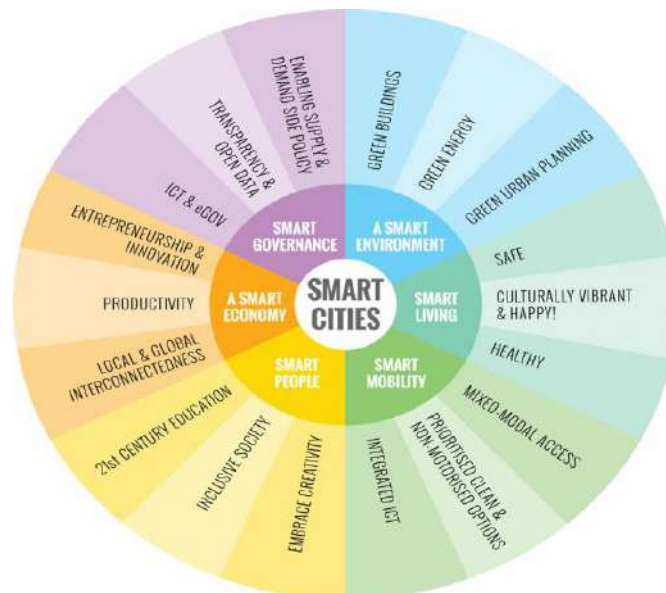


*Figure 4.1: Smart Cities*

4.6 India Opportunities*:*

- UID Integration with Planning and Execution

- GIS enables integration of planning, finance and management
- Fast growth in availability of Big Data
- 1143.91 billion wireless subscribers[21]
- 683.77 million wired and wireless Broadband subscribers
- Urban tele-density – 137.81
- Youthful society can fully utilize 'Smart' paradigm
- Innovation and Enterprise Potential (Frugal Technologies)
- IT industry among fastest growing in the country
- Under Common Service Center (CSC) 2.0 scheme, at least one CSC will be set up in each of the 2.5 lakh Gram Panchayats (GPs) across the country. CSCs functioning under the existing scheme will also be strengthened and integrated with additional 1.5 lakh CSCs across the country.

## B. Smart Cities Mission

4.7 India began its Smart Cities journey in June 2015 with the launch of a 100 Smart Cities Plan with the following initial Imperatives:

- To provide a secure and sustainable Basic Infrastructure and environment
- To use Smart Solutions to improve the Infrastructure, Services and quality of life of its citizens
- To Rely on Area-Based Development

4.8 To set examples that could be replicated both within and outside the Smart City and catalyze the creation of similar Smart Cities. The objective of the Smart Cities Mission[22] is to build the next generation of Indian cities, where infrastructure is easily accessible and affordable, and where citizen-government engagement is efficient and effective. Accordingly, the purpose of the Smart Cities Mission is to drive economic growth and improve the quality of life of people by enabling local area development and harnessing technology, especially,

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[21]Source: TRAI, Telecom subscription data May 2020
[22]http://smartcities.gov.in/upload/uploadfiles/files/SmartCityGuidelines(1).pdf

technology that leads to Smart outcomes. Area-based development will transform existing areas (retrofit and redevelop), including slums, into better-planned ones, thereby improving livability of the whole City. New areas (greenfield) will be developed around cities in order to accommodate the expanding population in urban areas. Application of Smart Solutions will enable cities to use technology, information, and data to improve infrastructure and services. Comprehensive development in this way will improve quality of life, create employment, and enhance incomes for all, especially the poor and the disadvantaged, leading to inclusive cities.

### i. Smart City Features

4.9    Some typical features for comprehensive development in Smart Cities as envisaged by the Smart Cities Mission are:

- Promoting mixed land use in area-based developments–planning for 'unplanned areas' containing a range of compatible activities, and land uses close to one another, in order to make land use more efficient. The States will enable some flexibility in land use and building by-laws to adapt to change;
- Housing and inclusiveness – expand housing opportunities for all;
- Creating walkable localities – reduce congestion, air pollution, and resource depletion, boost local economy, promote interactions, and ensure security. The road network is created or refurbished not only for vehicles and public transport, but also for pedestrians and cyclists, and necessary administrative services are offered within walking or cycling distance;
- Preserving and developing open spaces – parks, playgrounds, and recreational spaces in order to enhance the quality of life of citizens, reduce the urban heat effects in Areas and generally promote eco-balance;
- Promoting a variety of transport options – Transit Oriented Development (TOD), public transport, and last mile Para-transport connectivity;

- Making governance citizen-friendly and cost effective – increasingly rely on online services to bring about accountability and transparency, especially, using mobiles to reduce cost of services, and providing services without having to go to municipal offices. Forming e-groups to listen to people and obtain feedback and use online monitoring of programs and activities with the aid of cyber tour of worksites;

- Giving an identity to the city – based on its main economic activity, such as local cuisine, health, education, arts and craft, culture, sports goods, furniture, hosiery, textile, dairy, etc.;

- Applying Smart Solutions to infrastructure and services in area-based development in order to make them better. For example, making areas less vulnerable to disasters, using fewer resources, and providing cheaper services.

ii.  **Key elements of Smart City Proposals[23]**

- Area Based Development:
    - Only one 'Area' should be selected.
    - Area delineated should be contiguous, and not at separate locations in the city.

- Either of three types of development:
    - Retrofitting (approx. 500 acres),
    - Redevelopment (approx. 50 acres) or
    - Greenfield development (approx. 250 acres)

- Pan-City Solution
    - Cities may propose one or two such Smart Solution

iii.  **Indian Smart Cities – Key Focus Areas**

- Integrated Command Centre and Dashboard

- Citizen Services

- Unified and Secure ICT Backbone

- Energy, Water and Solid Waste Management

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[23]http://smartcities.gov.in/upload/uploadfiles/files/SmartCityGuidelines(1).pdf(page 8)

- Integrated Transport System

- Cyber and Network Security

- City Livability Index launched by Ministry of Urban Development

### iv. Smart city Mission-Updates[24]

- Total Urban Population Impacted **99,630,069**

- Total Cost of Projects – **2,05,018** Crores

- Total Area-Based Development Cost –**164,204**Crores

- Total Pan-City Solution Cost – **38,914** Crores

*Figure 4.2: Smart Solution[25]*

4.10   To manage an ever-increasing population in the cities, it is important that the infrastructure in the cities are upgraded and managed by ICT technologies to make them sustainable in the long run. At present, civic agencies spend a meagre amount on ICT. However, as per one survey[26], about 80% civic agencies allocate less than 1% of their budgets to ICT in the country.

4.11   The core of a Smart City is the Information and Communications Technology (ICT) infrastructure. It is the only horizontal that integrates

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[24]https://smartnet.niua.org/smart-cities-network
[25]http://smartcities.gov.in/upload/uploadfiles/files/SmartCityGuidelines(1).pdf
[26]http://articles.economictimes.indiatimes.com/2014-11-26/news/56490712_1_ict-cent-schneider-electric-india

all the verticals of a smart city. The concept of smart city cannot be successful without a robust, technology neutral, and dynamic ICT infrastructure.

4.12 Smart cities in India will herald in an ICT infrastructure with millions of connected devices, sensors, Internet of Things (IoT), M2M communications, Cloud computing, Big data, etc. Since most of these technologies/services are still evolving, in order to ensure smooth and uniform roll-out of smart cities in the country, it is incumbent to have a common framework in place for ICT and related activities at the planning stage of city implementation itself. Such a regulatory framework will provide clarity to various stakeholders of smart city on the ICT roadmap for the city.
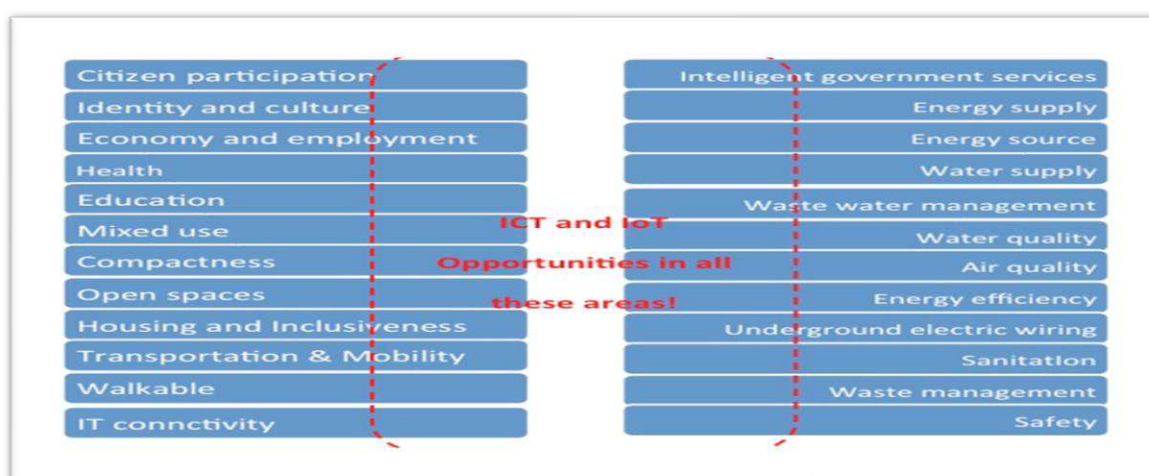


*Figure 4.3: ICT and IoT Opportunities in Smart Cities*

4.13 Smart Cities Mission of the Government is set to catalyzing the creation of similar Smart Cities in various regions and parts of the country. The core infrastructure elements[27] in a smart city would include:

- adequate water supply,
- assured electricity supply,
- sanitation, including solid waste management,
- efficient urban mobility, and public transport,
- affordable housing, especially for the poor,

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[27]http://smartcities.gov.in/upload/uploadfiles/files/SmartCityGuidelines(1).pdf (Page 5)

- robust IT connectivity, and digitalization,
- good governance, especially e-governance, and citizen participation,
- sustainable environment,
- safety and security of citizens, particularly women, children, and the elderly, and
- health and education.

4.14  As far as Smart Solutions are concerned, the above-mentioned list is an illustrative list only, and cities are free to add more applications. The Central Government has formed a national level monitoring Committee known as the Apex Committee (AC). The AC is headed by the Secretary, MoHUA, and comprises representatives of related Ministries, States/UTs, SPVs, and organizations. Apex Committee[28] approves the proposals for Smart Cities Mission, monitor their progress, and releases funds. It may be noted that the selection process of Smart Cities is based on the idea of Competitive and Co-operative Federalism and follows a Challenge process to select cities in two stages. The AC provides overall guidance and plays an advisory role to the Mission. Its key responsibilities are given below:

4.15  Review the list of the names of Cities sent by the State Governments after Stage 1.

- Review the proposals evaluated by panel of experts after Stage 2.
- Approve the release of funds based on progress in implementation. Recommend mid-course correction in the implementation tools as and when required.

**v.    Sector-wise investment**

4.16  Figure 4.4 depicts the sector-wise investment of Mission. The strategic components of area-based development in the Smart Cities Mission, which include city improvement (retrofitting), city renewal (redevelopment), and city extension (greenfield development) have the highest share of investment, followed by Urban Mobility.    More

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[28]http://smartcities.gov.in/content/innerpage/national-level.php

emphasis has been given to projects related with deployment of IT connectivity and digitalization (figuring one among top five investment portfolio).
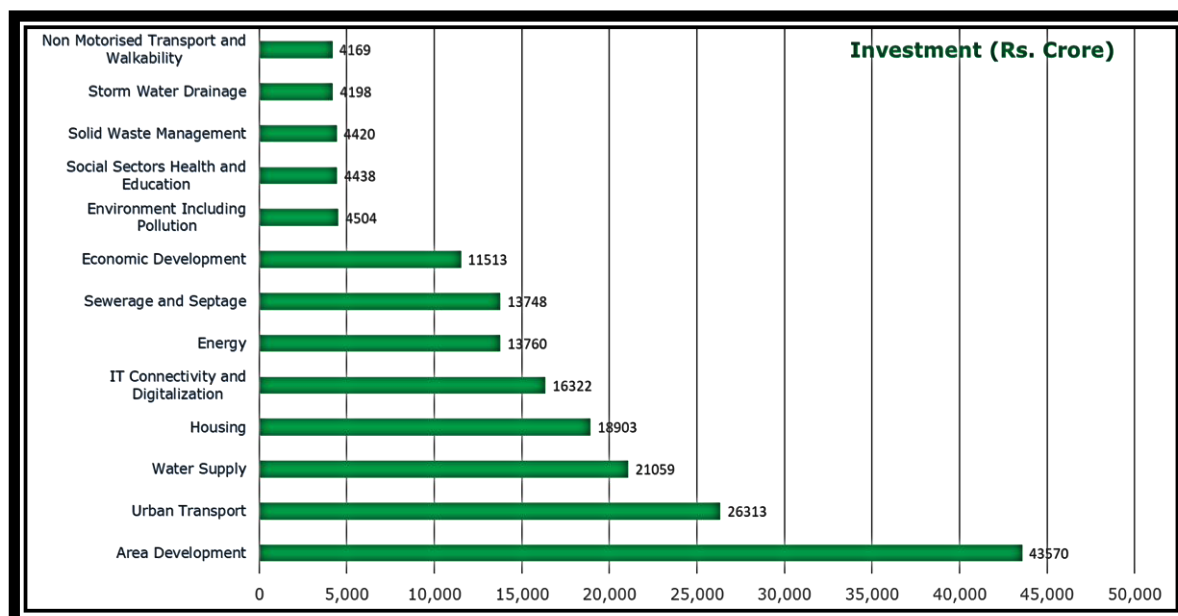


*Figure 4.4:   Sector-Wise Investment of Smart City Mission*

### vi.    Financial Landscape

4.17  The execution of projects in different Smart Cities is through joint ventures, subsidiaries, public-private partnership (PPP), turnkey contracts, etc., suitably dovetailed with revenue streams of State Governments' Schemes. The project cost of each Smart City proposal is varying depending upon the level of ambition, model, and capacity to execute, and repay. Government grants of both the Centre and State are being leveraged to attract funding from internal and external sources. The success of project implementation will depend upon the robustness of SPV's revenue model and comfort provided to lenders and investors.

4.18  State Governments have successfully set up financial intermediaries, which is tapping for financial resources such as PPP models to accomplish the mission.

## C. Digital India Mission

4.19 The Digital India Mission envisaged by the Government is a key enabler in the smart city initiative. The Digital India programme is centered on three key vision areas:

### (i) Digital Infrastructure as a Utility to Every Citizen:

- Availability of high-speed internet as a core utility for delivery of services to citizens
- 2,50,000 village Panchayats would be covered under the National Optical Fibre Network (NOFN)
- Cradle-to-grave digital identity to citizens that is unique, lifelong, online, and authenticable to them
- Mobile phone and bank account enabling citizen participation in digital and financial space
- Easy access to a Common Service Centre
- Shareable private space on a public cloud
- Safe and secure cyber-space

### (ii) Governance and Services on Demand

- Seamlessly integrated services across departments or jurisdictions
- Availability of services in real time from online and mobile platforms
- All citizen entitlements to be portable and available on the cloud
- Digitally transformed services for improving ease of doing business
- Making financial transactions electronic and cashless
- Leveraging Geospatial Information Systems (GIS) for decision support systems and development

### (iii) Digital Empowerment of Citizens

- Universal digital literacy
- Universally accessible digital resources
- Availability of digital resources/services in Indian local languages
- Collaborative digital platforms for participative governance
- Citizens not required to physically submit Govt. documents/ certificates

4.20 The India Stack: For a successful implementation of integrated architecture, it is essential to chart out various government departments and their evolving technology needs in the next few years and find a common ground. Technology-assisted governance models and platform-based implementation practices based on India Stack (JAM) should be a key foundation. India Stack[29] refers to the ambitious project of creating a unified software platform to bring India's population into the digital age. "India Stack is a set of APIs that allows governments, businesses, startups, and developers to utilize a unique digital Infrastructure to take India towards presence-less, paperless, and cashless service delivery". The four "distinct technology layers":

- The Presence-less Layer is where a universal biometric digital identity allows people to participate in any service from anywhere in the country.

- The Paperless Layer is where digital records move with an individual's digital identity, eliminating the need for massive amount of paper collection and storage.

- The Cashless Layer is where a single interface to all the country's bank accounts and wallets to democratize payments. And

- The Consent Layer is which allows data to move freely and securely to democratize the market for data.

4.21 India Stack is the largest open API in the world. Since its deployment, India has been organizing hackathons to develop applications for the APIs. India Stack is being implemented in stages, starting with the introduction of Aadhaar "Universal ID" numbers in 2009. These are linked to biometrics (fingerprints), and, authentication by Aadhaar is required for accessing many more services and subsidies. This raises issues of privacy, and surveillance, especially, as much of the users' interface is via mobile phones.

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[29]https://www.indiastack.org/about/
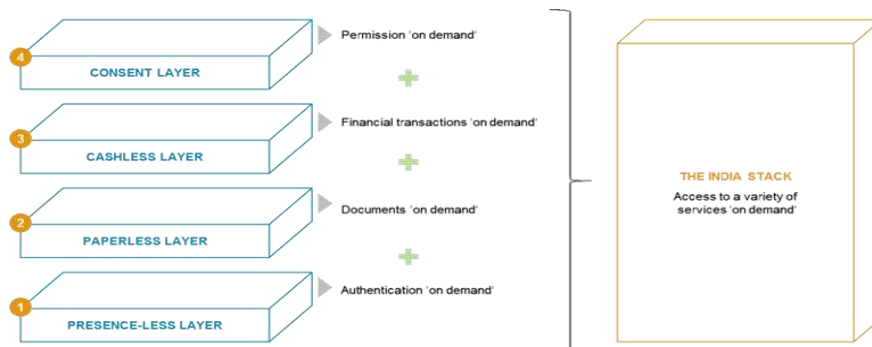
*Fig 4.5: India Stack*

4.22   The next stages were the introduction of eKYC (electronic Know Your Customer), which enables paperless and rapid verification of address, identity, etc., followed by e-Sign, whereby users attach a legally valid electronic signature to a document, and UPI (Unified Payments Interface) enabling cashless payments, and most recently, Digital Locker, a platform for issuance and verification of documents and certificates. Observers have argued that India Stack could fast-track the move to digital payment systems across the developed world and mark the end of cash.
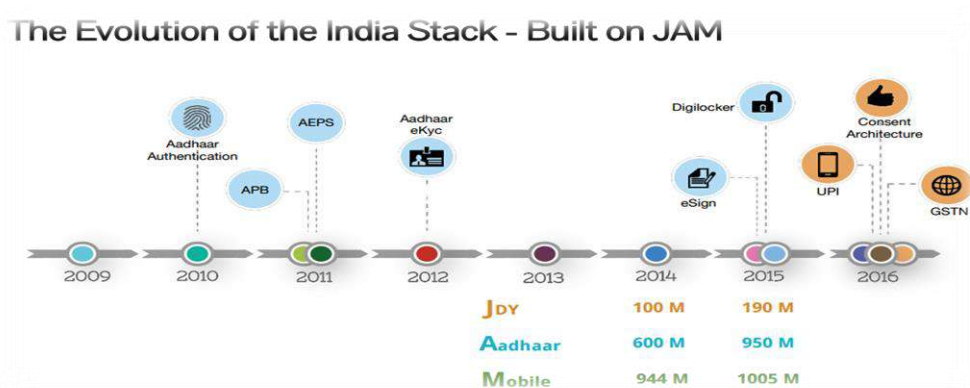


*Figure 4.6: Evolution of the India Stack[30]*

## D. Smart Cities Mission and Emergent Technologies

### i.      Artificial Intelligence

4.23   Artificial Intelligence (AI) is helping machines to learn, reason, act, and adapt to the real world, thus, amplifying human capabilities and

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[30] https://recro.io/blog/india-stack-the-high-tech-solution-to-billion-problems/

automating tedious tasks. The cognitive capability of strong AI is much more than that of humans, and AI would outperform humans at nearly every cognitive task. In the past few years, attention and energy poured into AI has gained prominence due to increased computing power of computers, increased speed, size, and variety of data the businesses are generating, and the development of technologies through which data can be efficiently stored. AI can perform tasks, such as identifying patterns in the data, more efficiently than humans, enabling businesses to gain more insight out of their data.

4.24 Smart cities need Artificial Intelligence: There is an interdependence the emerging technologies such as IoT and Artificial Intelligence (AI). IoT will produce a big haystack of data, and using the data AI can enable optimized productivity across industries through various means such as predictive maintenance of equipment, inventory management, etc. Artificial Intelligence can also help cities to improve healthcare system, avoid accidents and crimes, and optimize the use of public utilities.

4.25 Machine learning, an AI technology, brings the ability to automatically identify patterns and detect anomalies in the data that sensors and devices generate. It has significant advantages over traditional business intelligence tools for analyzing IoT data, including being able to make operational predictions earlier and with greater accuracy. Other AI technologies such as speech recognition and computer vision can help extract insight from data that used to require human review.

**Impact of AI and IoT on social and economic fabric of smart cities**

4.26 AI applications are actively growing in numbers, thus, improving people's lives and creating positive change in the world. Technological advances in AI promises to be pervasive, with impacts in health, economics, security, and governance. In combination with other emerging and converging technologies such as Internet of Things (IoT), AI has the potential to transform our society through better decision-making and improvements to the human condition. Apart from the various use case, applications based on Artificial Intelligence in smart cities are helpful in video surveillance, face-detection, and many more

security related aspects. AI can also be utilized for energy production based on the meteorological forecasts. Connected buildings allowing to monitor data, which can be used to optimize energy consumption through AI. City traffic management has huge potential in leveraging the AI with the help of IoT/M2M by installing Adaptive traffic lights that could ease congestion at choke points.

4.27 Other areas of AI use cases in smart cities could be health, environment, and public safety. It is wise to choose first use case carefully and then extend the solution to new areas and technologies. Over a period, AI will eventually help the smart cities to improve the services and bring in more efficiency in its operations and serving the customers.

### ii. 5G ROLL-OUT

4.28 The National Digital Communication Policy-2018 (NDCP-2018), released on 26th September 2018[31], envisions supporting India's transition to a digitally empowered economy and society by fulfilling the information and communications needs of citizens and enterprises by establishment of a ubiquitous, resilient, and affordable Digital Communications Infrastructure and Services. Timely deployment of 5G in India is very essential for achieving the objectives envisaged in NDCP-2018. 5G will further push the Digital India program and will help in making government's digital services available to all.
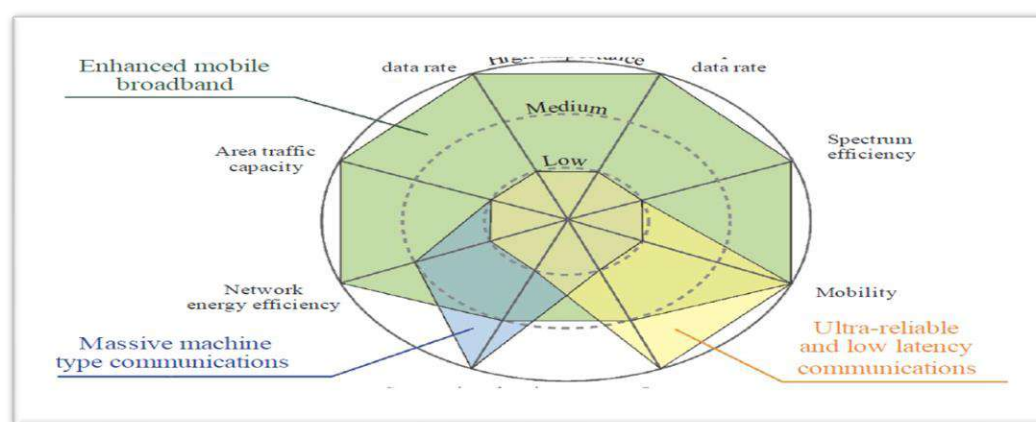


*Figure 4.7: Key performance requirements in different usage scenario (Source: ITU)*[32]

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[31]https://dot.gov.in/sites/default/files/Final%20NDCP-2018_0.pdf
[32]https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2083-0-201509-I!!PDF-E.pdf

4.29　5G use cases can be categorized into three different classes, namely, enhanced Mobile Broadband (eMBB), massive Machine-Type Communication (mMTC), and Ultra-Reliable Low Latency Communications (UR-LLC). The requirements for the use-case class, and the use cases within each class vary significantly. Figure 4.7 shows the key performance requirements in different usage scenarios.

**eMBB**: eMBB addresses the human-centric data-driven use cases for access to multi-media content, services, and data. This usage scenario comes with new application areas such as virtual reality, video monitoring, mobile cloud computing, $360^o$ Ultra-High-Definition (UHD) video streaming, real-time gaming, etc., and new requirements such as hotspot, wide area coverage, etc., in addition to existing Mobile Broadband applications.

**UR-LLC**: This use case has stringent requirements for capabilities such as throughput, latency, and availability. It will support the delivery of critical communications. Some examples include wireless control of industrial manufacturing or production processes, remote medical surgery, distribution automation in a smart grid, transportation safety, autonomous cars, etc.

**mMTC**: This use case is characterized by a very large number of connected devices, typically, transmitting a relatively low volume of non-delay-sensitive data. Devices are required to be low cost and have a very long battery life. This use case covers IoT applications. Some examples include health monitoring wearables, smart cities with smart grids, smart transport systems, and smart homes, etc. The use cases pertaining to massive Machine Type communications will directly help in the implementation of Smart Cities development across verticals.

### E. Indexes /Indicators Useful for Smart Cities in India
#### i. 'Ease of Living Index'

4.30　Considering the requirement of assessing the outcome-based initiatives by various cities, Ministry of Housing and Urban Affairs (MoHUA)

issued framework on 'Ease of Living' Index[33] for cities in June 2017. The framework envisages the use of indicators adapted from various national/international indicator sets and service-level benchmarks. The objective of framing the index was to enable a shift to data-driven approach in urban planning and management and promote healthy competition among cities. 'Ease of Living Index' is a system of performance evaluation, which truly reflects the evolution of the ease of living of Indian cities in consonance with these needs.

4.31 Ease of Living Index framework comprises of four pillars, namely, Institutional, Social, Economic, and Physical, which are further broken down into 78 indicators across 15 categories (governance, identity and 'culture, education, health, safety and security, economy, affordable housing, land use planning, public open spaces, transportation and mobility, assured water supply, waste-water management, solid waste management, power, and quality of environment). 2nd Edition of the 'Ease of Living Index 2019' has been released by the government recently.

### ii. 'Municipal Performance Index 2019: Assessment Framework'

4.32 Under another initiative, MoHUA releases "Municipal Performance Index 2019: Assessment Framework"[34] in 2019. Through the index, MoHUA has identified below mentioned four key objectives of the Municipal Performance Index as to:

- Generate information to guide evidence-based policy making;
- Catalyze action to achieve broader developmental outcomes including the Sustainable Development Goals;
- Assess and compare the outcomes achieved by municipal bodies with given set of resources;
- Give citizens an insight into the functioning of local bodies, and build a dialogue between the stakeholders.

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[33]https://pib.gov.in/PressReleasePage.aspx?PRID=1547042#:~:text=%E2%80%9CThe%20'Ease%20of%20Living',based%20on%20the%20liveability%20parameters.
[34] https://smartnet.niua.org/eol19/pdf/MPI_Methodology.pdf

4.33 With the Municipal Performance Index 2019, the MoHUA has sought to monitor the performance of Smart Cities and other million plus population cities. Municipal Performance Index has provisioned for the key enablers that influence the performance of urban local bodies. These enablers are broadly classified into five verticals – Services, Finance, Policy, Technology, and Governance. Performance of the cities can be measured as per the weightage assigned to these five verticals. These are the pillars based on which a performance measurement system that can be adopted at the local level for a granular assessment of performance of these urban local bodies.

### iii. Broadband Readiness Index (BRI)[35]

4.34 The National Digital Communication Policy (NDCP) 2018 acknowledged the need for building a robust digital communications infrastructure leveraging existing assets of the broadcasting and power sectors, including collaborative models involving state, local bodies, and the private sector.

4.35 Accordingly, the policy recommended that a Broadband Readiness Index (BRI) for States and UTs be developed to attract investments and address Right of Way (RoW) challenges across India. The Department of Telecom (DoT) and the Indian Council for Research on International Economic Relations (ICRIER) in July 2019 have signed a Memorandum of Understanding (MoU) to develop a BRI for Indian States and Union Territories (UT). The first estimate will be made in 2019/2020 and subsequently every year until 2022.

4.36 This index will appraise the condition of the underlying digital infrastructure and related factors at the State/UT level. Such an exercise will provide useful insights into strategic choices made by States for investment allocations in ICT programmes. In the spirit of competitive federalism, the index will encourage states to cross-learn, and jointly participate in achieving the overall objective of digital

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[35]https://pib.gov.in/Pressreleaseshare.aspx?PRID=1578920

inclusion, and development in India. The framework is aimed not only to evaluate state's relative development but will also allow for better understanding of a state's strengths and weaknesses that can feed into evidence-based policy making. As a result, ranking and understanding State/UT performance over time will be an important part of the exercise.

## CHAPTER 5
## SMART SOLUTIONS FOR SMARTCITIES

5.1 While several ICT-based smart solutions have already been proposed by cities as part of their Smart City Proposals, the sector is still in a nascent stage, and there is an enormous scope for large-scale innovation to meet the emerging needs of the sector. In this context, the Ministry of Urban Development has launched a scheme[36] for "Promoting Innovative Smart Solutions under Smart Cities Mission, AMRUT and Swachh Bharat Mission". The scheme will provide funding support for industry-sponsored, outcome-oriented projects focused on the needs of ULBs under the Smart Cities Mission, AMRUT, and Swachh Bharat Mission. Few of the important Smart solutions[37] are described in subsequent paragraphs.

### A.    Smart Metering

5.2 Conventionally, meter readers must physically visit and read electricity meters. The manual process of meter reading has many challenges as it lacks the accuracy and efficiency of IoT solutions and higher labor costs. Metered data cannot be collected and analyzed in real time, which results in electricity theft or line loss and decreases revenues. Smart metering solutions for automated metering are used to monitor and track utility consumption. This can be achieved by connecting smart meters or retrofitting smart modules to existing manual meters. Smart metering includes automated meter readings, consumption pattern monitoring and demand-supply management ensuring service level improvements and improved efficiency. Though the smart metering solution is usually provided by DISCOMS, the IoT connectivity can be provided by the common ICT infrastructure.

### B.    Smart Lighting

5.3 Smart lighting solutions enable two-way communication between streetlights and the City Command and Control Centre, providing

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[36]http://smartcities.gov.in/upload/smart_solution/5954cc108b07cInnovation_for_Smart_ Solutions%20FINAL.pdf

[37]https://www.mindteck.com/index.php?/smartcity-solutions

unified control of widely distributed streetlights. Administrators can define and automate the behavior of streetlights based on insights – optimizing energy consumption and enabling predictive maintenance.

## C.    Smart Water

5.4    The Smart water solution is the prominent area of improvement for the smart cities.  It offers several benefits, such as:

- The solution adopts a grid-based water meter system, monitors the pipeline network in real time, and rapidly locates pipeline failures to enable leakage analysis.
- The end user often experiences the errors in manual meter reading. Automatic meter reading effectively solves all these issues, helping to reduce user complaints and improve service quality.
- The real-time data related to water, such as quality, pressure, and temperature, can be managed elaborately and visually to enhance the capabilities of water utilities.

5.5    As per the estimation by Siemens India Ltd., key outcomes could be reduced transmission losses by leakage detection, reduction in the net required water by 20%–30%, recovery of wastewater through water reuse, and recycling of more than 70% of water.

## D.    Smart Grid

5.6    A smart grid is the integration of information and communications technology into electric transmission and distribution networks. There are unprecedented challenges before the electricity supply industry ranging from a supply-demand gap, pilferages and rising maintenance and monitoring costs, etc., which are driving the need for a smart grid. Smart power grid can manage and mitigate incidents such as transformer overloading, theft of electricity, or electric leakage as the real-time information is available, and alarms are automatically generated. The comprehensive analysis of the reports can help identify exceptions, so as to significantly reduce line losses and prevent electricity theft.

5.7    Smart Grid employs innovative products and services together with intelligent monitoring, control, communication, and self-healing

technologies in optimizing the operation of the system, significantly reduce the environmental impact of the whole electricity supply system and deliver enhanced levels of reliability and security of supply. Common ICT infrastructure may be utilized by the smart grid for managing their control system and providing information to smart city data center.

### E.  Smart Traffic (ITS) – Intelligent Transport System

5.8   Rapid urbanization has resulted in higher vehicle density and increased mobility woes. Traffic congestion and transportation management feature amongst top critical infrastructure challenges today. Congestion in cities and on highways is becoming more and more severe every day. Besides economic losses, traffic congestion is pushing up noise and environmental pollution levels to the dangerous levels.

5.9   Intelligent Traffic Management is aimed to monitor vehicle density, adaptive signal monitoring, Speed Monitoring, Number Plate Detection, Traffic Violation, and many more. Integrated Multi-Modal Transport comprises of City Guide Navigator and Multimodal Ticketing Solutions, Intelligent Transport System, Passenger information system, Advanced traveler information guide, Bus stop monitoring, Non-motorized transport (bicycle lanes and walkways), and e-Buses, Hybrid buses, and electric vehicle charging points. Siemens India Ltd. has estimated 15% reduction in road accidents, approximately 30% reduction in traffic violations, 25% increase in public transport usage, and increase in the usage of non-motorized transport (bicycle and walking).

### F.  Smart Video Surveillance

5.10  More and more cities in India have been revamping or renewing their security systems, and more are getting equipped with modern technologies to combat crimes, monitor road traffic, airports, railway, and other infrastructure. 24×7 video surveillance for safety and security has made it possible to solve various criminal instances. Video surveillance will have an important role to play in India's Smart City initiative and its development.

5.11 Video surveillance for safe and smart city have grown up multifold in the last few years. ICT plays an important role in communicating between surveillance systems, transportation sectors, control centers, and service providers for providing traffic management, building management, security services, etc. There are challenges of inter-operability and integrated command and control, those needs to be identified and resolved early. Also, to gain the maximum benefits of the city video surveillance system, an SOP should be put in place to share the footage or face detection analytics of one smart city with another city on need basis to identify and detect the criminals.

## G. Smart Sanitation and Solid Waste Management

5.12 Smart Sanitation is seen as a new way of looking at sanitation issues. Technologies such as the Internet of Things (IoT) and Artificial Intelligence (AI) can leverage and transform the sanitation by collection, and monitoring benefits of real-time data, just like already reshaping many other verticals. Toilets equipped with Wi-Fi or cellular network and smart sensors enable both the continuous capture of consumer data, and the provision of multiple additional services to be bundled with the toilet.

5.13 As part of the area-based development initiatives, Pune Smart city[38] is working to develop a model neighborhood of livability and sustainability matching global standards in the area of Aundh-Baner-Balewadi (ABB) by fully deploying all the 24 smart city features in a "future ready" manner. It has targeted for the 10% wastewater recycling in the ABB region, and zero waste and garbage ABB region through garbage truck augmentation, RFID tracking of vehicles, RFID-based attendance system, and monitoring of garbage areas.

5.14 Integration of GPS, RFID, and communication, technologies make the waste bin identification, and customer information accumulation framework efficient. RFID has numerous applications in the field of

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[38]https://punesmartcity.in/area-based-development-initiatives/

environment and assumed a vital part in solid waste accumulation operations. The GPS and wireless mobile communication technologies can be precisely used for vehicle monitoring and finding out the waste collection bins. It takes the choice for dumping place selection. GPS innovation can show and track vehicle position in subject advanced maps.

## H.    Smart Parking

5.15   Parking of the vehicles has become a widespread issue in urban development as the number of vehicles on the road is increasing rapidly. Smart parking aims to help individually match drivers to parking spots, improve parking space utilization, reduce costs, and improve traffic congestion. Isolated parking data cannot be connected to a unified urban parking management platform. As a result, the platform cannot obtain parking data, and the roll-out of valuable applications such as urban parking guidance and parking space sharing is negatively affected.

5.16   There are various underlying technologies such as – RFID, ZigBee, or NB-IoT, which can be deployed using the operator's network for connectivity. These devices are connected to public networks provided by operators directly or via a Gateway device. These devices can transmit parking data to the cloud management platform efficiently. Siemens India Ltd. has estimated 25%–30% reduction in searching time of parking spaces.

# CHAPTER 6
## STANDARDIZATION, POLICY AND REGULATIONS

6.1      To enable smooth roll-out of any National Level initiative, the Policies, the Regulations, and the Standards play a critical role. A homogeneous approach among these creates a uniform and robust foundation and framework for harmonized deployment of the various heterogeneous infrastructure components to yield the desired outcomes of the National Initiatives.

## A.      Standardization Imperatives[39]

6.2      Cities around the world are making their systems (health, transportation, logistics, water provision, etc.) smarter to deal with the growing problems of urbanization. The aim is to enable these systems to function more flexibly and respond rapidly to changing circumstances, and to better coordinate to provide more efficient solutions to the problems cities face.

6.3      New technologies, including sensing networks, IoT devices, and advanced data/information processing Systems, allow all the city domains to increasingly adopt seamless, interoperable methods to provide city applications and services to its residents. Now, with rapid technology developments and with an increasing convergence between city systems, a new approach is needed. Also, while electrical and electronics standards are vitally important, they form only part of the solutions to smart city requirements.

6.4      Standards provide a foundation to support *innovation.* Standards capture tacit *best practices,* and standards set *regulatory compliance requirements.* Governments worldwide are driving smart cities in order to achieve their policies on energy efficiency, sustainable development, and reliable, resilient, and cost-effective infrastructure and citizen services for the whole community. For a widespread cost-effective deployment, interoperability and 'open interfaces for future extensions'

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[39]BIS Pre-Standardization Study Report - Unified, Secure & Resilient ICT Framework for Smart Infrastructure, (Page 40)

standardized solutions are a necessity. Governments, therefore, also drive smart cities' standardization worldwide.

6.5     Standards-development organizations (SDOs) are busy mapping the imperatives for standardization in the Smart Cities and Smart Infrastructure Domain including IEC, ISO, ITU, IEEE, IETF, along with 3GPP, oneM2M, and other regional and National SDOs like ETSI, CEN, CENELEC, NIST, BSI, DKE, DIN, JSA, and BIS. Furthermore, many standardization bodies and industries from the ICT and infrastructure industry consider Smart City as a priority issue. All the Global SDOs, Industry Consortia, and Fora have been addressing the development of Reference Frameworks, Architectures, and Standards in this domain.

6.6     The extensive work done by various global SDOs has very comprehensively defined the frameworks and roadmap for future Information and Communications Technology (ICT) Infrastructure. However, the new paradigm of Internet of Things has given rise to a new aspect of the way humans, machines, and things are going to communicate with each other in the very near future. Internet of Things is all about "heterogeneous" and "aware" devices interacting to simplify people's life in some way or the other. The heterogeneity of the IoT paradigm has made it imperative to have a fresh look at the prevalent architectures and frameworks of the ICT Infrastructure being deployed or being developed.

6.7     The multiplicity of technologies[40] and their convergence in many new and emerging markets, however, particularly those involving large-scale infrastructure demand a top-down approach to standardization starting at the system or system-architecture rather than at the product level. Therefore, the systemic approach in standardization work can define and strengthen the systems approach throughout the technical community to ensure that highly complex market sectors can be properly addressed and supported. It promotes an increased co-

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[40]BIS Pre-Standardization Study Report - Unified, Secure & Resilient ICT Framework for Smart Infrastructure

operation with many other standards-developing organizations and relevant non-standards bodies needed on an international level. Further, standardization needs to be inclusive, top down, and bottom up; a new hybrid model with comprehensive approach is needed.

6.8 There is a need to create and suggest frameworks to achieve the interoperability among all the devices and layers at every interface in the networks, be it a smart home network, a smart building network, a smart city/community network, or the smart grid network that shall enable the stakeholders to prepare a set of detailed standards based specifications to cater to specific/defined/fixed use cases followed by development of a Compliance Testing Frameworks.

## B. The Benefits of Standards to Smart, Sustainable Cities and Communities[41]

6.9 Most of the city planners and SDOs agree that standards could help by:
- Enabling integration between systems, and between the physical and the digital Underpinning common understanding
- Helping to obtain funding, and to prevent vendor lock-in
- Enabling scale
- Standards on physical and digital environments that ensure accessibility for all citizens

6.10 It is well accepted that the development of relevant standards will help to deliver a smarter city in the following ways:
- Developing and managing an overall SSCC strategy
- Implementing and managing major SSCC projects
- Doing things smarter
- Putting in place a solid foundation

## C. Implementing Major New Smart/Sustainable City Projects[42]

6.11 The implementation of major new smart sustainable city projects presents many key challenges. They are often cross-cutting–needing

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[41]BIS Pre-Standardization Study Report - Unified, Secure & Resilient ICT Framework for Smart Infrastructure (Page 40)
[42]BIS Pre-Standardization Study Report - Unified, Secure & Resilient ICT Framework for Smart Infrastructure (Page 41)

joint investment procurement and management by a variety of agencies within the city that may not be used to working together. They tend to be transformational in nature, requiring completely new ways of working by those agencies involved. They are also new and pioneering, and it can be difficult to get the evidence needed to support the investment required.

6.12 Standards can help here in several ways. They can help with:

- Improving Assessment and Funding of Smart/sustainable City Initiatives: with common agreed references and tools for stakeholders.
- Improving and facilitating procurement, especially of these tailor-made solutions adapted to different circumstances.
- Supporting the take-up of new practices for industry.
- Supporting the implementation of new infrastructure/equipment platforms; standards can contribute to lowering investments costs, facilitating integration with existing infrastructure, and controlling operational costs.

## D. India Perspective for Smart Infrastructure:

6.13 The perspective of Smart Cities is a little different in the developed nations from the developing nations like India. Smart City paradigm is about integration of all the utilities, infrastructure, and citizen services on a single platform and a unified dashboard for efficient, reliable, and resilient operation of the city. In developed nations, when they started discussing the Smart City paradigm, most of their respective utilities were already smart, with their respective albeit siloed platforms and dashboards. Hence, what they needed was to just build/create another layer of IT Platform and dashboard to get all the data on this common platform and providing a unified, comprehensive, and user-friendly view of the O&M of the whole city. We in India have an opportunity to look at the Smart Infrastructure Design with a fresh perspective that shall be rather more relevant in the coming decades.

## E.    Categorizing Standardization Activities

6.14    The amount of activity in smart city standardization is truly broad and covers many areas. Some groups, such as Institute of Electrical and Electronics Engineers (IEEE), are looking at detailed technology aspects related to smart city networking or transportation, while others, such as the International Organization for Standards (ISO), have a focus on higher-level activities such as strategies for smart city governance or procurement. A useful way to categorize these different types of standardization activities is to group them by level of abstraction into strategic, process, and technical. (See the British Standards Institution (BSI) PD 8100 smart city overview[43] for more details.)

**Level 1: Strategic.** These are smart city standards that aim to provide guidance to the city leadership and other bodies on the "process of developing a clear and effective overall smart city strategy." They include guidance in identifying priorities, how to develop a roadmap for implementation, and how to effectively monitor and evaluate progress along the roadmap.

**Level 2: Process.** Standards in this category are focused on procuring and managing smart city projects–particularly those that cross both organizations and sectors. Essentially, these offer best practices and associated guidelines.

**Level 3: Technical.** This level covers the myriad technical specifications that are needed to implement smart city products and services so that they meet the overall objectives.

6.15    As stated in the BSI PD 8100: "Strategic-level standards are of most relevance to city leadership, and process-level standards to people in management posts. However, even technical specifications are relevant to people in management posts, as they need to know which standards they need to refer to when procuring technical products and services."

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[43]https://www.bsigroup.com/en-IN/smart-cities/Smart-Cities-Standards-and-Publication/PD-8100-smart-cities-overview/
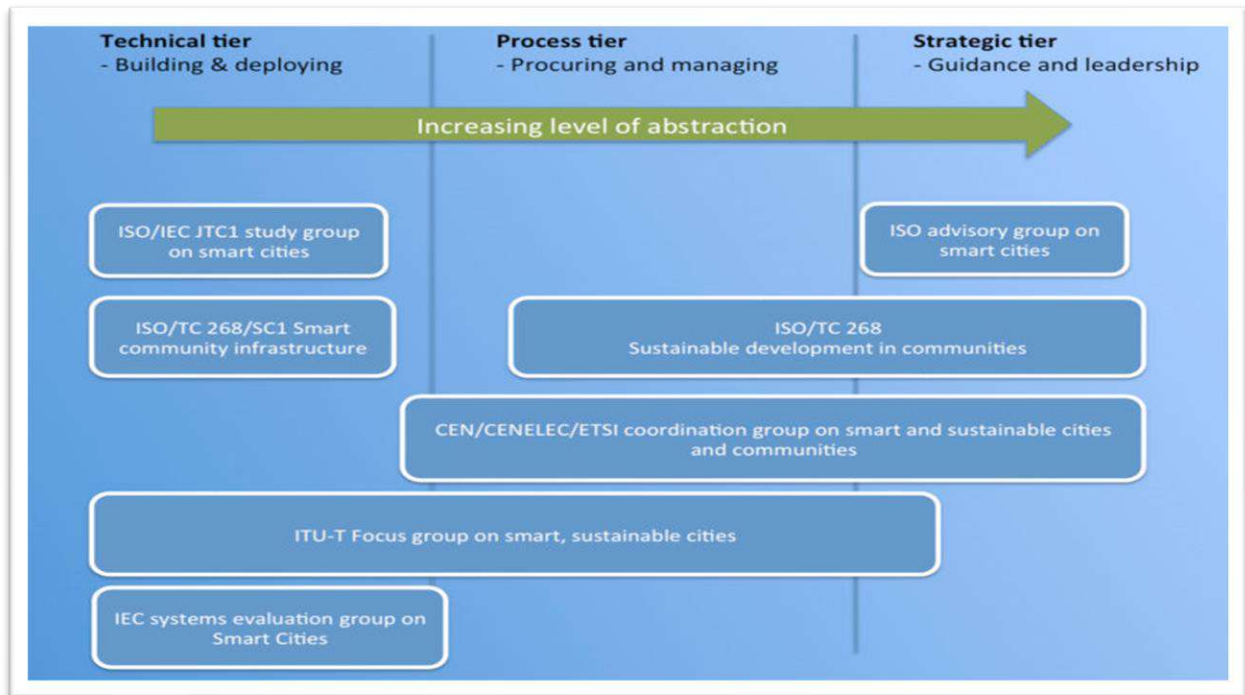
### F.    International Groups for Standards Activities

6.16    The major international groups that have smart city activities include:

- **ISO:** International Organization for Standards is the main global body that national standards bodies work with, and which many of us are familiar with via "ISO certified". ISO has set up a strategy advisory group (SAG) for smart cities, which is helping coordinate ISO activities and has been instrumental in helping in the formation of Technical Committee 268[44], which is developing standards across all three tiers.

- **IEC:** Founded in 1906, the IEC (International Electrotechnical Commission) is an established organization for the preparation and publication of international standards for all electrical, electronic, and related technologies, known collectively as "Electrotechnology." The IEC has a joint technical group with the ISO looking at smart cities, and its own Systems Committee on Smart Cities.

- **ITU:** The International Telecommunication Union is the United Nations' specialized agency for Information and Communication Technologies (ICTs) – It created a Focus Group on Smart Sustainable Cities (FG-SSC) that delivered a series of technical reports. A follow-on group 'Study Group 20' is continuing that work.

- **CEN/CENELEC/ETSI:** In Europe, standards are developed and agreed to by the three officially recognized European standardization organizations: the European Committee for Standardization (CEN), the European Committee for Electrotechnical Standardization (CENELEC), and the European Telecommunications Standards Institute (ETSI). These groups have set up a coordination group focused on smart and sustainable cities and communities. Figure 6.1 places these groups graphically and identifies which subgroups are active in each of the three tiers.

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[44]https://www.iso.org/committee/656906.html

*Figure 6.1: International standards activities and their respective foci*

6.17 Looking at the output from some of these groups, we can now identify ongoing activities or standards and place them into the appropriate categories.

i. **STRATEGIC:** Aimed at the Process of Developing a Clear and Effective Overall Smart City Strategy

- *ISO 37120,* Sustainable Development of Communities–Indicators[45] for city services and quality of life.

- Two ***draft*** ISO standards, also from TC 268, but looking very much at management and strategy, are **ISO 37101**, Sustainable development and resilience of communities–Management systems– General principles and requirements; and **ISO 37102**, Sustainable development and resilience of communities– An overview of this ongoing project can be found on the ISO's website.

- *ISO/TR 37150*– Smart community infrastructures – Review of existing activities relevant to metrics

- *ISO/TS 37151* – Harmonized metrics for benchmarking smartness of infrastructures

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[45]https://www.iso.org/obp/ui/#iso:std:iso:37120:ed-2:v1:en

- *ISO 37152*– Smart community infrastructures – Common framework for development and operation

   ii. **PROCESS:** Procuring and Managing Smart City Projects

- The development by the British Standards Institute[46] of a smart city framework standard (PAS 181) falls into the process category. "It provides practical, "how-to" advice, reflecting current good practice as identified by a broad range of public, private, and voluntary sector practitioners engaged in facilitating UK smart cities."

- Related to PAS 181 is the development of a data concept model for smart cities (PAS 182). This is an interesting activity, as a data model is critical for the development of smart city data hubs and data interoperability issues that are key components of any open data strategy.

   iii. **TECHNICAL:** Implementing Smart City Projects

- A useful overview of the technical activities of the ISO, IEC, and ITU can be found in a report from the ISO/IEC JTC1–Preliminary Report on Smart Cities. This document lays out the smart city space from a technical point of view with a good overview of the technical areas that the ISO, IEC, and ITU are working on, as well as details of their standards work and of the overall activities of JTC1.

- Two technical standards from the ISO/IEC JTC1 group, still under development, are ISO/IEC AWI 30145, Information technology - Smart city ICT reference framework, and the associated ISO/IEC AWI 30146, Information technology–Smart city ICT indicators, which are both looking at the ICT infrastructure needed for smart cities.

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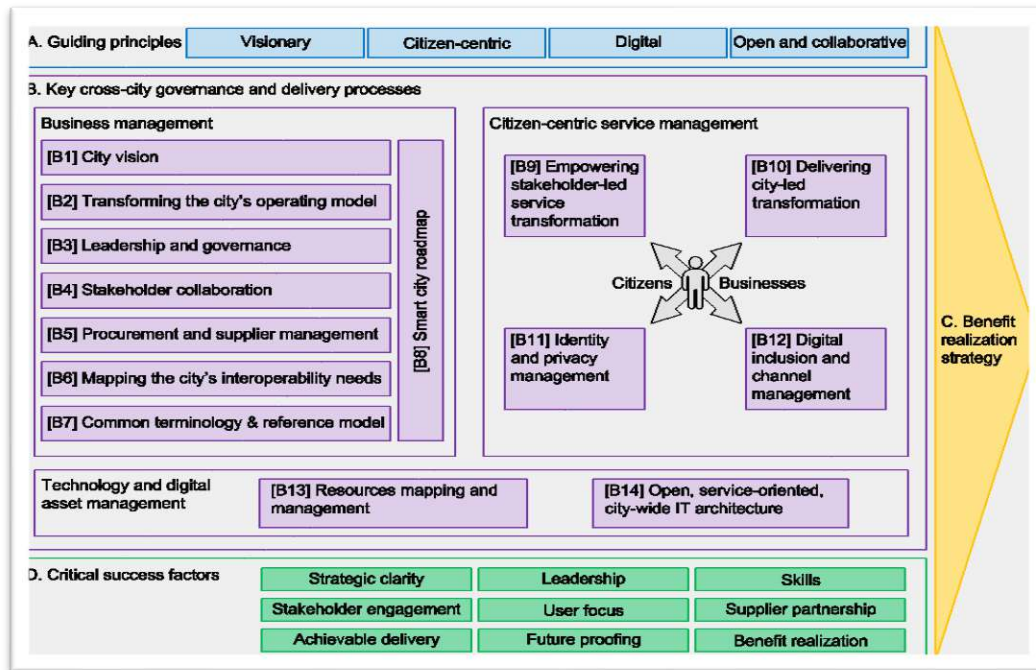[46]https://www.bsigroup.com/en-IN/smart-cities/Smart-Cities-Standards-and-Publication/PAS-181-smart-cities-framework/

*Figure 6.2: Components of open data strategy[47]*

### ii.    M2M/IoT standardization

6.18    The virtual representation of the physical objects (things) is an important part of all the new "smart" applications that are transforming our industry. The Internet of Things (IoT) is going to provide this in an Internet like structure. IoT covers a wide range of technologies from the lower communication layers to application protocols' semantic descriptions of the things, and their properties, services, and application programming interfaces that allow applications to interact with the things in a standard manner.

6.19    With the IoT Architecture Reference Model (IoT-ARM), developed by the EU research project IoT-A (*the European Lighthouse Integrated Project)[48]* such an architectural and service framework already exists. The IEEE P2413 activity for a Standard for an Architectural Framework for the Internet of Things is leveraging the IoT-ARM for further granular work.

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[47] https://bis.gov.in/other/USR_ICT_FSI_V_1_0.pdf Page no. 45
[48] https://cordis.europa.eu/project/id/257521

6.20 One specific issue for IoT is the unique identification of things, which is a pre-requisite for their virtual representation. Various methods for identification have been defined so far like barcodes, RFIDs, or visual identification. IEC (SC3D) and ISO (TC184) have defined requirements and rules for identification systems that will apply for the industrial automation domain. Alignment/interworking with identification schemas used in the various application domains is mainly being addressed by IEEE P2413, OneM2M/ETSI (Transposed in India as oneM2M/TSDSI), ITU, JTC1 SC41, OIC, AllSeen, W3C, OASIS, NIST CPS, IIC, IEC SC3D(v), IEC TC65(v), eCl@ss, ISO TC184(v).

## G.   Policies and Regulations in India

### i.   Ministry of Communications

6.21 Ministry of Communications, after holding wide range of consultations with various stakeholders, released "The National Digital Communications Policy, 2018"[49] in November 2018. The NDCP seeks to unlock the transformative power of digital communications networks – to achieve the goal of digital empowerment and improved well-being of the people of India, and towards this end, attempts to outline a set of goals, initiatives, strategies, and intended policy outcomes. NDCP focusses on creating an ecosystem using 5G Services, where Internet of Things (IoT) and Artificial Intelligence (AI) are mainstream, and connectivity is seamless, designed to improve the quality of e-governance and education, enable financial inclusion, smart cities, and an intelligent transportation system, etc.

6.22 The National Digital Communications Policy aims to accomplish the following Strategic Objectives by 2022:

- Provisioning of Broadband for All
- Creating 4 Million additional jobs in the Digital Communications sector
- Enhancing the contribution of the Digital Communications sector to 8% of India's GDP from ~ 6% in 2017

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[49]https://dot.gov.in/sites/default/files/EnglishPolicy-NDCP.pdf

- Propelling India to the Top 50 Nations in the ICT Development Index of ITU from 134 in 2017
- Enhancing India's contribution to Global Value Chains
- Ensuring Digital Sovereignty

6.23  Ministry of Electronics and Information Technology (MeitY) had published 'Revised Draft IoT Policy' in October 2016[50] whose stated objectives include:

- To create an IoT industry in India of USD 15 billion by 2020. This will also lead to increase in the connected devices from around 200 million to over 2.7 billion by 2020. It is assumed that India's share in global IoT industry would be 5%–6%.

- To undertake capacity development (Human and Technology) for IoT specific skill sets for domestic and international markets.

- To develop IoT products specific to Indian needs in the domains of agriculture, health, water quality, natural disasters, transportation, security, automobile, supply chain management, smart cities, automated metering, and monitoring of utilities, waste management, Oil and Gas, etc.

6.24  The strategy outlined to implement the IoT Policy is through five vertical pillars: demonstration of domain-specific applications, incubation and capacity building, R&D and innovation, incentives and engagements, human resource development, and two horizontal supports: standards and governance structure.

6.25  The initiatives launched for smart cities, smart water, smart environment, smart health, smart waste management, smart agriculture, smart safety, smart supply chain and logistics, smart manufacturing/industrial IoT are part of identification, deployment and demonstration of IoT concepts for solving the nation's challenges and addressing priorities with an inclusive approach.

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[50]'Revised Draft IoT Policy' in October 2016

6.26 Among the states Andhra Pradesh has published its IoT Policy (2016–2020) on 16th March 2016, and Jharkhand has published the Draft IoT Policy in 2017.

**Standardization Initiatives:**

6.27 Bureau of Indian Standards (BIS) and Telecommunications Standards Development Society, India (TSDSI), have dedicated working groups for formulating standards specific to M2M/IoT and Smart Infrastructure. TSDSI is an Organizational Partner (OP) of 3GPP and Partner Type1 of oneM2M. BIS is a founder member of International Organization for Standardization (ISO) and member of International Electrotechnical Commission (IEC) since 1949. BIS and TSDSI are also participating and proposing India-specific requirements at global platforms to address Indian concerns in global standards and facilitate harmonization of Indian M2M/IoT Standards with global standards to reap benefits of compatibility, interoperability, scale, and affordability. India has other organizations too responsible for Standards and Policies in the M2M/IoT domain, such as DoT/TEC, BIS, TSDSI, and MeitY.

**i.  Bureau of Indian Standards**

6.28 Bureau of Indian Standards (BIS)[51] is an autonomous body under the Ministry of Consumer Affairs, Food and Public Distribution, Govt. of India. BIS is the National Standards Body entrusted with formulation of Indian Standards, product certification, and also to represent India at the ISO, IEC, etc.

6.29 The Bureau of Indian Standards (BIS) Act of 2016 has positioned BIS in a leadership position as the National Standards Body (NSB) of India. In order to effectively perform its responsibility as the NSB of India, the Standards National Action Plan (SNAP) has been evolved by BIS. The action plan has prioritized standardization issues ranging from engineering to services, IoT to AI, and smart cities to e-mobilities.

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[51]https://bis.gov.in/

6.30  BIS being the National Standards body, Smart Infrastructure Sectional Committee LITD 28 (Standardization in the field of Smart Cities Electro-technical and ICT aspects) is continuously ensuring that all the standardization activities within India on similar subjects are comprehensively harmonized by monitoring the work progress in TSDSI, DoT/TEC and MeitY and ensuring close collaboration and coordination. Further, BIS LITD 28 continuously maps the work going on in various organizations/forums actively engaged in M2M/IoT Networks promotion to ensure development of latest, India specific, yet globally harmonized ICT, M2M/IoT, Smart Cities, and Cyber Security Standards. BIS LITD 27 on Internet of Things and Related Technologies is the National Mirror Committee of ISO/IEC JTC1/SC41 with the same Title and scope. Recently, BIS has constituted LITD 29 on Blockchain and Distributed Ledger Technologies as the National Mirror Committee of ISO/TC 307 with same title and Scope; LITD 30 on Artificial Intelligence as the National Mirror Committee for ISO/IEC JTC1/SC42 with the same Title and Scope.

6.31  The LITD 28 had also released a Pre-Standardization Study Report on Technical Requirements Analysis of Unified, Secure, and Resilient ICT Framework for Smart Infrastructure in November 2017[52]. This pre-standardization study report is aimed at wider dissemination of knowledge and concerns as well as to help proceed with standard development activities in the respective areas. It provides some critical Actionable Insights for Smart City Planner in the context of Unified Secure and Resilient ICT Infrastructure in Smart Cities. As an outcome of the in-depth studies of Indian requirements, the report illustrates a new Architecture for Unified and Secure ICT Backbone for Smart Cities leveraging the M2M/IoT technologies in a Standardized and interoperable framework.

6.32  The evolved Comprehensively Unified ICT Architecture[53] can be modelled as a "Classic Saucer Champagne Glass" with a wide Flat

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[52] https://bis.gov.in/other/USR_ICT_FSI_V_1_0.pdf
[53] BIS Pre-Standardization Study Report – Unified, Secure and Resilient ICT Framework for Smart Infrastructure

Bottom Base depicting the multitude of Field Devices and sensors, etc. The Saucer Shaped Bowl on the Top depicting being filled with an ever-increasing spectrum of City Applications and Citizens' Services. The Long Stem depicts all the Common Layers viz.: Unified Last Mile Communication, Common Standardized Gateways (application or Vertical Agnostic), Common Service Layer representing the Common Service Functions in the Gateways, as well as, in the Cloud and the Smart City Middleware and City Data Reservoir in the Cloud.

6.33 It is the "Long Stem" of the "Champagne Glass Model" instead of the Short and Narrow Neck in the "Hourglass Model" that brings the comprehensive harmonization, standardization, and interoperability in the Architecture leading to optimization in operational efficiency and Life Cycle Cost of the ICT Infrastructure in any Smart City.

6.34 LITD 28 is working to develop the following Standards for the "Unified Secure and Resilient ICT Infrastructure":
- Unified Last Mile Communication Protocols
- Unified and Secure ICT architecture for Digital Infrastructure
- Unified Framework for Data Semantics for Digital Infrastructure
- Standardized Gateways for Digital Infrastructure

6.35 BIS is coming up with standards for the Unified Gateways and even the Common IT Platform for all the civic Infrastructures on the Cloud. This shall help bring down the CapEx, Opex, Carbon Footprint of the ICT Infrastructure, and make it easier to Secure it and make it Resilient and Trustworthy.

**Study Report on Spectrum Implications:**

6.36 The BIS Smart Infrastructure Sectional Committee LITD 28 has undertaken an in-depth study on the Spectrum requirements for M2M/IoT Applications and Services in the near future, along with comprehensive analysis of Regulatory aspects in this context. This "Study Report on Spectrum Implications" based on "Technical Analysis of RF Spectrum Requirements in Constrained Applications'

Communication Networks for Smart Infrastructure" has been released recently for consideration of Ministry of Communications.

6.37 The Committee is considering developing a Standard with detailed regulatory requirements and rules for IoT devices to operate in the allocated Sub-GHz frequency band spectrum efficiently and in discipline.

**ii.    Telecom Standards Development Society, India (TSDSI)**

6.38 TSDSI is an autonomous, membership based, standards development organization (SDO) for Telecom/ICT products and services in India. TSDSI develops standards for access, backhaul, and infrastructure systems, solutions, and services that best meet India specific Telecom/ICT needs, based on research and innovation in India. TSDSI works closely with global standards' bodies to reflect Indian requirements into International telecom/ICT standards. TSDSI plays an important role in formulation and adoption of voluntary standards in the field of telecommunications encouraging generation of Indian IPRs in this technology-intensive field and gets them incorporated into International standards.

6.39 TSDSI is Partner Type I in the oneM2M project. TSDSI is supporting processes and initiatives of collaborations of oneM2M and various platforms, Open-Source initiatives, and Data Interoperability/Semantics/ Context for various sectors and smart cities.
- Transposition of oneM2M Specifications Rel 2 (comprising 17 specifications and 10 technical reports) into TSDSI Standards. These have been published on TSDSI website.
- Transposition of 295 Specifications of 3GPP (select specifications from Rel 10 to Rel 13) for IMT Advanced (as per ITU-R M.2012-3) into TSDSI Standards.

- TSDSI has been mandated by MoC to develop Standards for Cloud Services Interoperability and adapt 3GPP specifications related to Security.

- MoC set up a High Level 5G Forum to formulate strategy for India to take lead on 5G. TSDSI plays the lead role in terms of technical standards for various facets of "5G Systems" (including, but not limited to, radio and core network).

### iii. Telecom Engineering Center

6.40 Telecom Engineering Center (TEC) is an attached office of the Department of Telecommunications (DoT). TEC formulates standards about telecom network equipment, services and interoperability, the associated conformity tests, and fundamental technical plans. TEC has been appointed as the Designating Authority (DA) on behalf of DoT for conformity assessment and certification bodies located in India to perform testing and certification of telecom products. TEC has also come out with 9 technical reports on M2M detailing sector specific requirements/use cases to carry out gap analysis and future action plans with possible models of service delivery. Since 2015, TEC has been regularly releasing study reports on various topics in M2M/IoT domain.

6.41 The reports published by TEC are as below:
- Gateway and Architecture
- Power Sector
- Automotive (Intelligent Transport System) Sector
- Remote Health Management
- Safety and Surveillance Systems
- Number resource
- V2V/V2I Radio communication and Embedded SIM
- Spectrum requirements for PLC and Low power RF communications
- ICT deployment and strategies for India's Smart Cities: A Curtain Raiser
- Smart Homes

- Communication Technologies in M2M/IoT Domain

- Design and Planning Smart Cities with IoT/ICT

- Recommendations for IoT/M2M Security

6.42 TEC, on 8th January 2019, has released technical report titled "Design and Planning Smart Cities with IoT/ICT"[54]. The report has elaborated upon the role of ICT in Smart Cities and related use cases along with future work to be carried out, work on gap analysis, analyzing the Key Performance Indicators, and studying different Smart City designs worldwide that can be taken as sources of information for the design and development of Smart Cities in India.

6.43 The Department of Telecommunications, Ministry of Communications, and Government of India vide Gazette Notification No. G.S.R. 1131(E) dated 5th September 2017[55] has amended the Indian Telegraph Rules, 1951 (Amendment 2017), to introduce 'Mandatory Testing and Certification of Telecom Equipment'.

6.44 These rules have come into effect from 1st October, 2019. TEC is implementing Mandatory Testing and Certification of Telecom Equipment in India. For the compliance of these rules, testing, and certification, of the telecommunication equipment shall be done with the respective Essential Requirements (ER) documents framed by TEC. TEC is in the process of formulation of ERs for the Mandatory Testing and Certification of Telecom Equipment.

6.45 TEC has also been entrusted the Framing of ERs (Essential Requirements) for Testing and Certification of Smart Devices in M2M/IoT domain. Comprehensive consultations with all the ecosystem stakeholders are being undertaken by TEC senior officials to ensure smooth implementation of the Testing and Certification processes.

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[54]https://tec.gov.in/pdf/M2M/Design%20Planning%20Smart%20Cities%20with%20IoT%20ICT.pdf
[55] https://www.tec.gov.in/mandatory-testing-and-certification-of-telecom-equipments-mtcte/

Essential Requirements will have requirements mainly related to safety, security, technical, and functional parameters.

6.46 The Security Division of Telecommunication Engineering Centre (TEC), Department of Telecommunications, shall be responsible for activities related to the telecom network security under the overall policy on the cyber security and telecom security.

6.47 The focus areas of Security Division are:
- Contribute to defining the Security framework for ICT network, including security objectives, threats and vulnerabilities, management strategies and challenges associated with it;
- Contribute to defining the Security indexing guidelines for telecom equipment in line with ITU-T recommendations X.1521 on CVSS, i.e., Common Vulnerability Scoring System;
- Defining security auditing guidelines specific to telecom Service providers in accordance with ISO 27001;
- Co-ordinate with DoT, MHA, and other cyber-security agencies.

### iv. Testing and Certification

6.48 Testing and certifications of various technologies and devices are required to ensure the reliability and the quality of M2M/IoT service across large number of devices and networks. TEC is working on establishing device certification and responsibility centers for M2M/IoT domain in India. Based on TRAI's recommendations, TEC is also establishing a National Trust Centre for M2M device testing.

### v. DoT and Wireless Planning and Coordination Wing

6.49 Department of Telecommunications has already taken the following initiatives in respect of M2M policy:
- National Telecom M2M Roadmap was released by DoT on 12th May 2015. Roadmap document endeavours to assimilate various M2M standards, outline policy, and regulatory approaches and measures for increased M2M proliferation.

- DoT has implemented separate 13-digit numbering scheme for SIM-based M2M devices.

- Instructions for Know Your Customer (KYC) for SIM embedded M2M Devices were issued addressing identification and traceability of M2M Devices.

- DoT has issued instructions, permitting the   use of e-SIM with both single and multiple profile configurations with Over the Air (OTA) subscription update facility, as per prevailing global specifications and standards (GSMA).

6.50 DoT is engaged in framing of regulatory framework for M2M service providers, identifying critical services for M2M communications, including regulatory requirements for such identified critical services. Wireless Planning and Coordination Wing under the Department of Telecommunications, Ministry of Communication is responsible for developing, updating, and releasing the NFAP – National Frequency Allocation Plan. The latest NFAP was released in 2018. The *National Frequency Allocation Plan-2018* of India provides a broad regulatory framework, identifying which frequency bands are available for cellular mobile service, Wi-fi, sound, and television broadcasting, radionavigation for aircrafts and ships, defence and security communications, disaster relief and emergency communications, satellite communications, and satellite-broadcasting, and amateur service, to name just a few.

### vi.    MeitY

6.51 MeitY is continuously working on identifying and developing standards in the domains of e-Governance and Information Security. MeitY has released the following e-Governance Standards recently:
- E-Governance Service maturity Model
- Framework for Adoption of Open Source Software in e-Governance Systems
- Framework Document for e-Authentication: ePramaan
- Framework for Mobile Governance

Interoperability Framework for e-Governance:

- Code Directories of Generic Data Elements
- XML Schema for Generic Data Elements

MeitY is currently working on:

- India Enterprise Architecture Framework
- India Enterprise Architecture Adoption Guide A Method Based Approach
- Adoption of Mobile AppSec Verification Standard (MASVS)

# CHAPTER 7

## GAPS AND CHALLENGES

7.1 The standardization work in IoT segment is very complex and the global SDOs are extensively working to accomplish this task. The heterogeneity of the IoT paradigm has fragmented the market and somehow created unique challenges in reaping the benefits from this paradigm for the society. This heterogeneity and fragmentation have made it desirable to continuously monitor and standardize the prevalent architectures and frameworks of the ICT infrastructure being deployed or being developed.

7.2 Hence, true convergence[56] is still eluding the evolved citizens of today's super industrial society because of lack of harmonized standards in the respective ecosystems of Smart Homes, Smart Buildings, Smart Grid, and Smart Cities. The smart nodes of one network cannot talk to smart nodes of the other networks. Multitude of 'proprietary systems/solutions', or 'systems/solutions with very limited interoperability', are being deployed in each application area for today's Home Automation, Building Automation, Industrial Automation, or even the Infrastructure Automation needs of the society. This is certainly leading to a situation where we will not be able to derive the maximum benefits of these technologies unless a very strong push is made and sustained at the highest level for interoperable standards.

7.3 We are witnessing an exponential growth in consumer-facing applications, and hence M2M/IoT applications are poised to explode. They will drive order-of-magnitude increases in bandwidth consumption, and provisioning, and control actions. However, even today, many applications are poorly adapted for the constraints posed by wireless networks.  But wireless is essential in bridging the digital divide, especially in rural areas. Protocols that manage the services and

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[56]BIS Pre-Standardization Study Report - Unified, Secure & Resilient ICT Framework for Smart Infrastructure (Page 84)

devices efficiently are essential if the promise of untethered applications is to be fulfilled. Another challenge is how do mobile operators deploy networks that efficiently serve populated areas with connectivity to various M2M devices as well as rural areas that need both high speed data and M2M services.

7.4    The IoT paradigm is expected to be a solution for all the problems and is expected to have the characteristics of a Homogeneous Network of Heterogeneous Devices. It is expected to address applications in multiple diverse domains like Industrial, Consumer, Infrastructure, Enterprise, Buildings, Homes, and Cities, seamlessly. While it is expected to cater to a wide spectrum of applications and deliver multitude of services, it needs to be secure from end to end in the entire signal path and value chain. Hence, it is essential to have a homogeneous and secure IoT solution for heterogeneous devices and systems.

7.5    The Critical Infrastructure cyberthreat landscape is rapidly evolving and, with more frequent attacks, more numerous, and varied threat actors, and increasingly sophisticated malware, and tools that are more widely available, and sometimes indiscriminately deployed. Although, the Government of India has put measures in place to check for any mal-intentioned bug or subcomponent in these equipment/ systems, but these are not providing high level of assurance if there is intentional built-in mechanism meant to compromise security of system. This may be due to the following reasons/constraints:

**A.    Sheer Volume of Equipment and Their Subcomponents:**

7.6    It is difficult for 100% fool-proof testing/scrutiny while consuming. There is also a lack of required infrastructure to handle such volumes. It becomes even more challenging when majority of Indian companies import this equipment, which is seldom checked or just sample checked.

## B.   Gaps of Standards:

7.7   There is lack of holistic efforts and pro-activity on parts of countries and OEMs to participate in standards development, which provides an open and democratic approach to product development and ensures compliance with regulatory and national testing procedures.

7.8   The problem is not the lack of standards but the lack of understanding on relevance and usage of the right standard for Indian ecosystem. Internationally there are too many standards available and very often with duplicities, hence, these are required to be simplified and modelled for Indian Civic Infrastructure and Utilities. Utilities shall incorporate such standards, which are drafted by national organization.

## C.   Some Key Challenges in Protecting CII (Critical Information Infrastructure):

- Lack of **"**visibility over, and classification of CII**"**
- Identify and document incoming/outgoing dependencies on other infrastructure
- Gap analysis of dependencies on other infrastructure
- Evolve overall CMP for CII sectors at NCIIPC level
- Lack of **"**a standardized framework or metrics to identify and classify critical information infrastructure**"**
- Lack of **"**standard, nation-wide practices, for defining the baseline metrics" for identification of critical information infrastructure
- Lack of **"**knowledge and awareness about factors**"** impacting critical information infrastructure
- Inadequacy of "relevant and workable information to take decision at the national level"
- Inability in "Activating, driving, ensuring desired actions, and seeking conformance from the entities on the specific terms**"**

## D.   Challenges in Digital Infrastructure Security

7.9   The Smart Infrastructure essentially deploys SCADA systems. There has been a perceptible shift towards running such smart applications

on COTS non-embedded computing systems running on OS that are either open source or commercial in nature. Such systems traditionally run in client-server mode. These, in particular, need to be protected. All best practices relevant to a large IT base network will have to be incorporated.

### E. Current Challenges: Smart Cities including Smart Infrastructure[57]

7.10 In Smart Cities, a unified ICT backbone paradigm and a common infrastructure pool enable the creation of an interconnected and truly homogenous system with seamless communication between devices and services. Coordination, collaboration, and harmonization can be better implemented by the effective use of standards-based, open, common, and shareable, information, and communication technologies. The disconnect amongst technological trends being pursued by the stakeholders of the now homogenous smart infrastructure needs to be bridged without any further delay to maintain the Lifecycle Cost or TCO (total cost of ownership) of these individual components within viable economic thresholds.

7.11 The current state of Smart Cities Challenge Proposals has several gaps that need to be addressed:

- **Closed Solutions:** Available solutions are extremely closed with an ecosystem that is highly locked-in by vendors, i.e., a single vendor owns the vertical application, platform, communication, services, and data. While convergence of technology, unified standard, interoperability, etc., are necessary to ensure customer-centric systems, open markets are essential for competitive, affordable, and sustainable solutions. The existing ecosystem allows minimal or no flexibility. This leads to a high risk of a large-scale fragmentation, undermining the country's ambitious goals.

- **Force-Fitting Solutions developed for Mature Markets:** There is a natural tendency to force-fit existing solutions developed for other

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[57]BIS Pre-Standardization Study Report - Unified, Secure & Resilient ICT Framework for Smart Infrastructure (Page 130 and 76)

cities such as Madrid, Barcelona, etc., to the proposed smart cities in India. This may not be the right approach given the requirements, constraints, and challenges in India. India-specific needs should be factored-in upfront in the architecture of these solutions.

- **Inappropriate Last Mile Solutions:** Existing last mile technology for wireless sensor networks is undergoing rapid change to meet radical lower levels of capital and operation cost, and much higher levels of reliability for mass usage in smart cities. We may need to contract wisely to encourage experimentation and migration to successful new approaches rather than get locked into a high cost solution such as the Dabhol Power Station.

- **Deployment Diversity:** Under the Smart City Mission, different cities are expected to contract separately, but we need an approach to benefit from some commonality and State-to-State arrangements.

- **Non-Standard Disharmony:** There is no common framework and architecture defined for the various physical infrastructures to be deployed in the proposed smart cities, to work in an integrated, harmonized, and optimized manner.

- **Dichotomy:** There is a dichotomy between, on the one hand, the need for investment in R&D for new products, systems, and solutions based on an integrated and secure System Architecture when there is little awareness about the problem among stakeholders, and on the other hand, the creation of a unified System Architecture and Framework where there is no demand due to ignorance about the problem at hand.

## F.    Other Important Smart City Issues

- Smart cities development and deployment are often announced without any groundwork on preparedness of the stakeholders and the ecosystem.

- In a smart city, multiple utilities are going to leverage and deploy similar technologies and solutions to improve the operational efficiency.

- The technological trends in "Smart Homes", "Smart Buildings", "Smart Grid", "Smart Water", "Smart Transport", and "Smart Cities" are being considered and pursued in isolation from each other by the respective stakeholders. This is in spite of the fact that they form a very tightly interwoven and homogenous confluence of similar technologies being applied in different domains.

- Since there is no standardization or Harmonization groundwork undertaken to cater to the physical infrastructure's comprehensive and heterogeneous needs of the smart cities, most of the systems and solutions deployed shall have to be procured based on respective vendors' proprietary technologies with limited or NO interoperability with system/solution components from other vendors.

- Each city shall always be dependent on the respective vendors throughout the lifecycle of such systems/solutions for their Operation and Maintenance, and more so for their upgradation.

- Lack of harmonized standards in the respective "SILOs" ecosystems of the Smart Infrastructure shall imply that the smart nodes of one network cannot talk to smart nodes of the other networks. Thus, data sharing amongst the multiple stakeholders of a smart city shall be a major challenge.

7.12 In fact, there is a recursive cycle to the data in a Smart City. The generated information is the one that is consumed, which in turn adds to the information generated, and the cycle repeats.

## G.    Standardization Imperatives

7.13 Each application ecosystem like smart home, smart building, smart street lighting, and smart grid have, over the years, developed their own respective sets of standards and last mile communication protocols. In fact, some ecosystems like smart grid, smart building, and smart home have multiple sets of standards and protocols being advocated as the most appropriate for their respective applications. However, there is a need to unify the available multiple sets of standards and protocols to

come out with an inter-operable, unified, harmonized, scalable standards for the smart infrastructure.

7.14 Architectures and framework designs provide high-level guidelines to the stakeholders of respective components and layers of the overall smart infrastructure solutions. However, it is imperative to work on sufficiently fine granularity of each component and layer for standardization as well as harmonization for ensuring the interoperability among various similar components addressing different applications at semantic as well as syntactic levels. Further, the standards being adopted for the smart homes or smart buildings' deployments must be harmonized with the standards in all other relevant ecosystems and integrated with digital infrastructure paradigms. Lastly, a special effort shall be needed to develop standards for conformance and interoperability testing.

# CHAPTER 8

## NATIONAL ICT IMPERATIVES

### A. Core ICT Infrastructure and Resilience

8.1 In the process of meeting infrastructure demands, the challenges of ICT infrastructure required to run the smart infrastructure applications provides an opportunity to the cities for leapfrogging in technology. Often, there are challenges in maintaining legacy infrastructure. The legacy infrastructure can be augmented and upgraded from time to time to an optimal level. In respect of both developing and developed countries, the primary motive behind smart infrastructure applications is to respond to the sustainable development needs of the society.

8.2 Globally, in most cases, smart cities are an emerging concept, and, therefore, the ICT infrastructure plan may not be adequately integrated in the city's Master Plans. Governments may use ICT strategies to create the ecosystem required to facilitate core technologies and infrastructure related to smart cities (such as the Internet of Things). National and city governments have at their disposal a variety of policy instruments to promote smart city projects, including inter-alia output-based contracting, public–private partnerships, procurement policies, long-term contracting, and targeted research funds. In addition, Governments may play a variety of roles in promoting smart city concepts. For instance, in their roles as regulators, there is a need to review the regulatory frameworks to ensure that such frameworks are conducive to smart city innovations. In their roles as investors, they need to determine which skills development programme or infrastructure component they should invest in to drive innovation and economic benefits. City administrations and governments need to actively make use of such policy instruments and engage in these diverse roles to create and shape well-functioning markets for smart infrastructure that responds, to local sustainable urban development needs.

8.3   A city's ability to respond effectively to natural disasters heavily depends on its uses of ICT infrastructure, including mobile networks, to efficiently receive, process, analyse, and re-distribute data, and mobilise various city services.

## B.   Optical Fibre Cables and Backhaul

8.4   Development of a rich infrastructure of broadband networks that support digital applications and making it available throughout the city to all citizens is prime area of concern for the city developers. Ubiquitous ICT access should include a broadband infrastructure that combines optical fiber, cables, and the wireless networks. This will offer maximum connectivity and bandwidth to citizens and organizations located in the city. Fiber optic-based technologies are the most efficient and reliable for broadband service, and they provide fastest Internet connection. The existing quality copper infrastructure in many places can also be utilized for providing broadband connectivity through the reliable technologies such as Digital Subscriber Line (DSL). The fiber-optic networks act as a backbone for providing high-speed Internet access.

8.5   The long-term goal of such infrastructure is to have, open broadband network so that the entire city population can avail the services. In addition to the wired broadband networks, wireless broadband is becoming even more in demand, with the popularity of mobile applications, smartphones, the increased connectivity of smart devices, Internet of Things (IoT), and radio frequency identification (RFID) technology. On ICT's part, ensuring investment in high-speed broadband connectivity and increased storage capacity is the challenge facing the city.

8.6   In the Smart Cities context, optical fiber networks expand existing operations (FTTx) and are used to interconnect services: schools, hospitals, traffic light systems, public security systems (civil defense, firefighters, police), etc. Passive Optical Network (PON) solutions can enable the connectivity, which allows access of up to 10 Gbps and

provide interconnection with other networks to integrate various services in a single pipe. The optical network infrastructure of a Smart City can be augmented and built-up based on PON technology.

8.7    Different data streams in a city are aggregated under a single roof in the form of an operations center or command center. Co-locating different infrastructure components is another way to achieve the integrated development of a smart city. Gujarat International Finance Tec (GIFT)-City near Gandhinagar in India has adopted an integrated approach while creating utility infrastructure, including ICT infrastructure such as Optical Fiber Cables and ducts. In GIFT city, multiple utilities are provided through a single tunnel, resulting in huge cost savings and a better management of urban space. Geographic Information Systems (GIS) based town planning enabled with the latest in technology and infrastructure can be mandated and fruitfully implemented.  The GIFT city has an all-purpose 12km long utilities tunnel through which sewer lines, telephone lines, water pipes, power cables, and other pipelines are being managed, preventing the need for underground and outdoor cables for the same.

8.8    Backhaul is an essential part of the telecommunications networks. In the brownfield cities and dense urban areas, due to various constraints, microwave technology is also used as a substitute to the optical fiber. Microwave technology can provide high capacity backhaul for the broadband networks in a cost-efficient way and is more suitable for operations in the cities and difficult terrains, where laying fiber is not possible. Due to these reasons, globally, mobile backhaul network is evolving with the mix of both fiber and microwave.

8.9    It is forecast that by 2022[58], more than 65% of all radio sites in the world (excluding China, Japan, South Korea, Taiwan) will be connected by microwave.

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[58]https://www.ericsson.com/en/microwave-outlook/reports/2017
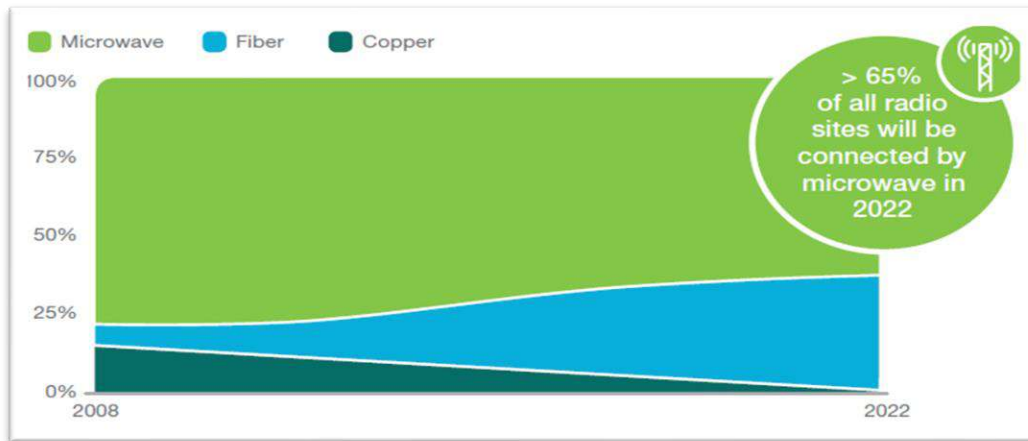
*Figure 8.1: Backhaul Media distribution*

8.10 As the dominant backhaul media in today's networks, microwave plays a significant role in providing good mobile network performance. However, the constant pressure to increase performance levels translates into requirement of more bandwidth for microwave backhaul. Regulators world over are opening up higher frequency bands such as V-band (60GHz) and E-band (70/80 GHz) to satisfy the high-capacity backhaul requirements of future networks. According to industry analysts[59], E-band will satisfy the high-capacity demands of today's networks. Moreover, it will also be suitable during the coming years when 5G is rolled out. However, in the long term, more spectrum will be needed for the backhaul transmission. To enhance the capacity of backhaul links of mobile network, TRAI has given its recommendations on 29th August 2014 on "Allocation and Pricing of Microwave Access (MWA) and Microwave Backbone (MWB) RF Carriers" on the basis of reference received from DoT. The recommendations include assignment of spectrum in E-Band and V-Band for high capacity backhaul purpose.

8.11 Besides optical fiber cable, Fixed Wireless Access (FWA) is another option through which high speed home broadband can be provided using a 5G radio network in mid-band and mmWave bands. Further,

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[59]https://www.ericsson.com/en/microwave-outlook/reports/2017

the load of Mobile network traffic is to be offloaded to wired network through VoWiFi and Wi-Fi hotspots.

8.12 Fibre-To-The-Home (FTTH) technology and In-Building Solutions (IBS) are the two most important solutions for improving connectivity. FTTH solutions will improve the fixed line broadband penetrations to each household, and IBS solution will improve the mobile coverage inside the buildings and apartments. Implementation of IBS solution is faster as compared to Fiber to the Home; therefore, it can provide immediate respite in respect of connectivity. Both FTTH and IBS are sharable infrastructure, whether installed by a TSP or an Infrastructure Provider.

8.13 TRAI has recently given its recommendations on 13th March 2020 to enhance the scope of Infrastructure Provider category-I (IP-I), and recommended to allow the IP-I to establish the following sharable infrastructure for mobile operators:

- Wireless Access Network (Radio Access Network)
- In-Building Solutions (multi-operator infrastructure to provide in-building coverage)
- Fibre to the Home (FTTH) Broadband infrastructure
- End-to-end Bandwidth

8.14 These recommendations will boost the fixed line infrastructure. The State Governments too have to play their role in facilitating the development of telecom infrastructure in their State by streamlining the Right-of-Way permission process, and incorporating FTTH and IBS requirements, as is mandatory in the building specifications, local municipal corporation by-laws and guidelines.

8.15 To attract investment in the fixed line Broadband segment, the same needs to be promoted and incentivized. Investments in laying of optical fiber cables for fixed line broadband networks would also improve the performance of wireless networks. TRAI through its recommendations dated 17th April 2015 on 'Delivering Broadband Quickly' had recommended that "To promote fixed line Broadband, the license fee on

the revenues earned on fixed line BB should be exempted for at least 5 years". Such kind of incentivization is much needed at the moment in the fixed line broadband segment. As per the initial estimates, additional revenue to be earned by the Government due to the growth in economy would be more than the license fee exemption.

## C.    Cloud and Data Centers

8.16    Smart cities have to use a wide variety of ICT solutions to deal with urban problems, and monitor their functions; they do not only require the use of new technologies and devices (sensors, RFID devices, smartphones, smart household appliances, etc.) to collect land use, transport, sanitation, water, and environmental monitoring data, which are generated every minute in the urban environment, but also the capacity to manage and process all this large scale data (Big data) in real time, in an interconnected and service/applications' specific way. The emergence of cloud computing facilitates big data storage and big data integration, visualization, processing, and analysis in acceptable time frames.

8.17    When customers move computer systems and data to the cloud, security responsibilities become shared between the customer and the entity providing the cloud computing. The entity providing the cloud computing is responsible for securing the underlying infrastructure that supports the cloud, and the customers are responsible for anything they put on the cloud or connect to the cloud, i.e., ownership of data remains with the customer only. The ownership and control over the content through simple, powerful tools allow the customers to determine where their content will be stored, secure their content in transit, and at rest. Entities also implement responsible and sophisticated technical and physical controls that are designed to prevent unauthorized access to or disclosure of the content. Although cloud entities implement the best security standards and industry certifications, storing data and important files on external entities always opens up risks. Any discussion involving data must address

security and privacy, especially when it comes to managing sensitive data.

8.18    Importance of cloud-based service-delivery platforms has been recognized by Government of India in the Digital India Programme. It has been envisaged that these cloud services will form the foundation of Digital India, as it integrates smart devices and infrastructure, and processes data from the large number of scattered sources in real time.

8.19    The Cloud Services in Smart Cities can be broadly categorized into two categories, i.e., (1) critical city operations (2) non-critical city applications/operations. In case the Cloud Service model, as envisaged by MeitY through MeghRaj, is chosen for deployment in Smart City critical operations, the computational capabilities shall require to be developed to meet the requirement of handling Big Data analytics and a variety of applications.

## D.    Smart Pole

8.20    Unified smart pole for Telecom Service Providers is suggested to be an important requirement in a smart city. Pan-city deployment of Unified smart pole can be a revolutionary idea as it can reduce the connectivity costs and provide connectivity access to various public and commercial applications such as Emergency Call Box, Public Announcement System, Public Wi-Fi, Environmental Sensor, Flood Sensor, Smart Lighting), Variable Message Display boards, Surveillance Cameras, etc.

8.21    Smart pole has been gaining traction recently across the globe, particularly in the smart cities. There are certain benefits of having Smart Pole, such as it has in-built Li-ion batteries to eliminate requirement of connection from a secondary power source. Smart pole provides a ready build telecom infrastructure to facilitate telecom operators to place their equipment and can provide Wi-Fi connectivity at the locations where city resident footfall is high or rising. CCTV cameras can be installed with the smart pole to improve upon safety and security in the city, and live footage can be analyzed by the City Command and Control Center. Environmental sensors can be installed

to monitor air quality, temperature, and humidity. Simultaneously, the implementation of LED-based streetlights helps to improve the quality of life of city residents by improving the city lighting. Last but not the least, smart pole has telecom tower infrastructure to match with city aesthetics, and ready to accommodate upcoming technology such as 5G. Bhopal Smart City Development Corporation Limited (BSCDCL) has launched first of its kind public private partnership (PPP) based smart poles and intelligent streetlights' project in India under the Smart Cities Mission.

8.22 Though, backhaul connectivity to the smart pole remains an issue as the problem has been highlighted by the all the smart cities. Also, there should be clarity on the smart city's provisions for sharing of these smart poles with many TSPs, and it should not be restricted to be used by a single TSP. As per the regulatory perspective, the sharing of active infrastructure amongst the service providers is permitted based on the mutual agreement entered amongst them. Active infrastructure sharing is limited to Antenna, feeder cable, Node B, Radio Access Network, and transmission system only. Smart poles can be gainfully monetized by a smart city, provided the policies are transparent and enabled in the right direction.

### E. Disaster Recovery and Resilience

8.23 Natural disasters such as extreme weather, flooding, heat, and water stress caused by climate change are seen as major threats, and challenges being faced around the world have gained traction now a days. Discussions are happening on building up resilience to cope up with such disasters. Confronted by a natural disaster, smart cities can use sophisticated ICT infrastructure and analytical capabilities to enhance and coordinate the information flow between multiple public agencies, such as transport authorities, emergency services, and energy providers, and citizens.

8.24 As per the data published in the UN Data Booklet on 'The World's Cities in 2018'; of the 1,146 cities with at least 5,00,000 inhabitants in 2018,

679 (59%) were at a high risk of exposure to at least one of six types of natural disaster, namely cyclones, floods, droughts, earthquakes, landslides, and volcanic eruptions. Taken together, cities of 5,00,000 inhabitants or more facing high risk of exposure to at least one type of natural disaster were home to 1.4 billion people in 2018[60].

8.25 The data also indicated that one hundred and eighty-nine cities—most of them located along coastlines—were at a high risk of exposure to two or more types of natural disaster; 26 cities—including megacities Manila, Osaka, and Tokyo—faced high risk of exposure to three or more types of disaster.

8.26 Ideally, it is already a practice that a critical ICT system will also have a hot standby Disaster Recovery (DR) back-up server running in a different seismic zone (physical location) to take over the load immediately if the main server fails. Further, it is also a practice to store the back-up data in two other geographically distant locations in addition to one that is kept on-site for easy access. The backup strategy must be tested, which means keeping additional servers/ cloud running all the time to achieve this.

8.27 The backbone of any comprehensive smart city disaster solution is ICT run by technology vendors and telecom operators, overseen by the operational management of a public agency. In the present scenario, as tele-density has increased substantially and most of the population is covered with access to mobile phones, a city municipality can reach most of its citizens at a short notice with the help of mobile networks.

8.28 Capabilities of ICT infrastructure to process, store, and share vast amounts of data is crucial for building up their resilience and preparedness for natural disasters. In the recovery phase, the backbone ICT infrastructure needs to be assessed to determine if any repairs and restoration are necessary. For example, Tokyo Metropolitan

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[60]UN report 'The World's Cities in 2018'

Government[61] has a manual covering a range of measures and tasks that have to be completed. Japan's mobile operators also have a recovery strategy for mobile infrastructure that applies to different disaster scenarios. This strategy, which was deployed in the aftermath of the March 2011 Japan earthquake, includes the following elements:

- Improve disaster resilience of the networks and establish restoration methods;

- Improved reconnection and re-establishment of coverage for local relief sites;

- Establish secure means of information distribution after the disaster;

- Provide services and solutions useful during a disaster and during recovery.

8.29 As the services are hosted over the cloud, and cloud itself is not confined to a physical location. Therefore, besides resilience of physical location, there are major challenges in ensuring the security of today's networked IT systems. The most secure infrastructure is the one to which all the latest security techniques are applied as soon as they become available. This is best achieved by professional data center managers for whom security is a full-time job. Security of the applications can be most effectively realized in the cloud where there is the capacity to test backup routines rigorously and to apply big data analytics to filter out the false alarms which often overwhelm in-house IT teams.

8.30 In order to have a pan-India dedicated Public Protection and Disaster Relief (PPDR) network for Mission Critical Push to Talk (MCPTT) services, TRAI has given its recommendation on 4th June 2018 on 'Next Generation Public Protection and Disaster Relief (PPDR) communication networks'. Vide this recommendation, TRAI has stated that Government should set up pan-India integrated Broadband PPDR

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[61] https://www.gsma.com/iot/wp-content/uploads/2013/02/cl_SmartCities_emer_01_131.pdf

(BB-PPDR) Communication Network (to be called "National BB-PPDR Network") based on 3GPP (Public Safety) PS-LTE technology. TRAI has also recommended to assign 10 MHz of paired spectrum to MHA for setting up this network. This will be an important element for a Smart city, and the network can be part of the smart city's ICT infrastructure.

## F.    Spectrum Bands identified as Licensed and Unlicensed

8.31  As it is apparent, the concept of Smart City encompasses several smart solutions concepts in governance, economy, management, infrastructure, technology, and people. The requirement of these Smart solutions grows with the growth of Smart City.  This means that besides the conventional communication systems, a Smart City has different communication needs, especially the implementation of IoT solutions. The Smart City assumes a multitude of communicating machines at high density, which requires improved spectrum management flexibility. Wireless technologies such as Wi-Fi, ZigBee, Bluetooth, WiMAX, 2G/3G, 4G or LTE, and 5G have presented themselves as solutions to the communication needs of Smart City initiatives. Most of them, other than Cellular technologies, deploy unlicensed spectrum bands. The growing need for licensed spectrum in 5G will also lead to massive demand in wireless spectrum availability in urban areas. Efficient spectrum management is a pre-requisite for connectivity enablers, and a large number of applications in the Smart City context, which include wireless sensor networks, industrial automation, smart grid, public safety, smart metering, smart parking, e-healthcare, smart house, and office automation and green energy among others.

8.32  Presently, spectrum assignment in India is being done through auction process, and the spectrum sold is liberalized (technology agnostic), i.e., the service provider has the freedom to decide the technology to be deployed in the given spectrum band. With the passage of time, several spectrum bands have been earmarked for IMT services in India. Figure 8.2 provides the details of these spectrum bands.
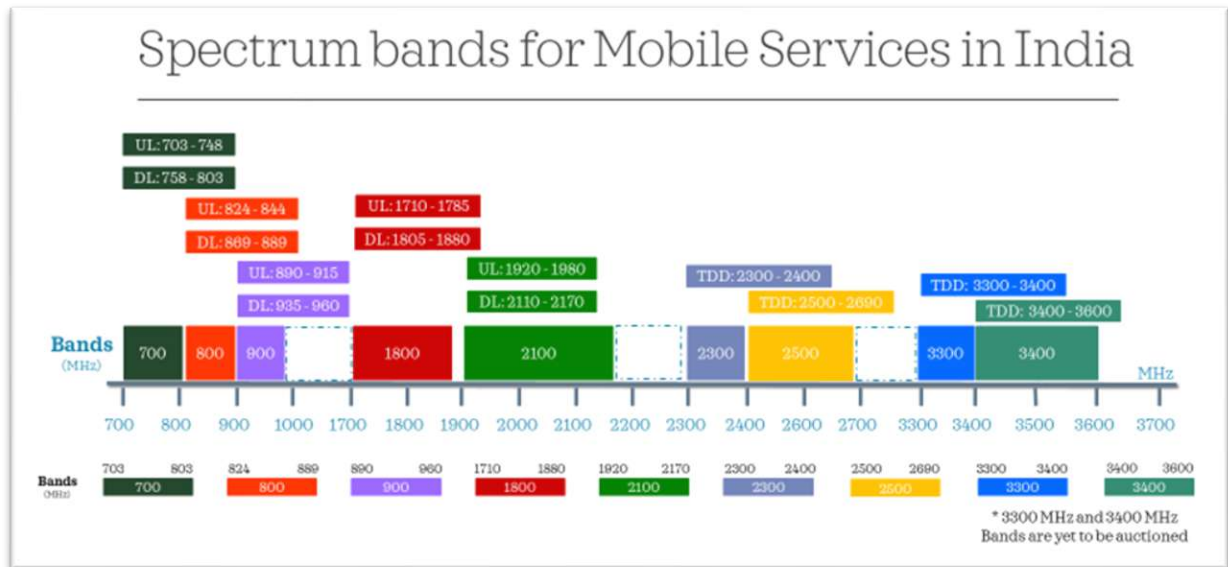
*Figure 8.2: Spectrum Bands for Mobile Services in India*

8.33   New capabilities of mobile communication networks enabled by 5G technology will allow higher quality video services with mobility at high speed, business automation delivered through billions of connected devices, delivery of critical services such as tele-surgery and autonomous cars assured by low latency and ultra-reliable networks, and improved productivity assisted by high quality, real-time data analytics. Unlike existing mobile communication networks, 5G networks will allow tailoring of requirements for each of these different use cases within the same network.

8.34   In case of the unlicensed spectrum in India, earlier, only 2.400–2.4835 GHz and 5.825–5.875 GHz were unlicensed bands for indoor and outdoor use of low power equipment. Recently, 5150–5250 MHz, 5250–5350 MHz, 5470–5725 MHz, and 5725–5875 MHz frequency bands have been included as unlicensed for use in indoor and outdoor environment. Availability of additional 605 MHz unlicensed frequencies will ease the capacity constraints for Wi-Fi and low power equipment and will contribute to further growth of telecom deployments, particularly in urban areas and smart cities.

8.35   TRAI through its recommendations on "Spectrum, Roaming and QoS related requirements in Machine-to-Machine (M2M) Communications"

issued on 5th September 2017, has recommended to delicense 1 MHz of spectrum from 867–868 MHz, and a chunk of 6 MHz of spectrum at 915–935 MHz in order to facilitate smooth roll out of M2M services. The Authority, on various occasions, has recommended to the Government for delicensing the V-band (57–64 GHz). In this regard, it may be noted that additional 1 MHz spectrum from 867–868 MHz for M2M services and other similar applications is under consideration for license exception as per para 1.13 of National Frequency Allocation Plan-2018 (NFAP-2018).

8.36 The access network can be implemented using any or a combination of wired access using FTTX, DSL, etc., and a wireless commercial access using HSPA, LTE /4G, WiMAX, etc., and wireless personal access networks like ZigBee, RFID, NFC, Wi-Fi, Bluetooth, etc. based on the requirement.

## G.   Common Duct Policy

8.37 TRAI had observed that a study should be conducted with inputs from all stakeholders on the reasons for low penetration of broadband and the ways to improve the same. From the discussions, it had emerged that a common duct policy can be evolved, which shall enable the TSP's/lSP's to lay fiber easily for providing the broadband services in areas they desire as the duct would already be available. Availability of a common infrastructure would save time, cost, and efforts. Only the OFC would need to be laid to complete the outside plant. Accordingly, Telecommunication Consultancy India Ltd. (TCIL) was awarded to carry out a feasibility study and cost-benefit analysis for laying of a common duct in Deoghar city of Jharkhand.

8.38 In the pilot proposed, it was envisaged that three types of ducts as mentioned below should be constructed:

(i)   Duct Type 1[For Primary Routes]

(ii)   Duct Type 2 [For Secondary Routes]

(iii) Duct Type 3 [For Tertiary Routes]

8.39   The feasibility report has mentioned different model of financing:

- **Total investment (EPC):** ln this model, the entire cost of duct network shall be borne by the government. The USP is that being the only investor government will own the network, and to increase broadband penetration in city, it may lease the ducts at nominal rates to encourage more TSPs to expand their network.

- **Hybrid Annuity Model (HAM):** Under this model, government provides 40% of the project cost during the construction period, and the release of funds is linked to the progress of construction; the private player needs to raise the rest 60% in the form of equity and loan. Under this model, the asset created shall belong to government, and revenue collection would be the responsibility of the government. Advantage of this model is that it gives enough liquidity to the developer and the financial risk is shared by the government.

- **Investment by providing Viability Gap Funding** The third option is the investment by both; private sector may invest a set amount as per its suitability, and the gap funding is done by public. ln case private operator does not show interest in laying duct network because of no business case, the government may provide viability gap funding to make the business case feasible for private partner to make incremental investment and operate the project. ln this model the private partner shall own the network.

8.40   In order to have a robust ICT connectivity in Smart Cities, Ministry of Housing and Urban Affairs has issued an advisory[62] on 14th July 2017 regarding Laying of Common Duct for OFC network in Smart Cities on Public Private Partnership (PPP) DBOT Hybrid Annuity Model. In the advisory issued, it has been recognized that in the proliferation of broadband in the country, one of the most consistent issues observed is the issue of obtaining Right of Way (RoW). Further, the levies are not uniform and vary from state to state and city to city. While the charging mechanism may vary from one place to another, the common point is that the charges are very high. The time taken to obtain the RoW

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[62]http://smartcities.gov.in/upload/uploadfiles/files/Advisory(1).pdf

clearance is too long. Further, un-coordinated development activities such as road expansion, laying of electrical cable, etc., are undertaken by multiple agencies and private contractors, result in frequent cuts in cable, leading to depreciated life of the cable and increase in operating costing for service providers.

8.41   The Advisory has emphasized on improvement of ICT infrastructure in the city (e.g., replacing overhead wiring with underground wiring). Also considering the implementation of robust IT connectivity and digitalization as a core infrastructure, it has been advised that a common duct for OFC be laid in the smart cities to meet these mission objectives.

8.42   In the Advisory, reference has been made to the feasibility study carried out by TRAI for laying of common duct for optical fiber. It suggests that the Smart Cities may carry out the project development exercise such as preparation of technical and financial feasibility and procurement of concessionaire through the smart city PMC.

8.43   TRAI has issued a consultation paper on 20th August 2020 on "Roadmap to Promote Broadband Connectivity and Enhanced Broadband Speed," seeking comments of stakeholders on many aspects for enhancing the broadband in the country.

## H.   Reliability of Cellular Communication for Critical Infrastructure

8.44   The critical Information Infrastructure is the backbone and foundation of any modern society/community today. It needs highly reliable Communication Backbone. Because of ubiquitous availability and comprehensive Network coverage, Cellular Communication has become the most preferred Communication Technology for critical communication.

8.45   The ease of connecting anytime, from anywhere to anywhere, has made it the default choice for WAN Communication requirements in the IoT/M2M solutions' deployments.

8.46 Cellular Communication, using radio waves propagation in access network, is subject to various factors that affect the reliability of radio communications, and therefore, it is difficult to ensure a reliable, resilient, and ubiquitous communication uniformly in entire geographical territory. For communication backbone for any Critical Information Infrastructure or Critical IoT/M2M Applications, such networks require further hardening and self-healing capabilities.

8.47 To resolve this issue further, we need to have a fresh approach in developing a use-cases-based Communication Architecture followed by enumerating the changes needed in the Regulatory Framework to enable evolution and deployment of a robust yet cost-effective and ubiquitous communication backbone using the latest cellular communication infrastructure. 5G technology can provide solutions to these issues using Network function virtualization, software-defined network, and network slicing.

8.48 Robust ICT Infrastructure acts as a backbone of Smart Cities and 5G is going to make smart cities a common reality. We may explore the 5G & Smart Cities interplay. 5G Technology provides complete transformation of mobile connectivity. It has the potential to serve to the communication needs of various economic verticals be it health, agriculture, transportation, industrial IoT, utilities and smart cities. Together with AI and ML, the 5G technology is capable of providing optimized and affordable solutions to large number of applications.

8.49 5G technology is able to configure differentiated services to cater to different use cases and application requiring high speed mobile broadband, low-latency applications, ultra-reliable communication for mission-critical applications and massive machine type communication for low-rate high density IoT applications. Looking at the connectivity and ICT requirements of a Smart City, it can be observed that diversified kinds of connectivity are required for different applications of Smart cities. There is no single network to cater to all the requirements of Smart city and multitude of connectivity options are being used

currently to achieve the objectives. Features of 5G such as Network Slicing, Network Function Virtualization, Common API Framework, Service Enabler Architect Layer etc. make it versatile and robust to serve the needs of Smart City applications.

8.50    Availability of fiber is one of the prime requirements for the successful implementation of a smart city program. From the telecom service providers' prospective, network cell density within the city will grow multifold, bearing in mind the upcoming 5G technology. This gives enough potential for the monetization of optical fiber in long run as it has the useful life of 25–30 years.

8.51    Network blueprint of the city, for required network capacity in the next 10 years or so, as suggested by a smart city is quite reasonable. The network reach and availability of bandwidth should be such that it covers the entire city as well as expansion planned in near terms. Additional ducts can be provisioned for future expansion so that future CapEx is saved by avoiding frequent digging. This will also ensure aesthetic look of the city. Besides the core layer of optical fiber, another access layer of fibers can also be planned based on the Passive Optic Network (PON) technologies which can provide access to various elements such as Wi-Fi nodes, Fiber-to-the-X (FTTx) and backhaul connectivity for cellular or LPWAN networks.

8.52    There is no straightforward 'one-size-fit-all' solution to enable fiber infrastructure for smart cities. Cost-benefit analysis by an expert agency can help in decision making on choosing the best suited model for a city depending on the investment opportunities, economic viability, scope, and duration of the work and rights proposed to be granted. Every model has its merits and demerits. In case rights of construction and monetization of fiber is granted to a third party, the non-discriminatory access to other stakeholders has to be ensured so that there is healthy competition among the service providers in providing services at reasonable rates.

8.53    Pan-city deployment of Unified smart pole is a revolutionary idea as it can significantly reduce the connectivity costs and can provide universal infrastructure for various existing and upcoming features/ services. Infrastructure-as-a-service model can also be explored by the cities so that telecom service providers can share this infrastructure on rental basis. BSCDCL has already launched first of its kind public private partnership (PPP) based smart poles and intelligent streetlights' project in Bhopal city. Smart poles have capabilities to deliver bundled smart services to citizens, and maximum values for money to the city authority.

8.54    DoT in November 2016 has notified the rules to regulate underground infrastructure (optical fiber) and over-ground infrastructure (mobile towers) governed under Indian Telegraph Act, 1885. The authority providing RoW permission should designate a nodal officer for the purposes of these rules and develop an electronic application process for submission of the applications. Generally, the authority that provides RoW permissions is the city administration. City administration should immediately rationalize the RoW charges by making them realistic and designate the Nodal officers in the city on priority. This way the cities will be able to get enough bandwidth for their own purposes and future expansion as well as monetize them.

8.55    The various standards formulated and accepted by many international organizations may not exactly fit into the requirements of the Indian scenario. We are a country with a large population, varied terrain, culture, traditions, and have some unique problems to be addressed at the right cost. The focus should be more towards developing indigenous standards, and making them visible at a global level. For this, academic institutions such as IISc, IITs, NITs, and many other prominent institutions can contribute through more research and filing of patents. This brings in more responsibility for the organization dealing with the issues of standardization. Rather working in silos, agencies involved in making of standards such as, BIS, TSDSI, and TEC should come

together, and work together to understand and achieve the common goals.

8.56 There could be issues relating to the Quality of Service for running various applications. Some critical applications related to life and real-time applications such as smart grid, remote patient surgery, autonomous vehicle, are the ones that require high bandwidth, and efficient protocols cannot be compromised on a lower QoS. The requisite QoS should be in-built and taken care by the vendors, manufacturers, and network providers. For example, there could be different QoS specification as specified by the manufacturers for different type of CCTV cameras, and accordingly the devices aggregating the traffic can sense the priority of the traffic data to be shared over the communication network to the intended destination. Some of the use cases may work on low bandwidth with lower QoS but some of them like cameras may require a threshold (minimum) required bandwidth throughout the network to get the desired output. The government and industry along with SDOs can decide the specifications for a uniform implementation in all the smart cities, so that a minimum set of QoS is maintained across the entire value chain irrespective of the mode of communication.

8.57 In future, most of the decision making will be made through cognitive platform. Cognitive is not just about AI (Artificial Intelligence) but it is a partnership in making decisions using data. Many leading global enterprises are leveraging IoT broadly in three keyways by building platform strategy, deriving insights from new data access, and coming up with Cognitive IoT roadmap for the future. Smart cities should apply the Cognitive capability to their systems so as to generate new revenues, bringing efficiency, and competitiveness in the delivery of services.

8.58 Today, no smart city can be planned without Geographical Information Systems (GIS) mapping. GIS is deployed at every stage of planning and development of a smart city. The common platform operates through all stages of the life cycle - from modeling, planning, building to managing

- across the full spectrum of functionalities. Accordingly, GIS is thus an integrated cross-sectoral platform to collect, manage, compile, analyze, and visualize spatial information for sustainable urban planning, development, and management.

8.59 Proposed smart cities should mandate the GIS mapping of all existing physical infrastructure such as Water, Sewer, Electric, and Telecom, etc., so that further improvements and retrofitting can be implemented on ease. GIS mapping of existing cities is a tough challenge, and can be achieved through the help of advance robotics and AI.

8.60 The concept of a 'Test City' or 'Lab City' has been adopted by various countries to test the robustness of standards and best practices. The results of 'Test city' or 'Lab city' once successful could be replicated for other cities for implementation or could be adopted on a voluntary basis. Based on the best solution deployed by a city, Central government and concerned States may designate such cities as 'Test city' or 'Lab city'. This will save the time and cost for every other city to roll-out the best practices as smart-city solution.

8.61 As suggested by one of cities, the standardization in smart cities has several dimensions (including but not limited to) such as:
- standardization of common processes,
- standardization of terminologies,
- standardization of KPIs
- standardization of technology components (identification /development of Open standards for IoT/M2M and interoperability between disparate data sets).

8.62 The recently released framework by MoHUA for "Municipal Performance Index 2019: Assessment Framework" can help in formulating KPIs, and the same can be improvised further by adopting more and more measurable parameters.

8.63 Security and privacy in a smart city are additional challenges due to the information collected from people and environments through

devices and networks in various manners. Government should ensure mechanism and adequate safeguards to guarantee the security and privacy of its citizens and take appropriate steps to ensure the security and confidentiality of the data. The government must ensure the mechanism and categorize the data as sharable and non-sharable. From a technical point of view, there could be security issues during:

- Collecting and transmitting Data,
- Storing and processing Data, and
- Mobility

8.64 Security feature built-in with the devices at manufacturing level could be the baseline for bringing and building security of the entire ecosystem of smart cities.

8.65 To mitigate the cybersecurity challenge for smart cities in India, a Task Force like CERT-IN should be established. The Task Force should be comprising of the experts from the Government and Industry to take up and mitigate the security-related challenges hand in hand.

8.66 In the context of Indian smart cities, since India is vulnerable to various kind of disasters, therefore, a sound resilience and recovery plan for smart cities should be a necessity. Based on the level of vulnerability for natural disasters and considering all the physical and other parameters, out of the 100 smart cities, a pair of cities can be designated interchangeably as main and Disaster Recovery sites for ICT infrastructure. Application or cloud providers can create 'sandbox' to enable resilience and Disaster Recovery at earliest. The 'sandbox' created by application/cloud providers on their systems' backups can be tested without any disruption to operational systems.

# CHAPTER 9

# CONCLUSION AND THE WAY FORWARD

## A.   Unified, Secure, Resilient and Scalable Digital Infrastructure

9.1   The objective of smart city is to enhance quality of life of people and provide a clean and sustainable environment by establishing a common core infrastructure and deploying 'Smart Solutions' using digital infrastructure. It is essential to develop a standardized Digital Infrastructure with secure, reliable connectivity between government offices to improve government's efficiency, citizens' access to services digitally and thus impacting positively on the citizens' perception of the government.

The following are the key considerations, and the way forward for harmonized growth of Smart Cities' ICT infrastructure in the country:

### SMART CITIES: ECOSYSTEM OF ECOSYSTEMS

9.2   A city is a complex system of systems, involving many different domains, infrastructures, organizations, and activities. It could also be considered as an Ecosystem of Ecosystems. All these need to be integrated and work together effectively for the city to become smart. There are many levels at which integration needs to take place. This is not just integration at a technical level, but also about integration of business processes, management, strategic, and regulatory integration. The alignment of ecosystems should fulfill the following norms:

- Alignment within Ecosystems - each activity is consistent with the overall strategy.
- Alignment among ecosystem – connected ecosystems complement each other.
- Optimization of ecosystems – smart coordination and information exchange across ecosystems.

9.3   ICT has been recognised as a true enabler of the smartness in every aspect of the smart city paradigm. But there is a need of consensus

among city administration, consulting companies, service companies, and technology companies on what ICT components are necessary and how cities should approach to have a standard and interoperable ICT reference framework.

9.4    Smart Technologies[63] and city-scale ICT is part of a new and emerging market where many of the products - both hardware and software, in a multi-vendor environment across sectors and services, are still being developed. However, the current smart technologies suffer from certain barriers such as – technical interoperability and institutional interoperability -which need to be overcome in order to have growth and maturity of the market. The Smart Cities Mission of the Government of India that backs the use of ICT tools, and solutions for improving the quality of infrastructure and citizen services, have brought the issue of standardization, interoperability, and seamless integration of numerous physical infrastructures, utilities, and services to the forefront.

**B.    Standardization:**

9.5    The convergence of multiple networks and technologies, particularly in new and emerging markets, involving large-scale infrastructure require a top-down approach to standardization, starting at System Architecture rather than at the product level.

9.6    The systems level approach is recommended in design and standardization, which is likely to not only enable newer and better services, but also allow far greater synergies and cost-effective deployments, reducing the lifecycle (total) cost of ownership of any infrastructure, be it the grid, a home, a building, or even a city, with attendant environmental benefits, including carbon reductions, and building system resilience.

9.7    Deployment of proprietary systems of the IoT/M2M infrastructure is not the effective way to build smart cities, rather we have to steer for a

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[63]https://narnix.com/resources/

standardized and harmonized Communication Infrastructure architecture to tackle the problem. In a Smart City scenario, such approach is nothing less than essential, as only this would enable true interoperability between divergent devices as well as applications while maintaining identity and access control. Along with this, the sharing of data with ensured security and privacy becomes a practical feasibility. TSDSI and TEC are already working towards adoption of TSDSI transposed Standards of International Organizations specifically oneM2M to have a common standard for IoT/M2M infrastructure in the country.

9.8    The IoT value chain[64] is perhaps the most diverse and complicated value chain of any industry or consortium that exists in the world. There is a need to focus on the creation of a secure, standardized, and open infrastructure model for the delivery of services. The concept combines standards-based, end-to-end software with a converged smart infrastructure gateway/DCU design to establish a common, open framework for secured service delivery and management.
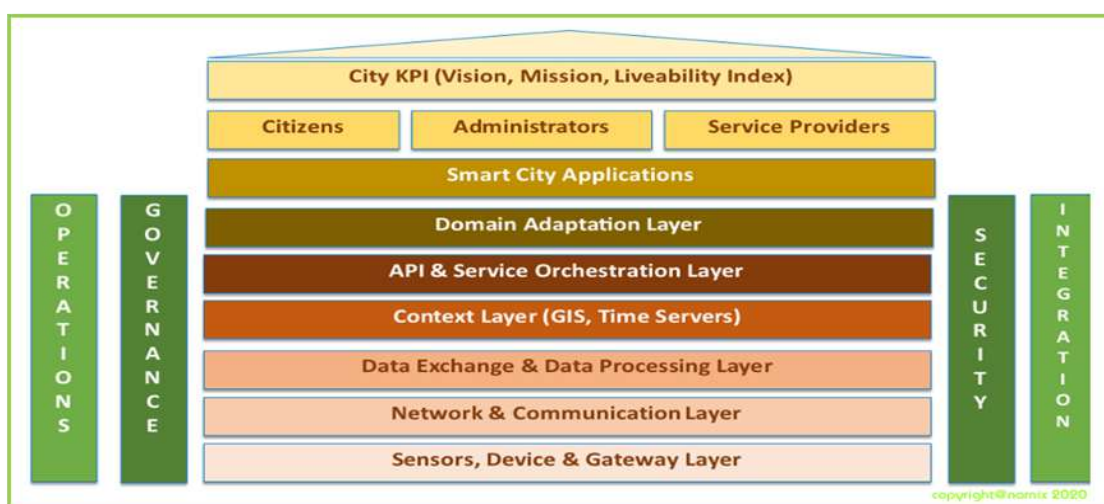


*Figure 9.1: Smart City ICT Reference Framework – Simplified View*

9.9    The Standard Reference architecture for Smart Infrastructure, shall lead to tremendous savings and optimization of Capex and Opex of the

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[64]BIS Pre-Standardization Study Report - Unified, Secure & Resilient ICT Framework for Smart Infrastructure (Page 85)

"Smart, Sustainable and Secure Cities", as well as lead to very significant reduction in the 'Carbon Footprint' of the ICT Infrastructure in any earmarked geographical territory.

9.10 To achieve these imperatives, smart cities and their respective ecosystem stakeholders are recommended to adopt the standards for **"unified digital infrastructure"** developed and being developed by SDOs in the country.

## C. Interoperability

9.11 A defining feature of Smart Cities is the ability of the component systems to interoperate. The optimal use of resources across a complex urban environment depends on the interaction between different city services and systems. To identify the most effective use of resources, it requires communication between the different component systems (e.g., energy consumption monitored by Smart Metering combined with external temperature, and sunlight monitoring on the building to reduce the energy consumption).

9.12 Smart Infrastructure is the result of combining physical infrastructure with digital infrastructure, providing improved information to enable better decision-making, faster and cheaper. As there are large numbers of short-range and medium-range communication technologies available, the adoption of technology for a specific use case has become a challenging decision. In the backdrop of this confusion, the stakeholders of different verticals have developed their own ecosystem using different technologies, and protocols leading to creation of vertical silos. In some cases, even different segmented stakeholders of a common ecosystem have developed/adopted different, communication technologies, protocols, data semantics, and standards. A common, unified, harmonized, inter-operable and sharable ecosystem is desirable to be built and deployed for Smart city infrastructure.
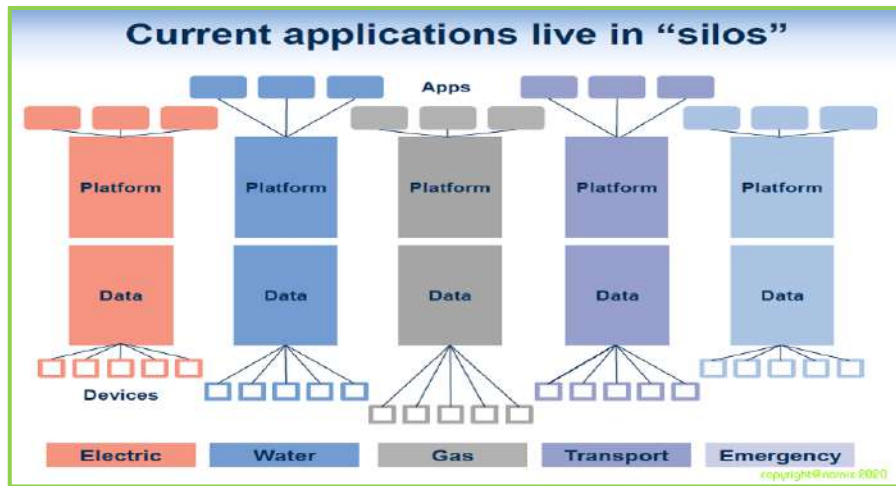
*Figure 9.2: Current Applications*

9.13 Organizations and citizens of a city have a need to share data. At an operational level, systems can interoperate, and at a strategic level, information is used to manage the effective use of resources to bring about beneficial change. However, data is often labelled using language and terminology specific to the sector which is collecting the data. Each sector has its own models and terminologies that enable data to be discovered and understood within that sector but it may form a barrier to interoperate with terminology of other sectors. Interoperability features should also address this issue and achieve seamless interoperability among different ecosystems.

### D. Compliance Testing Infrastructure and Ecosystem

9.14 To ensure seamless homogeneity of the Deployment Architecture in each city along with interoperability of all hardware and software Smart Components of the Digital Infrastructures in the Cities, it would be critical to develop the comprehensive Compliance Testing Scheme to ensure efficient Testing of all the Products, Systems, and Solutions for Interoperability and other Specifications to ensure trust of the procuring and deploying organizations.

### E. Secure Cyberspace Assurance – Promise of a trustworthy Cyber-ecosystem

9.15 **Internet Resilience of India–**It is of utmost importance to ensure the security and resilience of the internet within the country to enhance

cyber-security capabilities to better protect Indians and defend critical government and private sector systems.

9.16 Cities' Digital/Smart Solutions Systems are among the most complex and critical infrastructures of a modern digital society, serving as the backbone for its economic activities and security. It is, therefore, in the interest of country to secure its operation against cyber-risks and threats.

9.17 It is imperative to delve into the security, privacy and trustworthiness aspects and implications of the new paradigm of "Critical Information Infrastructure" and "Internet of Things" that the pervasive computing has enabled, thus raising new challenges for the 'IT and Communication Security' Development and Evaluation Eco-system. Hence, needing a new rigorous and vigorous effort in developing a "Comprehensive Cyber Security, Resilience and Trustworthiness" Strategy Framework encompassing all the critical domains and Stakeholders' classifications, and their respective imperatives from Cyber Security, Resilience and Trustworthiness Perspective.

9.18 Considering the current and future evolving Cyberthreat Landscape, it would be absolutely critical to have the following in place:

- A concise yet comprehensive **'National Cyber Security Strategy'** that sets clear, top-down directions to enhance the cyber resilience for the ecosystem.

- A separate **'National Cyber Security Policy'** based on principles laid down in the 'Strategy'.

9.19 Since the adoption of National Cyber Security Policy (NCSP) 2013[65], the technologies, platforms, threats, services, and aspirations have changed tremendously. The transformational Digital India push, as well as Industry 4.0 are required to be supported by a robust cyberspace. However cyber intrusions and attacks have increased in scope and

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[65]https://ncss2020.nic.in/

sophistication, targeting sensitive personal and business data, and critical information infrastructure, with impact on national economy and security. The present cyber threat landscape poses significant challenges due to rapid technological developments such as Cloud Computing, Artificial Intelligence, Internet of Things, 5G, etc. New challenges include data protection/privacy, law enforcement in evolving cyberspace, access to data stored overseas, misuse of social media platforms, international cooperation on cybercrime and cyber terrorism, and so on. Threats from organized cybercriminal groups, technological cold wars, and increasing state sponsored cyber-attacks have also emerged. Further, existing structures may need to be revamped or revitalized. Thus, a need exists for the formulation of a National Cyber Security Strategy 2020.

9.20 The Indian Government, under the aegis of National Security Council Secretariat, through a well-represented Task Force is in the process of formulating the National Cyber Security Strategy 2020 (NCSS 2020) to cater for a time horizon of five years (2020–25).

## F.    National Trust Centre

9.21 To support the recommended National Cyber Security Strategy and Policy, it is imperative to set up a National Trust Centre (NTC), as recommended by TRAI in 2017. The NTC must be geared up to undertake the Security Testing and Evaluation, comprehensively, including but not limited to Devices, Systems, Networks, Application and System Software's, Firmware's, Communication Stacks to ensure that the deployed Devices, systems, and solutions are completely trustworthy. For this purpose, National Trust Centre shall be enabled and empowered by a comprehensive and granular Cyber Security and Trustworthiness Reference Architecture to address all the stakeholders' concerns in a wholistic manner duly supported by granular Compliance Testing Framework and Test Labs ecosystem for total assurance to the stakeholders. The matter has already been prioritized, and the National

Test Centre is being set up under the aegis of TEC an attached office of DoT.

## G.  National Charter of Trust

9.22  Beyond setting up the National Trust Center, it would be crucial to develop a National Charter of Trust. Following the example of "Charter of Trust"[66] founded in 2018 by a group of Global Technology Vendors. India needs its own National Charter of Trust to develop an eco-system of trustworthy vendors that Cities, Utilities, and other Critical National Infrastructure agencies can trust absolutely by establishing the best practices in the domain of Cyber Security that are globally harmonized in Standards, strategy, innovation, certification, transparency, and all other core characteristics required to build an absolutely trustworthy ecosystem.

## H.  Unique Secure Device Identity

9.23  As the saying goes, a chain is as strong as the weakest link. Any single device connected to the civic infrastructure could cripple the national critical infrastructure if it is not Secure and Trustworthy. Any Node Device in the Infrastructure could be replaced with a Rogue Device that could provide access to the core of any network, and infrastructure. To alleviate such risks, each and every device that connects to the City or Nations infrastructure must be securely identifiable through a Unique Secure Identity.

9.24  Hence, it is imperative to create a framework to allocate a unique, secure, and un-cloneable identity to each and every device connected to the Civic and/or Critical Infrastructure.

## I.  Unique Device Address

9.25  Similarly, it is crucial to develop an Addressing Scheme to allocate unique address to each device connected in any network. This addressing scheme is beyond the MAC Address of Network devices and

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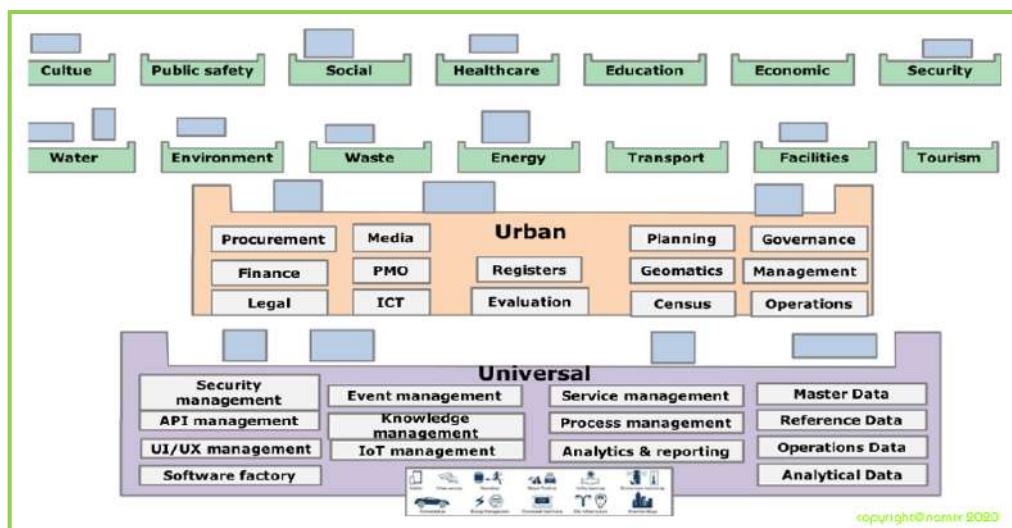
[66]https://www.charteroftrust.com/topics/

or Unique Secure Identity. Improving cyber safety and resilience requires all stakeholders to act together at scale and in a coordinated way, including governments, the engineering profession, operators of critical infrastructures and other systems, and developers of products and components. The evolving nature of the challenges will require continual responsiveness and agility by governments and other stakeholders.

## J.    Agile Cloud Strategy

9.26    The growth of "cloud computing" (CC) services in the last decade has transformed the way governments, enterprises, and consumers store and process their data and manage their resources. City Administrations and Civic Infrastructure Operators need to leverage the latest disruptive technologies to ensure Agile, Elastic yet Secure, and Resilient IT infrastructure. Using the Cloud Technologies makes a robust strategy with all flexibilities and robustness feasibility. However, it is mandatory to use the Data centers located within the country to ensure unhindered Lawful Interception (as and when needed for National security reasons) and maintaining the Data Sovereignty.

## K.    Data Sharing

9.27    Smart City technologies based on digital infrastructure and digital services offer a potential way of monitoring and managing physical and social resources in the city. Digital technologies can collect sufficiently large amounts of data to support very close matching of supply availability against demand requirements. The use of historic information to correlate with actual events can also inform immediate reaction where the data sets match those of a previous historic event. The new communications potential from sensors on buildings, roads, and other elements of the City and the sharing of data between service delivery channels, if integrated, will enable the City to improve services, monitor, and control resource usage and react to real-time information.

*Figure 9.3: Common Platform Approach for ubiquitous Data sharing*

## L.    Reference Architecture

9.28   BIS is developing a new Reference Architecture[67] for Unified and Secure ICT Backbone for Smart Cities leveraging the M2M/IoT technologies in a standardized and interoperable framework. According to BIS, Unified Secure and Resilient Architecture, if implemented in Indian Smart Cities, shall enable optimization of the ICT infrastructure and help bring down the total cost of ownership in terms of capital and recurring expenditure in the upcoming smart cities deployments. It shall bring down the Carbon Footprint of the Digital Infrastructure in the Cities contributing towards the sustainability of the infrastructure. It is envisaged that if cities adopt the Unified Digital Infrastructure approach, it shall be relatively easier to make the Digital Infrastructure of the Cities Cyber Secure and Resilient.

9.29   The evolved Comprehensively Unified ICT Architecture has been modelled as a "Classic Saucer Champagne Glass"[68] with a wide Flat Bottom Base depicting the multitude of Field Devices and sensors, etc. The Saucer-Shaped Bowl on the Top is depicted being filled with an ever-increasing spectrum of City Applications and Citizens' Services.

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[67]https://bis.gov.in/
[68]BIS Pre-Standardization Study Report - Unified, Secure & Resilient ICT Framework for Smart Infrastructure (Page 134)

The Long Stem depicts all the Common Layers viz., Unified Last Mile Communication, Common Standardized Gateways (application or Vertical Agnostic), Common Service Layer representing the Common Service Functions in the Gateways, as well as, in the Cloud and the Smart City Middleware and City Data Reservoir in the Cloud.

9.30 However, Standards per say do not make the cities smart and/or sustainable by themselves. They need to be supported by well harmonized Policies and Regulatory Frameworks, Pro-active City Administrations who work in a completely collaborative manner with all other stakeholders be it the Citizens or the different Infrastructure and Services Providers, Technology Providers, Local and Global Civic Agencies, District, State and Central (National) Administrations.

9.31 This Strategy Framework for Scalable, Secure, Sustainable and resilient Unified Digital infrastructure provides a Systemic approach to developing and deploying Digital Infrastructure across cities, districts, states rather even at the National level to bring homogeneity in technology and business ecosystems as well, by creating economy of scale.

9.32 With the emergence of new technologies and ICT domains like artificial intelligence, big data, robotics, cloud computing, and IoT, the importance of standardization goes beyond interoperability required for completing the Global Digital Single Market. Given the fast pace of change in our world, and its possible implications for our societies and workforce, all nations' policymaking aims to reap the maximum benefits from Digital Transformation. In some instances, the availability of standards can become a precondition for implementing policy or legislation. The safety and security of 'smart' 'products, automated devices, and IoT, together with the reliability and validity of artificial intelligence, data and privacy protection, are all challenges that may require standards to be developed and used for regulatory or public policy purposes.
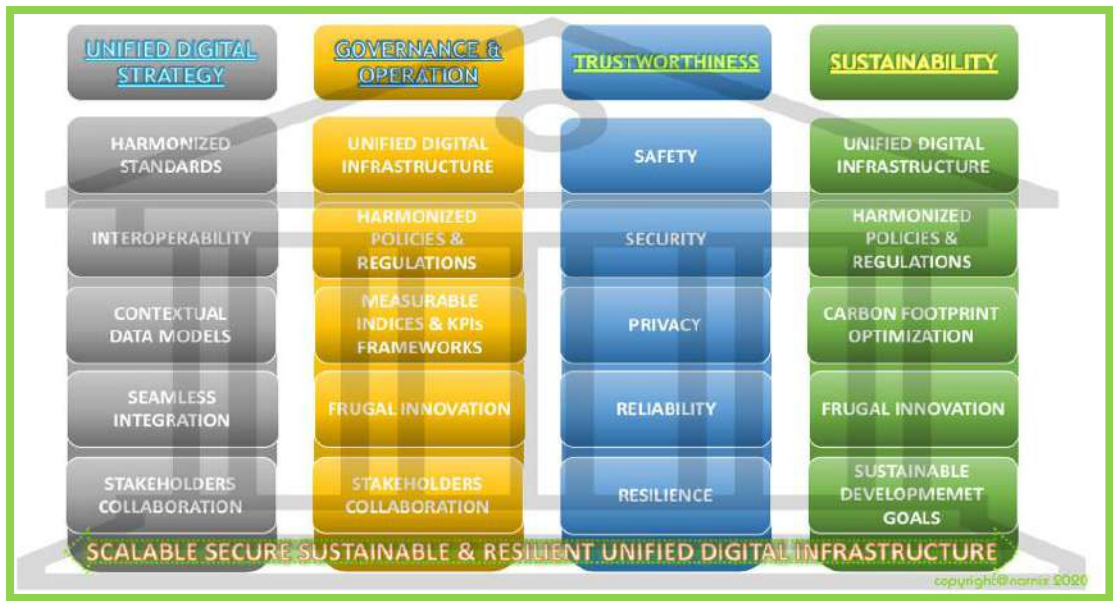
*Figure 9.4: Strategy Framework for Unified Digital Infrastructure*

9.33   We need to develop sustainable solutions for a balanced ecosystem by empowering people to learn and apply nature-inspired strategies in design. Further, we also need to develop repositories of resources, and launch design challenges where people learn by practicing, provide comprehensive support for bringing solutions to market, and create a conducive environment and platform for a global network of innovators. In short, together, we need to learn about, teach, and practice a radically different way to build our world.

### M.   Harmonized Standards, Regulations and Policies

9.34   To ensure reaping the benefits of efforts and initiatives of different sections of the Government, Administration, and Legislature, it is imperative that the instruments created individually by them are coherent and help to create a seamless homogenous framework in which Standards, Regulations, and Policies dovetailed with each other.

9.35   Policies provide the overarching statements of the intent, goals, and objectives, while Standards function as rules to achieve the intent, and regulations provide the legal sanctity to the standards, and guidelines for the stakeholders and help realize the intent. Unless all three work

in an absolutely coherent manner no standards, policies, or regulations shall be implementable seamlessly.

9.36  In the Smart Cities scenario, the National and State Governments form the Policies, while BIS, TSDSI, TEC, and MeitY formulate standards with the help of Industry and other stakeholders, and respective Departments formulate the Regulation to implement the Policies by leveraging the relevant Standards.

9.37  Further, within a State, the Administration is at multiple tiers – State, District, and City level. To ensure ubiquitous transformation of the Urban landscape, collaboration, and co-ordination, at all the levels are needed.

9.38  The proliferation of smart cities will lead to a Smart Nation, and that will further lead to a nature-aware society that balances societal, economic, and technological advancement with the climate and nature's equilibrium making our planet Carbon Neutral by leveraging nature-inspired technology solutions to practice the tenet of Circular Economy.

## References

1.  http://www.who.int/gho/urban_health/situation_trends/urban_population_growth_text/en/

2.  https://www.un.org/en/events/citiesday/assets/pdf/the_worlds_cities_in_2018_data_booklet.pdf

3.  https://censusindia.gov.in/2011-prov results/paper2/data_files/India2/1.%20Data%20Highlight.pdf

4.  https://narnix.com/standards-chromosomes-smart-infrastructure/

5.  https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html#:~:text=By%202030%2C%20the%20world%20is,of%20them%20in%20developing%20regions.&text=While%20one%20in%20eight%20people,with%20fewer%20than%20500%2C000%20inhabitants.

6.  https://www.un.org/sustainabledevelopment/cities/#:~:text=The%20world's%20cities%20occupy%20just,living%20environment%2C%20and%20public%20health.

7.  https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf

8.  https://population.un.org/wup/Publications/Files/WUP2018-KeyFacts.pdf

9.  http://mohua.gov.in/upload/uploadfiles/files/1Mission%20Overview%20English(1).pdf

10. https://www.itu.int/en/wtisd/2020/Pages/default.aspx

11. https://www.itu.int/en/wtisd/2020/Documents/WTISD2020-Toolkit-en.pdf

12. https://www.rockefellerfoundation.org/wp-content/uploads/City-Resilience-Framework-2015.pdf

13. https://www.dqindia.com/cyberspace-global-commons-the-challenges-1/

14. https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/Risk/Our%20Insights/McKinsey%20on%20Risk%20Issue%208%20Winter%202019/McKinsey_on_Risk_Issue_8.pdf

15. BIS Pre-Standardization Study Report - Unified, Secure & Resilient ICT Framework for Smart Infrastructure, Page 66.

16. http://smartcities.gov.in/upload/uploadfiles/files/SmartCityGuidelines(1).pdf (Page 5)

17. https://www.iso.org/committee/656906/x/catalogue/

18. https://www.iso.org/committee/656906/x/catalogue/

19. https://smartutilities.net.in/2020/06/28/energy-transition/

20. http://bbnl.nic.in/

21. Source: TRAI, Telecom subscription data May, 2020

22.   http://smartcities.gov.in/upload/uploadfiles/files/SmartCityGuidelines(1).pdf

23.   http://smartcities.gov.in/upload/uploadfiles/files/SmartCityGuidelines(1).pdf( page 8)

24.   https://smartnet.niua.org/smart-cities-network

25.   http://smartcities.gov.in/upload/uploadfiles/files/SmartCityGuidelines(1).pdf

26.   http://articles.economictimes.indiatimes.com/2014-11-26/news/56490712_1_ict-cent-schneider-electric-india

27.   http://smartcities.gov.in/upload/uploadfiles/files/SmartCityGuidelines(1).pdf (Page 5)

28.   http://smartcities.gov.in/content/innerpage/national-level.php

29.   https://www.indiastack.org/about/

30.   https://recro.io/blog/india-stack-the-high-tech-solution-to-billion-problems/

31.    https://dot.gov.in/sites/default/files/Final%20NDCP-2018_0.pdf

32.   https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2083-0-201509-I!!PDF-E.pdf

33.   https://pib.gov.in/PressReleasePage.aspx?PRID=1547042#:~:text=%E2%80%9CThe %20'Ease%20of%20Living',based%20on%20the%20liveability%20parameters.

34.   https://smartnet.niua.org/eol19/pdf/MPI_Methodology.pdf

35.   https://pib.gov.in/Pressreleaseshare.aspx?PRID=1578920

36.   http://smartcities.gov.in/upload/smart_solution/5954cc108b07cInnovation _for_Smart_Solutions%20FINAL.pdf

37.   https://www.mindteck.com/index.php?/smartcity-solutions

38.   https://punesmartcity.in/area-based-development-initiatives/

39.   BIS Pre-Standardization Study Report - Unified, Secure & Resilient ICT Framework for Smart Infrastructure, (Page 40)

40.   BIS Pre-Standardization Study Report - Unified, Secure & Resilient ICT Framework for Smart Infrastructure

41.   BIS Pre-Standardization Study Report - Unified, Secure & Resilient ICT Framework for Smart Infrastructure (Page 40)

42.   BIS Pre-Standardization Study Report - Unified, Secure & Resilient ICT Framework for Smart Infrastructure (Page 41)

43.   https://www.bsigroup.com/en-IN/smart-cities/Smart-Cities-Standards-and-Publication/PD-8100-smart-cities-overview/

44.   https://www.iso.org/committee/656906.html

45.   https://www.iso.org/obp/ui/#iso:std:iso:37120:ed-2:v1:en

46.   https://www.bsigroup.com/en-IN/smart-cities/Smart-Cities-Standards-and-Publication/PAS-181-smart-cities-framework/

47.   https://bis.gov.in/other/USR_ICT_FSI_V_1_0.pdf Page no. 45

48.   https://cordis.europa.eu/project/id/257521

49.      https://dot.gov.in/sites/default/files/EnglishPolicy-NDCP.pdf

50.      'Revised Draft IoT Policy' in October 2016

51.      https://bis.gov.in/

52.      https://bis.gov.in/other/USR_ICT_FSI_V_1_0.pdf

53.      BIS Pre-Standardization Study Report - Unified, Secure & Resilient ICT Framework for Smart Infrastructure

54.      https://tec.gov.in/pdf/M2M/Design%20Planning%20Smart%20Cities%20with%20IoT%20ICT.pdf

55.      https://www.tec.gov.in/mandatory-testing-and-certification-of-telecom-equipments-mtcte/

56.      BIS Pre-Standardization Study Report - Unified, Secure & Resilient ICT Framework for Smart Infrastructure (Page 84)

57.      BIS Pre-Standardization Study Report - Unified, Secure & Resilient ICT Framework for Smart Infrastructure (Page 130 and 76)

58.      https://www.ericsson.com/en/microwave-outlook/reports/2017

59.      https://www.ericsson.com/en/microwave-outlook/reports/2017

60.      UN report 'The World's Cities in 2018'

61.      https://www.gsma.com/iot/wp-content/uploads/2013/02/cl_SmartCities_emer_01_131.pdf

62.      http://smartcities.gov.in/upload/uploadfiles/files/Advisory(1).pdf

63.      https://narnix.com/resources/

64.      BIS Pre-Standardization Study Report - Unified, Secure & Resilient ICT Framework for Smart Infrastructure (Page 85)

65.      https://ncss2020.nic.in/

66.      https://www.charteroftrust.com/topics/

67.      https://bis.gov.in/

68.      BIS Pre-Standardization Study Report - Unified, Secure & Resilient ICT Framework for Smart Infrastructure (Page 134)

*Note: While preparing the Whitepaper, apart from the in-house research work, excerpts have been taken from resources available at websites of the various Government / Non- government organisations such as BIS, MoUD, TSDSI, TEC, ITU, DoT, ISO and many other sources. Detailed information has been received from Bureau of Indian Standard, Bhopal Smart City Development Corporation Limited, Chennai Smart City Limited, Pune Smart City Development Corporation Limited and some vendor/ platform provider/ developer organisations. Extreme care has been taken in collating and interpreting the information / data provided by these organisations. However, variance, if any, found with correctness or completeness of the information/ data is sincerely regretted.*