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**SATRC REPORT ON**

**INCREASING ROLE OF NETWORK SHARING FOR SATRC COUNTRIES: FROM PASSIVE INFRASTRUCTURE SHARING TO MOBILE VIRTUAL NETWORK OPERATION**

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**EXECTIVE SUMMARY**

* 1. Traditionally, the Mobile Network Operators (MNOs) use to own entire infrastructure to provide services. It results in increased cost of operations due to rigorous regulatory requirements and ever increasing capital expenditures. Stiff competition in the market and trend of separation of network and service provisioning are key factors behind the operators’ move to explore various strategies to synchronise operations and reduce costs. Now, network sharing is not limited up to sharing of passive infrastructure elements. There are other dimensions of network sharing. There are possibilities of sharing active infrastructure sharing with varying degree of penetration which results into different models of sharing.
	2. Infrastructure sharing model can be categorized into two broad categories:

**Horizontal Sharing:** Horizontal sharing refers to the sharing of infrastructure amongst telecom operators. Passive Sharing and Active Sharing are the possible domains under this categorization. Virtual Network Operations (VNO) also amounts to sharing of resources between Telecom Service Providers.

**Vertical Sharing:** There is another dimension of spectrum sharing i.e. Vertical Sharing. Vertical Sharing refers to sharing of spectrum resources between MNO and other agencies (Non-MNO) such as TV broadcasters or Security Agencies. Collective/Unlicensed use of spectrum falls under this category. Now days, alternative approach of sharing the spectrum such as Licensed shared access (LSA), cognitive radio etc. are also being experimented with.

* 1. **Passive Sharing** is the sharing of non-electronic infrastructure or passive elements of network infrastructure like, building, tower, sites, cabinet, power, air-conditioning, dark fiber, security arrangement, poles, trenches sub-loop, local-loop etc. Such sharing of radio sites is also known as “site sharing” or “collocation”.
	2. Various models of sharing are possible under **Active Sharing**, viz:
	+ **RAN Sharing with Dedicated Spectrum (i.e. without Shared Spectrum):** In this type of RAN sharing, the shared elements are functionally separated, allowing the operators to independently control all the parameters that are determinant of the quality of the network. This implies that the communication between the RNC (Radio Network Controller) and NodeB remains under the independent control of each operator. Thus, the operators independently control all the parameters that determine the quality of the network, such as coverage, speed and the handover parameters.
	+ **RAN Sharing with Shared Spectrum:** Different varieties of spectrum sharing concepts are prevalent among service providers world over. Spectrum sharing in most simple form can be leasing of the given quantum of spectrum in a geographical area/ LSA for a given period. The other method is pooling of spectrum resources jointly by the concerned service providers and effectively deploying it to provide better services to customers and economize on number of BTS to roll out the services. In such cases dependency of the operators on each other increases and such spectrum sharing are generally preceded by active infrastructure sharing among them. Sharing can provide additional network capacities in places where there is network congestion due to a spectrum crunch.
	+ **Roaming-based sharing (i.e. RAN and Core Network sharing):** Roaming is the ability for a customer of mobile communications to automatically make and receive telephone calls, send and receive data or access other services while travelling outside the geographical coverage area of the home network, by means of using a network of another operator. Customers of one operator can roam seamlessly in the other, ‘host’ operator’s network. It includes both RAN sharing as well as Core Network sharing.
	1. **Collective/unlicensed use of spectrum** falls under Vertical Sharing Category.Collective or unlicensed use of spectrum allows an unlimited number of independent users and/or devices to access spectrum. There is no licensed user of licence-exempt frequency bands. There exist certain rules for the use of frequency defining maximum permissible radiated power level. The common applications are low power applications and can be used at the same time by a great number of users. The unlicensed use of frequency may be permitted for generic applications or for some specific applications.
	2. **Alternative Approaches of Sharing the spectrum-** Current spectrum allocation mechanisms are based on either exclusive allocation to an operator or unlicensed/license-exempt operation. Despite the great success of exclusive licensed spectrum and the increasing possibility of unlicensed spectrum for mobile services, spectrum crunch still exists. Further, the 5th generation communication systems are foreseen to provide a 1000x to 10,000x capacity increase compared to legacy 4th generation technology. For this ambitious goal, the identification of new spectrum for 5G applications is necessary. It is of utmost important that identification of new/additional spectrum is done in higher frequency bands (typically 10 GHz and above) and also in lower frequency band (6 GHz and less). Therefore, the NRAs (national Regulatory Authorities) are ready to use the innovative and novel means for managing spectrum such that enough spectrum is made available for 5G applications while satisfying the needs of existing incumbents.
	3. Typically there are two types of innovative spectrum sharing schemes widely considered. One is the TV whitespaces where upcoming technologies like cognitive radio and/or software defined radios (SDR) seem to allow their exploitation. Key to whitespace use is the idea of license exempt and free access for everyone and every service under a secondary right of use.
	4. Alternative approach is to give the secondary licence(s) to share spectrum with the incumbent users in such cases when the incumbent user is not using its spectrum all the time and/or using it in limited area(s). This approach is known as Authorised Shared Access (ASA) / Licensed Shared Access (LSA). LSA is a new category of spectrum rights which allows the holder to use unused spectrum to offer commercial services without interfering with the incumbent user. It is a right to utilise under-used spectrum without interfering with the incumbent user, subject to the terms defined by the relevant authority (government/ regulator) and/or upon an agreement with the incumbent user. LSA sharing technology is being developed in Europe.
	5. **Existing Regulatory framework for sharing the infrastructure in India:** In India most of the access service licensees are integrated TSPs providing access, long distance and internet/broadband services. They provide services either by using their own infrastructure or by sharing infrastructure of other TSPs. Over a period of time, restriction on sharing the telecom infrastructure has been removed in India and greater degree of freedom has been given to the TSPs on the issue. The existing regulatory framework for sharing of infrastructure has been evolved following types of sharing has been permitted: (a) Sharing of Passive Infrastructure (b) Sharing of Active Infrastructure without Shared Spectrum (d) Spectrum Sharing (e) Roaming i.e. Complete RAN and Core Network Sharing. (f) Virtual network Operations (VNO). (g) Unlicensed use of Specrum. Each of these has been discussed in detail in the report.

# CHAPTER-I: INTRODUCTION

1. **Significance of Sharing of Telecom Resources**
	1. In developing countries like India, telecom sector, specifically mobile telephony plays an important role by providing wireless services to large proportion of population. The digital infrastructure is recognized as the key for citizens to participate in the information economy and take advantage of modern methods of education and health care. Given the central role that information and communication technologies (ICT) play in the global economy, broadband access is now seen as a public asset similar to roads and railways.
	2. There are two main challenge areas for the operators; (a) Demand for data services is pushing the operators to expand the capacity of their networks with unprecedented pace. This requires a lot of capital investment, but does not lead to the proportionate increase in the revenues. The data realization is in decline and the data growth in not sufficient to compensate it. Therefore, operators are facing lot of pressure on the profitability. (b) The broadband services are concentrated in the urban pockets only. There is hardly any broadband network in the rural/remote areas. Requirement of more resources is a challenge for the operators to expand their network and reach to the areas which are less remunerative. Both these challenges require that the operators should focus on reducing both Capex as well Opex requirements of their networks.
	3. Physical resource sharing amongst telecom service providers (TSPs) plays an important role to avoid duplication of the costly infrastructure and, thus, crucial to support efficient, competitive and innovative wireless communication markets, particularly in the less remunerative areas. Sharing mobile infrastructure helps in reducing the cost of network deployment. It may also encourage operators to migrate to new technologies and deployment of mobile broadband. In the absence of infrastructure sharing, each TSP would be required to make huge investment, which would make mobile services less affordable and may discourage them to innovate and migrate to new technologies in emerging markets. Higher costs of infrastructure may also act as a barrier to the entry of new operators in the market and additionally, it may be too costly for TSPs to roll-out mobile networks in rural and less populated areas, resulting in exclusion of a part of the population or certain regions from access to mobile telecommunication services. The cost savings by infrastructure sharing enables TSPs to reallocate their capital on the development of other services and technical innovation. It also leads to optimal utilisation of scare resources like spectrum.
2. **Different Models of Sharing of Telecom Infrastructure**
	1. The sharing does not mean only the passive infrastructure sharing. Even the active network elements can also be shared. There are many models which permit sharing of infrastructure in varying degrees. Some allows sharing of only passive infrastructure while some allows sharing of Radio Access Networks (RAN) also. There are models to share the core network and even the complete mobile network. Various possible models are discussed in the subsequent chapter.
3. **Sharing of Spectrum Resources**
	1. Spectrum is a scarce and valuable resource which is subject to demand from a wide range of wireless services including mobile broadband, broadcasting, programme making and special events (PMSE), satellite, radar, emergency services, military use and the IoT cellular as well as non-cellular applications. Much of the spectrum in use today has been allocated on dedicated basis. This has the advantage that it makes it easier for services to operate at higher power without causing inference, enabling wide area coverage to be achieved with a good quality of service. However, as the demand for spectrum grows from an expanding range of wireless services, it is becoming increasingly difficult to accommodate new services in their own dedicated spectrum bands.
	2. An alternative approach of utilising spectrum resources is to share it among different users. Spectrum accessed on a shared basis can play a complementary role alongside dedicated spectrum bands in meeting the significant growth in demand for mobile and wireless data. Sharing can occur geographically, where spectrum is unused in a particular location, or on a temporal basis, where spectrum is only being used at certain times Enabling different users to share access to the same frequency band can deliver three important benefits: (a) It can extend spectrum access to a wider range of services; (b) It can increase spectrum efficiency by allowing spectrum to be optimally utilised; and (c) It can reduce barriers to spectrum access, which can act as an enabler for innovation in new wireless services.
	3. Previously, the benefits provided by spectrum sharing have been limited by the difficulty associated with managing interference between different users than with a dedicated spectrum band. However, with the advancement of technology, it is possible to explore the alternate ways in which the spectrum can be shared. These include:
	4. **Geo-location database technology**: This can make it easier for devices to identify spectrum that can be accessed on a shared basis in a given location without causing interference to other spectrum users. This approach is being used to enable white space access to the UHF TV bands and can also be applied in other frequency bands and in other concepts of spectrum sharing such as Licensed Shared Access (LSA);
	5. **Dynamic spectrum access (DSA) technology**: This can allow devices sharing spectrum to identify the presence of other devices operating in their vicinity so they can avoid causing interference to them. At a simple level, this approach is already used by some Wi-Fi equipment to help select the least congested frequencies.
	6. It is important for the regulators to evolve the enabling policy and regulatory framework which support various models in which the telecom resources can be shared. It is equally important to be vigilant about the competitive issues so that cartelization is not formed. The paper discusses the key areas where spectrum sharing can play an important role in delivering future benefits to citizens and consumers.
4. **Composition of the Paper**
	1. This paper is divided into five chapters. Chapter II discusses about various models of Infrastructure sharing. It also gives the international persective of emerging spectrum sharing techniques such as Cognitive radio technologies and Licenced Shared Access (LSA). Chapter III is about regulatory framework for sharing the infrastructure and its role in Indian telecommunication Industry. Chapter IV includes recommendations for SATRC member countries on the subject matter.

# CHAPTER- II: MODELS OF INFRASTRUCTURE SHARING

* 1. The continuous growth and demand for mobile and other telecom services, TSPs has been forced to expand their infrastructure for the expansion in their capacities and improving quality of services to the consumers. It is not always easy, particularly for a new entrant, to arrange adequate infrastructure. One of the main reasons for this is the capital expenditure required for acquiring infrastructure. Infrastructure sharing is an approach that leads to optimum utilization of infrastructure and resources. It provides an opportunity to the new entrants to use the telecommunication infrastructure already set up by other existing operators on either lease or on rent basis or swapping infrastructure on a non discriminatory basis. Even for the well established operators, infrastructure sharing provides an effective means to reduce their capital as well as operating costs. This is particularly important in the price sensitive countries such as India. In short, it helps the TSPs to reap the benefit of economies of scale and promotes healthy competitive environment, reduces the entry cost for new entrants and further reduces the wastage non-optimal use of the telecommunication network and infrastructure.
	2. Investment in technology and network deployment requires huge costs[[1]](#footnote-1). There is an inherent risk factor of these network elements becoming obsolete as technologies are changing rapidly. Fast evolving technologies forces both fixed-line and mobile operators, to continuously adopt the new technologies and upgrade their infrastructure. Infrastructure sharing minimizes the risk by distributing it among several players. It also leads to optimal use of scarce natural resources, for example- spectrum.
	3. Infrastructure sharing model can be majorly categorized into two broad categories:

**Horizontal Sharing**: Horizontal sharing refers to the sharing of infrastructure amongst TSPs. It includes passive sharing of antenna, tower sharing, site sharing etc as well as active sharing involving sharing of Radio success Network (RAN), Core Sharing etc.

* + **Vertical Sharing**: Vertical sharing refers to the sharing of infrastructure between two different sectors i.e. sharing of spectrum between commercial telecom operations and some other sector, say Defence. It includes Authorised shared access, cognitive radio etc.

Figure: 2.1 depict different models of Infrastructure Sharing, each of the verticals have been discussed in detail in the subsequent section.

**Figure: 2.1- Models of Infrastructure Sharing**

1. **Horizontal Sharing**
2. **Passive Sharing**
	1. Passive Sharing is the sharing of passive elements of network infrastructure like, building, tower, sites, cabinet, power, air-conditioning, dark fiber, security arrangement, poles, trenches, local-loop etc. Such sharing of radio sites is also known as “site sharing” or “collocation”. Passive sharing does not require active operational co-ordination between network operators.
	2. In an increasingly competitive market, low cost is the key to profitability, and operators can save on CAPEX and OPEX by sharing passive infrastructure such as towers. Site costs constitute approximately 30% of CAPEX (capital expenditure) and OPEX (operating expenditure). Both these costs are reduced by sharing the cost associated with shared infrastructure between multiple operators. In other words, site sharing reduces both CAPEX and OPEX by minimizing their investments in passive network infrastructure and in network operating costs.
	3. Site sharing facilitates network expansion into underserved areas that would otherwise be unprofitable or have a payback period greater than the business target. Because of the cost saving aspects, site sharing may also contribute to making wireless services more affordable. In the early phases of network development, infrastructure sharing is most commonly used to facilitate quick network roll-out, at a lower cost, by new entrants. Facilitating sharing can provide an additional revenue source and lower costs to the incumbent operators.



 **Figure: 2.2: Passive Infrastructure Sharing**

* 1. There are different types of site sharing agreements that are considered by Telecom Service Providers. These agreements may be bilateral, in which two operators agree to provide mutual access to facilities or multilateral that involves several operators. Sometimes, it is being done through intermediary, a specialist tower company. Tower companies usually enjoy scalable and long-term recurring revenues with contracted annual escalations. They also benefit from low churn rates and low operating and capital costs. Tower management companies thus can ensure fair treatment of new entrants while providing financial benefits to the incumbents by buying the latter’s infrastructure and managing it, hence lowering operating expenses in the long run.
1. **Active Sharing**
	1. Active Sharing, in contrast to passive sharing, means sharing of electronic infrastructure and facility. It includes sharing of elements of the active layer of a mobile network, such as antennas, entire base stations or even elements of the core network. Operators focusing on emerging markets normally look for economic options for coverage and capacity growth and will be more inclined to passive sharing approaches; where as the operators in mature markets are seeking cost optimizations and new technology options, through active sharing opportunities. There are many ways in which infrastructure sharing is possible. Depending upon the degree of the depth of network sharing, there are various models of Active Sharing possible as discussed below:
2. **RAN Sharing with Dedicated Spectrum (i.e. without Shared Spectrum)**
	1. Radio Access Network (RAN) is a part of mobile telecommunication system that involves implementation of radio access technology. Conceptually, RAN connects devices such as a mobile phone with the core network.



**Figure: 2.3: Active RAN Sharing with Dedicated frequencies**

* 1. In this type of RAN sharing, the shared elements are functionally separated, allowing the operators to independently control all the parameters that are determinant of the quality of the network. This implies that the communication between the RNC (Radio Network Controller) and NodeB remains under the independent control of each operator. Thus, the operators independently control all the parameters that determine the quality of the network, such as coverage, speed and the handover parameters.
1. **RAN Sharing with Shared Spectrum**
	1. Spectrum sharing typically involves more than TSP sharing the spectrum for same or different wireless services. Sharing is a viable option for two or more TSPs because spectrum is a scare resource that is often underutilized by one TSP in a given area. It can also be useful for new operators to cut initial roll- out cost in terms of reduced number of Base Trans-receiver Stations (BTS) by pooling the spectrum.
	2. Different varieties of spectrum sharing concepts are prevalent among service providers world over. Spectrum sharing in most simple form can be leasing of the given quantum of spectrum in a geographical area/ LSA for a given period. The quantum of spectrum taken on lease is totally available to other licensee for the period of lease and can be most optimally used for design of the network or to provide better services to its subscribers.
	3. The other method is pooling of spectrum resources jointly by the concerned service providers and effectively deploying it to provide better services to customers and economize on number of BTS to roll out the services. In such cases dependency of the operators on each other increases and such spectrum sharing are generally preceded by active infrastructure sharing among them. Sharing can also provide additional network capacities in places where there is network congestion due to a spectrum crunch. The gain in spectral efficiency increases non-linearly with the quantum of spectrum. As an example, with 5 MHz of paired spectrum (for GSM technology), it is possible to carry 33.03 Erlang traffic, whereas 10 MHz of paired spectrum can carry 138.6 Erlang traffic.
	4. Some of the possible spectrum sharing requirements may be:
* When there are pockets in licensed service areas (LSA) where one operator does not have spectrum or has less spectrum.
* Operators have non-uniform and complementary subscriber base in different parts of licensed service area.
* When more than one TSP wants to set up a common network with pooled spectrum reducing initial rollout cost.
* When TSP wants to rollout some services for which others are having the suitable spectrum and willing to share.
	1. To facilitate sharing of spectrum resources, it is important to ensure that the administrative costs for permitting shared use of spectrum is kept as low as possible. To make spectrum sharing both transparent and efficient, it is necessary to provide direct access to information on current spectrum usage to all interested parties.

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**Figure: 2.4: Active RAN sharing with Shared frequencies**

1. **Roaming-based sharing (i.e. RAN and Core Network sharing)**
	1. Roaming is the ability for a customer of a TSP to automatically make and receive telephone calls, send and receive data or access other services while travelling outside the geographical coverage area of the home network, by means of using a network of another TSP. In other words, roaming enables customers of a particular MNO to use mobile services when they are not in an area covered by its MNO. It includes both RAN sharing as well as Core Network sharing. National roaming or domestic roaming allows a new entrant operator to have nationwide coverage from the beginning of its operation.

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**Figure: 2.5: Full Network Sharing**

1. **Virtual Network Operators (VNO)**
	1. Today, we are in the convergence era where the same network is capable of providing various services and where the application or services are independent of the underlying network layer, i.e. it is possible for one entity or operator to own the network and for another to independently provide a service to consumers using the network. There can be a number of small entrepreneurs (VNOs), who desire to provide a service to a niche consumer group but do not have either the resources or expertise to build and operate a telecommunication network. There are many un-served and under-served areas where basic telecom connectivity, internet and broadband services need to be provided. VNOs may invest in less competitive areas (like ‘C’ class towns / villages) where Mobile Network Operators (MNOs) have not ventured. This will increase the rural tele-density and broadband penetration in such areas.
	2. There are several areas where VNOs can be useful in service provisioning. They can provide localized services in small towns and rural areas using the networks of existing NSOs or by laying last mile connectivity. The VNO model of service delivery can also be effective in structurally defined geographic areas like airports or smart cities.
	3. Internationally, VNOs have focused mainly for provisioning of mobile access services; and are known as Mobile Virtual Network Operators (MVNOs). However, there are other services also, where VNOs can be useful to increase their penetration. For example, VSAT operators like Telestra Global (Australia), Orbit Research (UK) and VSAT Systems (USA) are providing satellite based VSAT services by leasing hub space to VNOs in some of the countries.
	4. To understand the concept of VNO, we can divide the licensing of telecom services in two broad categories: (a) Network service operator (NSO) licence; and (b) Service Delivery Operator (SDO) licence. The NSO is licenced to set up and maintain networks capable of delivering various types of telecom services e.g. Voice, Data, Video, broadcast, IPTV, VAS etc. in a non-exclusive and non-discriminatory manner and the SDO is licensed to deliver any/all services using the network infrastructure set up by NSO. VNOs are SDO licensees, who do not own the underlying network(s) but rely on the network and support of NSOs for providing telecom services to end users/customers. As these operators do not have their own networks, they are termed ‘Virtual Network Operators’. VNOs can provide any telecom service being provided by the network providers’ viz. teleservices (voice, data, video), internet/broadband, IPTV, Value Added Services, content delivery services etc.
	5. VNOs go by different names in different regions/countries across the world. In Saudi Arabia they are called ‘Service Based Provider (SBP)’ while in Singapore they are known as Services-Based Operator (SBO). An SBP in Saudi Arabia is a service provider who does not build or own a public telecommunications network and utilizes such networks from any Facilities-Based Provider (FBP) to offer Information and Communication Technology (ICT) services to users. Similarly in Singapore, SBOs take telecommunication network elements (such as transmission capacity and switching services) on lease from any Facilities-Based Operator (FBO), licensed by the Infocomm Development Authority (IDA), to provide their own telecommunication services. Services-Based Operators (SBO) are also licensed by the IDA in Singapore. In Hong Kong, the SBOs refer to telecom service providers which rely on the fixed or mobile networks established by FBOs to provide their own telecom services. Examples from other countries are provided in the following section.

**International Perspective**

**MALAYSIA**

* 1. There are four categories of licensable activities as per under the Communications and Multimedia Act 1998.
1. **Network Facility Providers**
	1. Network Facility Providers are the owners of facilities such as satellite earth stations, broadband fiber optic cables, telecommunications lines and exchanges, transmission equipment, mobile communications base stations, and transmission towers and equipment. They are the fundamental building block of the convergence model upon which network, applications and content services are provided.
2. **Network Services Providers**
	1. Network Service Providers provide the basic connectivity and bandwidth to support a variety of applications. Network service enables connectivity or transport between different networks. A network service provider is typically also the owner of the network facilities. However, these services may also be provided by a person using network facilities owned by another.
3. **Application Service Providers**
	1. Application Service Providers provide particular functions such as voice services, data services, content-based services, electronic commerce and other transmission services. Applications services are essentially the functions or capabilities, which are delivered to end-users.
4. **Content Applications Service Providers**
	1. Content Application Service Providers are special subset of applications service providers including traditional broadcast services and the latest services such as online publishing and information services.
	2. Four type of MVNO categories as defined by The Malaysian Communications and Multimedia Commission (MCMC) , exists in Malaysia
5. **Full MVNO**
	1. As defined by the regulator MCMC, a full MVNO is one that owns or provides network facilities and network services such as towers, mobile switching centres, home location registers (HLR) and cellular mobile services. A key feature that distinguishes a full MVNO from other business models is its ability to operate independently of the MNOs. Full MVNOs are able to secure their own numbering ranges, offer its own SIM card and have full flexibility on the design of the services and tariff structures.
	2. Full MVNOs are to require a network facilities provider (NFP) individual licence and a network service provider (NSP) individual licence for the network facilities and network services that they own or provide. In addition, full MVNOs will require an application service provider (ASP) licence in order to provide public cellular services to end users.
6. **Enhanced Service Providers**
	1. Enhanced service providers are those who do not own or provide network facilities but have the ability to secure its own numbering range, operate its own HLR and offer its own SIM cards with its own mobile network code. They are dependent on MNOs for network facilities, as well access to radio network.
	2. Enhanced service providers require NSP individual licence and an ASP licence to provide public cellular services to end users.
7. **Enhanced Reseller**
	1. Enhanced resellers are primarily distributors who resell services provided by MNOs. As with enhanced service providers, enhanced resellers rely on MNOs for access to the radio network and network facilities. The key feature that distinguishes enhanced resellers from enhanced service providers is that enhanced resellers do not have their own SIM cards. While they may still be able to offer their own branded packages, they will not be able to distinguish their services by their MNC. Enhanced resellers are likely to carry out customer care and billing in house.
	2. Enhanced resellers require an NSP individual licence and ASP licence for providing public cellular services.
8. **Resellers**
	1. Resellers merely resell subscription to end users. In most cases, resellers are completely dependent on MNOs for every aspect of service provision, billing and customer care. However, end users will not be able to make a distinction between resellers, other form of MVNOs and MNOs as resellers have direct relationship with end users. MVNOs that operate as resellers are required an ASP license.
	2. The MCMC allocate a specific block of numbers for mobile virtual network operators who wish to establish their own brand names. These numbers are assigned for those Service Providers who operate their own home location registers and billing systems. The MCMC do not regulate the terms and conditions of access for MVNOs, however it intervene only if it is satisfied that such intervention is necessary to ensure long term benefits to end users and growth in the industry.

**SINGAPORE**

* 1. Licensing in Singapore is categorized into two segments: (a) Facility Based Operators (FBOs) and (b) Service Based Operators (SBOs). **Facilities-based operations** refers to the deployment and/or operation of any form of telecommunication network, systems and/or facilities by any person for the purpose of providing telecommunication and/or broadcasting services to third parties, who may include other licensed telecommunication operators, business customers or the general public. Licensees who are licensed as FBO will be able to offer the services that **Services-Based Operators (SBO)** can offer, but not vice versa.
	2. SBOs are operators who have to lease telecommunications network elements such as transmission capacity, switching services, ducts and fiber from any FBO licensed by IDA to provide telecommunications services to third parties or resell the telecommunications services of FBO. The range of operations and services that requires individual licensing under the SBO (Individual) Licence category includes International Simple Resale (ISR), Resale of Leased Circuit Services, Public Internet Access Services, Internet Exchange Services, Virtual Private Network Services, Managed Data Network Services, **Mobile Virtual Network Operation**, Live Audiotex Services, Prepaid Services for other telecommunication services such as Call-back / Call Re-origination Services, Internet Based Voice and Data Services, International Calling Card (ICC) Services, Resale of Public Switched Telecommunication Services, Store-and-Retrieve (S&R) Value-Added Network Services, Store-and-Forward (S&F) Value-Added Network Services etc. Services that requires individual licensing under the SBO (Individual) Licence category also includes Global Mobile Personal Communications by Satellite (GMPCS) Services, IP Telephony Services, Voice and Data Services with Masking of Calling Line Identity, Satellite Mobile Telephone or Data Services, Mobile Communications on Aircraft, Machine-To-Machine (M2M) Services and White Space Geo-Location Database Services.
	3. All SBO licensees are regulated in accordance with the licensing and regulatory frameworks formulated under the provisions of the Telecommunications Act. Licensees are also required to comply with the Code of Practice for Competition in the Provision of Telecommunication Services (Telecom Competition Code), which aims to ensure the development of a fair and competitive telecommunication environment in Singapore. The MVNO must use part of the networks of the mobile operator(s) licensed by IDA under the FBO Licence to originate and deliver its customers’ calls. All SBO (Individual) licences are valid for a period of five years and renewable every five-yearly.
1. **Vertical Sharing**
	1. Vertical sharing refers to the sharing of spectrum resources between two different sectors. For example- Defence and telecom sector, aeronautical and telecom sector etc. It includes collective or unlicensed use of spectrum, cognitive radio, Licenced shared access, etc.
2. **Collective/unlicensed Use of Spectrum**
	1. In the licenced use of spectrum, a spectrum band is exclusively designated for a specific application/user, thus making use within the band more predictable and, therefore, manageable. However, application-specific designation may have costs, notably in terms of spectrum efficiency if usage of the band does not develop as anticipated or the user does not use the spectrum assigned to it most optimally.
	2. Collective or unlicensed use of spectrum is an alternate way of using the spectrum which allows an unlimited number of independent users and/or devices to access spectrum. There is no licensed user of licence-exempt frequency bands. There exist certain rules for the use of frequency defining maximum permissible radiated power level. The common applications are low power applications and can be used at the same time by a great number of users. The unlicensed use of frequency may be permitted for generic applications or for some specific applications. One example of successful implementation of un-licensed band for generic applications can be found in the 863 - 870 MHz band. Within this band, millions of devices are in use (Table 2.1).

**Table 2.1: Applications in the 863 - 870 MHz band**

|  |  |  |
| --- | --- | --- |
| **Sl. No.** | **Category** | **Application** |
| 1. | Non-Specific SRD | Remote controls, Building automation, Sensors |
| 2. | Radio microphone applications including aids for hearing | Wireless Microphones, Hearing aids |
| 3. | Radio frequency identification applications | Payment transactions, Access controls, People and goods tracking |
| 4. | Wireless Audio Applications | Audio transceivers, Tour guides, 2-way communications |
| **5.** | Alarms | Smoke detectors, Emergency lighting |

* 1. Most of the applications, specific or non-specific, are using the band 2400 - 2483.5 MHz. The maximum power is 10 mW for non-specific application and 100 mW for some specific applications. The bands 5150-5350 MHz and 5470-5725 MHz have been designated for radio local area networks, the band 5725-5875 MHz is designated for non-specific applications and the band 5795–5805 MHz is designated for intelligent transport systems in many countries.
	2. Wi-Fi based broadband network has emerged as one of the visible and important technology alternatives which have seen unprecedented growth. Unlicensed spectrum can improve the chances of market entry and can help accelerate the build-out of rural networks. Although the administrations do not get any upfront payment, unlicensed spectrum use will serve a multitude of public interest objectives, including socio-economic development of the underprivileged masses for which it is difficult to put a price tag on; its real value may accrue in terms of technological innovation and competitive entrepreneurship entry.
	3. One of the main concerns with adopting the licence exempt approach is that, with the introduction of numerous new applications, the band itself may be rendered unusable for other applications due the potential interference generated by the different applications. More specifically, it can be difficult to refarm the spectrum if a ‘better’ use emerges in future. The unlicenced scheme provides no QoS guarantees since there is no limit on the number of users/operators in a given geographical area. Still, the availability of unlicensed spectrum has played a crucial role in the rapid growth and evolution of wireless broadband access globally. Moreover, it has fostered the establishment of standards that has enabled the development of applications used by numerous heterogeneous devices.
1. **Alternative Approaches of Spectrum Sharing**
	1. Current spectrum allocation mechanisms are based on either exclusive allocation to an operator or unlicensed/license-exempt operation. Despite the great success of exclusive licensed spectrum and the increasing possibility of unlicensed spectrum for mobile services, spectrum crunch still exists. Further, the 5th generation communication systems are foreseen to provide a 1000x to 10,000x capacity increase compared to legacy 4th generation technology. For this ambitious goal, the identification of new spectrum for 5G applications is necessary. It is of utmost important that identification of new/additional spectrum is done in higher frequency bands (typically 10 GHz and above) and also in lower frequency band (6 GHz and less). Therefore, the NRAs (national Regulatory Authorities) are ready to use the innovative and novel means for managing spectrum such that enough spectrum is made available for 5G applications while satisfying the needs of existing incumbents. Therefore, there has been greater emphasis to find innovative solutions to access those underutilized spectrums held by other services. Many bands already host important services that must have access to spectrum but it is possible that the incumbents may not be fully utilizing it. Some only use spectrum in certain regions. For example, spectrum allocated to defense organizations might only be required in a few geographic locations, with the potential for it to be made available to IMT in other parts of a country. Some spectrum have been only used by licensees at certain times of the year, e.g. driven by events, seasonal, etc, and could at other times be made available to other parties.
	2. Some bands have been assigned to IMT service in some countries but are difficult to be released by incumbents in foreseeable time. New emerging alternative approaches could make it possible to share these spectrums, which allow multiple systems to occupy the same spectrum.
	3. Typically there are two types of spectrum sharing schemes widely considered. One is the TV whitespaces where upcoming technologies like cognitive radio and/or software defined radios (SDR) seem to allow their exploitation. Key to whitespace use is the idea of license exempt and free access for everyone and every service under a secondary right of use. Alternative approach is to give the secondary licence(s) to share spectrum with the incumbent users in such cases when the incumbent user is not using its spectrum all the time and/or using it in limited area(s). This approach is known as Authorised Shared Access (ASA) / Licensed Shared Access (LSA). Both of these approaches have been discussed in the following section.
2. **TV White Spaces**
	1. According to the ITU report “Digital Dividend: Insights for spectrum decisions”[[2]](#footnote-2), TV white spaces (TVWS) are “portions of spectrum left unused by broadcasting, also referred to as interleaved spectrum”. TVWS are also referred to as those currently unoccupied portions of spectrum in the terrestrial television frequency bands in the VHF and UHF TV spectrum (be it analogue or digital, generally in the UHF band). These TV spectrum “gaps”, with advantageous propagation properties inherent to UHF spectrum (excellent outdoor and indoor coverage and non line-of-sight propagation properties) have been identified in some administrations as an alternative for providing commercial wireless services other than broadcasting. Some of the wireless technologies being explored in TVWS are low-power, machine-to-machine (M2M) communication devices and low-power wireless broadband applications, capitalizing on the longer coverage ranges achievable with UHF spectrum.
	2. There are different ways in which TVWS can arise at any given location. Nonetheless, the amount of spectrum available in the form of TVWS can vary significantly across different locations and will depend on various factors, including: geographical features, the level of interference potential to the incumbent TV broadcasting service, TV coverage planning, and television channels utilization. TVWS availability could be because of idle channels of a TV band plan in some geographical areas due to interference avoidance techniques by means of frequency separation (guard channels).
	3. Spectrum sharing in VHF/UHF bands, which implies proper utilisation of TVWS, can be achieved through technical means using evolving advanced technologies such as cognitive radio. Cognitive Radio as a radio system employing technology that allows the system to obtain knowledge of its operational and geographical environment, to dynamically and autonomously adjust its operational parameters and protocols according to its obtained knowledge in order to achieve predefined objectives using an advanced technology referred to as software defined radio (SDR); and to learn from the results obtained. Cognitive radio technologies can offer services in coexistence with TV transmitters, the primary service in the UHF band, by using location-based information to determine unused spectrum in and between broadcasting frequency bands.
	4. There are many ‘Dynamic Spectrum Access’ based cognitive technologies which allow users to access spectrum for a defined time period or in a defined area. It involves unitizing spectrum in terms of temporal and geographical time slots and allows users to apply for access to a particular portion of spectrum for a defined time period or in a defined area, which they cannot exceed without re-applying for the resource. Some potential capabilities of cognitive technology for spectrum access are given below:
3. **Sensing**: where devices monitor frequencies for any radio transmissions and if they do not detect any, assume that the channel is free and can be used;
4. **Geo-location**: where devices determine their own location and query a database which returns the frequencies they can use at their current locations; and
5. **Beacon transmission**: where a network of fixed transmitters or base stations are established and broadcast signals informing devices which channels are free to use in each relevant location.
	1. Of these three techniques, beacon transmission has not been actively pursued because of the costly infrastructure that would likely be involved in setting up a network. Some potential capabilities of initial development of white space technology focused on the sensing approach where devices monitor frequencies for any radio transmissions and if they do not detect any, assume that the channel is free and can be used. However, in response to the technical challenges that sensing technologies has posed, the focus for cognitive radio deployment in very recent years has moved to geo-location where devices determine their own location and query a database which returns the frequencies they can use at their current locations.
	2. Development in some of the countries with respect to TV White Space technologies is discussed below:

**TV White Spaces: International Scenarios**

**UNITED KINGDOM**

* 1. The UHF TV band in UK is currently allocated for use by Digital Terrestrial Television (DTT) broadcasting and Programme Making and Special Events (PMSE). The channels that are not used by DTT/PMSE at any given location can be used by lower power devices on an opportunistic basis.
	2. On 12 February 2015, OFCOM published its Statement on ‘Implementing TV White Spaces’. Through this document, OFCOM set out its decision on the framework that will be put in place to enable dynamic spectrum access to white spaces in the 470 to 790MHz band (the UHF TV band). Following are the main points of the OFCOM Statement:
	+ This Statement set out the way forward for the implementation of the UK framework for authorising access to TVWS.
	+ The new technology, known as white spaces devices, will share this band with the existing uses, Digital Terrestrial Television (DTT), including local TV, and Programme Making and Special Events (PMSE), including in particular wireless microphone users.
	+ The sharing will take place dynamically, controlled by databases which will hold information on the location of DTT and PMSE users and white space devices. This information is used to allow white spaces devices access to the spectrum band, but only to the extent that this does not cause harmful interference to the existing users of the spectrum.
	+ OFCOM will enter into contractual arrangements with white space database providers who are able to demonstrate that their databases meet certain requirements and are able to provide information on TV White Space availability to devices.
	1. A high level framework that OFCOM intends to implement is given in Figure 2.6 below. The aim of this framework is to enable WSDs to use spectrum in the UHF TV band at a particular location and time on a shared basis subject to ensuring that there would be a low probability of harmful interference to other spectrum users in the band or adjacent to the band.
	2. WSD (White Space Device) operation in TVWS will be controlled by WSDBs (White Space Databases) qualified by Ofcom to provide spectrum information services to WSDs. A WSD will need to contact a WSDB, which will respond to the WSD with a set of operational parameters including the frequencies and maximum powers at which the WSD can transmit.



**Figure 2.6- Framework for authorising the use of TVWS including the interactions between WSDs and white space databases**

* 1. There are four data sets that Ofcom will provide to a WSDB:
1. Ofcom will generate a set of data containing the maximum allowed powers a WSD can transmit at in each 100 x 100 m pixel in the UK taking account of the need to ensure a low probability of harmful interference to DTT use of the band and also to respect their international obligations to neighbouring countries use of DTT in the band. They term this data set “DTT Coexistence data”. To generate this data set they will use underlying information on the DTT network from the UK planning model;
2. Furthermore, Ofcom will generate additional constraints that relate to taking account of PMSE use of channel 38, and the services above and below the band. The location of these existing users is not known, so the constraints will be a set of maximum powers for each channel in the band that do not change with the location of the WSD. They term this data “Location Agnostic data”;
3. Ofcom will provide the WSDB with information on licensed PMSE use in the band (other than in channel 38). They term this data “PMSE data”. The WSDB will use all this data in accordance with the algorithms specified by Ofcom to calculate the maximum power a particular WSD is allowed at a particular location at a particular time;
4. Finally, Ofcom may provide WSDBs with data they term “Unscheduled Adjustments data.” This a set of revised allowed power limits that they may introduce at a particular geographical area on an ad hoc basis.
	1. In Ofcom’s arrangements with WSDBs, they will specify how a WSDB is to use this data to determine the operational parameters for a WSD. Once a WSDB is qualified, it will be listed in the licence exemption regulations, and it will also be listed on a website hosted by Ofcom so that it can be selected by a WSD through a process known as “database discovery”. A master WSD[[3]](#footnote-3) will download the list of qualifying databases from the website and then select a database with which to exchange parameters.
	2. Once a master WSD has selected a particular database, it will report to that database its “device parameters” which identify specific characteristics of the WSD. These will include its location and other information about the device. A master WSD may also communicate to the WSDB the device parameters of any slave WSD it is controlling.
	3. WSDBs will use device parameters together with information provided to them by Ofcom, to determine, what frequencies are available for that particular device and at what powers it is able to transmit in those frequencies. This information is known as the “operational parameters” and will be communicated to the device. These operational parameters will only be valid for a short period of time so the device will have to query the database on a regular basis in order to ensure that it can transmit in accordance with valid operational parameters.
	4. Ofcom has made the Wireless Telegraphy (White Space Devices) (Exemption) Regulations 2015. These regulations enable licence exempt use of White Space Devices (WSD) in the UHF TV band. To avoid harmful interference being caused to existing spectrum users, devices will need to communicate with databases which will apply rules, set by Ofcom, to put limits on the power levels at which devices can operate. The regulations come into effect on 31 December 2015.[[4]](#footnote-4)

**UNITED STATES[[5]](#footnote-5)**

* 1. In Sept 2010, FCC finalised the rules for use of TVWS. Devices are allowed to operate on a licence exempt basis, provided that they communicate their location to certified database and operate according to the channel list provided by the database. Spectrum sensing can be performed, but is not required.
	2. Devices must contact database at least once in every 24 hours for new channel list. All devices must report location, and technical characteristics. Personal/Portable devices must get new channel list if they move more than 100 m or lose power.
	3. In Jan 2011, FCC designated nine database providers, subject to an approval process. It has so far approved 4 of them for operation: Google, SpectrumBridge, KeyBridge and iConectiv.
	4. WSDs rely on the geo-location and database access mechanism to identify the available television channels consistent with the interference protection requirements. FCC has defined two types of WSDs: fixed devices and personal and/or portable devices. The fixed devices have geo-location capability with embedded global positioning system (GPS) capability and are able to communicate with a central database to identify other transmitters in the area operating in TV White Space. The personal/portable devices can be classified as Mode I or Mode II. Mode I devices do not have geolocation capability and depend on Mode II devices that have geo-location capability and can access the database to obtain a list of available channels.
	5. As per FCC guidelines, fixed devices in the white space spectrum are allowed a power output of up to 4 watts EIRP. Personal/portable devices are restricted to 100 milliwatts EIRP. Because the range at which a TV band’s device can cause interference increases as the height of the device’s antenna increases, the fixed devices are only allowed to operate at a maximum antenna height limit of 30 meters above ground and a maximum of 76 meters above the average terrain for a tower site. There are no height restrictions on personal/portable devices as it is not practical to administer an antenna height limit for those devices and the lower power and limited antenna gain of personal/portable devices would generally result in propagation over a shorter range than fixed devices.

**CANADA[[6]](#footnote-6)**

* 1. Industry Canada (IC) – the Government Department in charge of spectrum management – released in October 2012 its policy decision to enable access to TVWS with the following characteristics:
	+ TVWS devices permitted on a no-protection, no interference basis to licensed users in the band;
	+ Existing users require a license to receive protection from TVWS devices;
	+ No limits on number of database administrators;
	+ Spectrum sensing is allowed but initial implementation of rules will focus on a geo-location database;
	+ TVWS devices will require certification.
	1. IC expects that TVWS technology will deliver improved, Wi-Fi–like services in rural regions. TVWS devices will initially provide broadband Internet, similar to Wi-Fi, but with expanded coverage that exceeds traditional Wi-Fi.
	2. In February 2015 IC, published a Specification (RSS-222) describing the technical and operational requirements for WS devices. This Standard broadly follows the US requirements in terms of equipment types and technical characteristics.
	3. IC will put in place a process for database and device certification involving a call for applications to become a database provider, a review, evaluation and testing of applicants, the designation of databases and finally certification of devices against a database.

**SINGAPORE[[7]](#footnote-7)**

* 1. Singapore’s Infocomm Development Authority (IDA) has approved in November 2014 the rules enabling access to TVWS. Operation of TVWS devices will be on a licence-exempt basis provided that devices comply with the technical requirements specified by the IDA, contact a licensed database to obtain channel availability, and are registered with the IDA following a comprehensive validation process. The device types and requirements are broadly in line with the US model, although Singapore allows for variable EIRP levels (like the UK model).
	2. Organisations interested in becoming Database providers must apply for an SBO (Individual) Licence from IDA. There will be no limit set for the number of providers to be licensed. The application must include their vision for TVWS deployment in Singapore and their business plans, in particular the pricing and, terms and conditions of the service.
1. **Licensed Shared Access (LSA)**
	1. An innovative spectrum sharing technology is being developed in Europe and the US with the objective to provide global coverage in the applicable bands. ETSI[[8]](#footnote-8) and CEPT[[9]](#footnote-9) have developed a number of documents enabling the usage of the so-called **Licensed Shared Access (LSA)** scheme in Europe in the 2.3-2.4 GHz LTE Time Division Duplex (TDD) band 40. It is also referred to as **Authorised Shared Access (ASA)**. LSA is a new category of spectrum rights which allows the holder to use unused spectrum to offer commercial services without interfering with the incumbent user. It is a right to utilise under-used spectrum without interfering with the incumbent user, subject to the terms defined by the relevant authority (government/ regulator) and/or upon an agreement with the incumbent user. LSA could be appropriate in bands used by government entities, by establishing new sharing arrangements with commercial operations.
	2. LSA, as defined by RSPG, is “A regulatory approach aiming to facilitate the introduction of radio-communication systems operated by a limited number of licensees under an individual licensing regime in a frequency band already assigned or expected to be assigned to one or more incumbent users. Under the Licensed Shared Access (LSA) approach, the additional users are authorised to use the spectrum (or part of the spectrum) in accordance with sharing rules included in their rights of use of spectrum, thereby allowing all the authorised users, including incumbents, to provide a certain Quality of Service (QoS)”.

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**Figure 2.7: Licensed/Authorized Shared Access**

* 1. A key feature of the LSA concept is to ensure a predictable quality of service for all rights holders and for consumers. ASA rights can be granted on a temporary or long term basis. ASA can progressively enable spectrum to be brought into use much more efficiently in a dynamic manner to meet consumers' needs and demand. ASA concept allows more efficient use of spectrum whilst also providing an alternative to permanent segmentation or refarming of a band when there is a need to find new spectrum. A general advantage of the ASA concept over the licence exempt model is that it gives some rights to a new user, thus making it possible for them to provide services where a predictable quality of service can be ensured. In this respect, spectrum sharing conditions have to be sufficiently attractive and predictable to provide incentive for new users to invest in equipment and networks.

 **How does LSA work? An illustration**

* 1. LSA assures a shared access to spectrum, subject to an authorisation scheme with defined use rights and obligations. It is better suited to mobile broadband services that require predictable quality of service. There are two obvious scenarios of LSA.
	2. **Geographical spectrum access sharing with LSA**: In this type of LSA, a given incumbent user only operates equipment in certain geographic areas. In such a case, there could be a possibility for LSA rights holders to use the spectrum in other geographic regions to meet market demand. The number of LSA rights granted to users will depend on the quantity and quality of spectrum available and the sharing rules that govern the coexistence. As an example, consider the following diagram that shows the incumbent’s use of its spectrum over a range of locations. The incumbent user is making use of different parts of the frequency band in different locations (the dark sections), meaning that the rest of the band (the white sections) could be available for use in particular places. This is likely to be the most straightforward form of sharing, since a geo-location database should be sufficient to prevent interference.



**Figure 2.8: Usage of a whole frequency range in different locations**

* 1. The scenario described above with shared access to spectrum, under an ASA regime, with two users granted ASA rights, would result in the situation depicted below, with each colour (other than the incumbent user blue) representing an ASA rights holder.

Frequency Range

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |

Location

**Figure 2.9: Authorised Shared Access (ASA) of unused capacity**

* 1. In this case, access to unused spectrum in a specific location is granted to a specific user, which will have multiple devices using this spectrum in a managed and efficient manner. This arrangement will be able to guarantee predictable level of capacity and operating conditions for each authorised user, resulting in quality of service. In this manner, ASA can help unlock harmonized spectrum, even if it is not available in all locations and at all times, creating an environment suitable for the successful deployment of global standards, with economies of scale that can spur innovation and encourage investment.
	2. In **Time spectrum access sharing with LSA,** an incumbent user only uses their assigned spectrum at certain times. In this case, there might be the possibility for LSA users to use the available capacity at other times.

**Scope of LSA**

* 1. As per The Electronic Communications Committee (ECC)[[10]](#footnote-10) Report[[11]](#footnote-11) 205[[12]](#footnote-12) on Licensed Shared Access of February 2014,
	+ LSA is a complementary spectrum management tool that fits under an “individual licensing regime”.
	+ LSA facilitates the introduction in a frequency band of new users while maintaining incumbent services in the band.
	+ LSA aims to ensure a certain level of guarantee in terms of spectrum access and protection against harmful interference for both the incumbent(s) and LSA licensees, thus allowing them to provide a predictable quality of service.
	+ LSA excludes concepts such as “opportunistic spectrum access”, “secondary use” or “secondary service” where the applicant has no protection from primary user(s).
	+ LSA licensees and incumbents operate different applications and are subject to different regulatory constraints. They would each have exclusive individual access to a portion of spectrum at a given location and time.
	+ The first practical use case of LSA will be to provide access to additional spectrum for mobile broadband services.
	1. The exact nature and implementation of LSA is likely to differ from country to country, in order to adapt to national circumstances. The introduction of LSA will always require a dialogue involving Administration/NRA, Incumbent(s) and prospective LSA Licensees, in order to identify the frequency bands wherein possibility of the implementation exits and to define the sharing framework. Finally, the award of LSA licences will be through the established process in the country.



**Figure 2.10: Regulatory process required before the introduction of Mobile Broadband Services in a band under LSA**

**Sharing framework**

* 1. ECC Report 205 of February 2014 sets out the sharing framework for LSA. As per this report, the sharing framework may include, depending on the specific circumstances:
* The identification of the incumbent(s) to be protected;
* Identification of frequencies, locations and times that must be protected for the incumbent, together with the level of protection;
* The terms and conditions under which the incumbent has access to the spectrum;
* The terms and conditions under which the potential LSA licensees may access the spectrum.
* Mechanism for transmission of information on spectrum availability between Incumbent and LSA licensee;
* Duration of the sharing framework;
* Financial terms and conditions of the sharing framework;
* Terms and conditions for the operation of both the LSA repository and the LSA controller;
	1. There is an effort to evolve general principles for LSA implementation so as to streamline the process and facilitate provision of pan-European services; however, LSA implementation remains a voluntary national decision. Each Member State may determine the subset of harmonised LSA frequencies that can be made available to the market under an LSA license, according to its own appropriate timeline. Each Member State may devise its own path for awarding LSA licenses, in accordance with national authorisation regimes, including deciding the number of LSA licensees that may be present in each LSA frequency band and the duration of each LSA license.

**LSA Architecture:**

* 1. Following Figure illustrates the LSA system architecture as defined as ETSI[[13]](#footnote-13). In this context, spectrum management mainly relies on a centralized database known as the LSA Repository. Incumbents are required to provide a priori usage information to the database on the availability of LSA spectrum over space and time. Depending on this information, the LTE system is either granted access or requested to vacate concerned bands through the control mechanism within the LSA controller. In this operational approach, no sensing mechanisms are required to support the system for the identification of incumbent operation.

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**Figure 2.11: LSA Architecture**

**Standards and Regulation Framework and associated Challenges**

* 1. LSA is progressing at various levels in Europe. As stated earlier, ETSI and CEPT have developed a number of documents enabling the usage of Licensed Shared Access (LSA) scheme in Europe in the 2.3-2.4 GHz band. LSA and SAS related standards activities are currently ongoing in the ETSI’s Reconfigurable Radio Systems (RRS) Committee with a focus on LSA; in the Wireless Innovation Forum[[14]](#footnote-14) (WInnForum) with a focus on SAS; and in 3GPP targeting a global solution encompassing LSA and SAS. 3GPP has to deal with the integration and linkage of the LSA and SAS components into the 3GPP architecture.
	2. The standards work is in an advanced stage in ETSI’s RRS Technical Committee while 3GPP will provide its first solution in 3GPP’s Release 13 standard by 2016. The technology is likely to further evolve in 3GPP Release 14 and beyond. The main challenge relates to the willingness of the NRAs to finally enable the usage of target 2.3-2.4 GHz band and possibly other bands in future. Corresponding trials are in progress in France, Finland and Italy and additional countries are expected to follow. Once LSA has been proven to operate efficiently, the next step will be to identify additional target bands.

# CHAPTER III: REGULATORY FRAMEWORK FOR INFRASTRUCTURE SHARING IN INDIA

## Significance of Telecom Infrastructure Sharing in India

* 1. The National Telecom Policy (NTP)-2012 of India is conceived with the vision is to transform the country into an empowered and inclusive knowledge-based society, using telecommunications as a platform. One of the strategies outlined in NTP-2012 is:

“*To move towards Unified Licence regime in order to exploit the attendant benefits of convergence, spectrum liberalisation and facilitate delinking of the licensing of Networks from the delivery of Services to the end users in order to enable operators to optimally and efficiently utilise their networks and spectrum by sharing active and passive infrastructure*.”

* 1. Infrastructure sharing in telecom is an important measure to reduce costs. It is useful in start-up phase to build coverage quickly and in the longer term scenario to build more cost effective coverage in un-serviced area. In the Indian context, both in urban and rural areas infrastructure sharing should be adopted as an imperative for sustained telecom growth. Infrastructure sharing in India is considered very important due to following reasons:
1. **Large number of TSPs**:
	1. For the purpose of spectrum assignment, India is divided into 22 Service Areas and there are 7-12 TSPs providing their services to the end-consumers in their each of these LSAs.

**Table 3.1: No. of TSPs having spectrum rights in each Service Area**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sl. No.** | **Spectrum Band** | **No. of TSPs having spectrum rights in each Service Area.** | **Remark** |
| 1 | 800 MHz Band | Typically 3-4 TSPs |  |
| 2 | 900 MHz Band | Typically 3-4 TSPs |  |
| 3 | 1800 MHz Band | Typically 7-9 TSPs |  |
| 4 | 2100 MHz Band | Typically 4-5 TSPs |  |
| 5 | 2300 MHz Band | 2 | One more slot is likely to be auctioned soon. |
| 6 | 2600 MHz Band | 1 in most Services Areas. | One/Two more slots are likely to be auctioned soon. |
|  | **Overall** | **7-12 TSPs in each Service Area.** |  |

* 1. Each TSP provides telecom services using multiple spectrum bands/technologies, requiring placing multiple base stations and associated antenna etc. Not all of these TSPs have pan-India presence. Following table showing various service providers in India and their respective area of operation.

**Table 3.2: Service Provider and their Areas of operation**

|  |  |  |
| --- | --- | --- |
| **Sl. No.** | **Service Provider** | **Area of Operation** |
| 1 | Bharti | All India |
| 2 | Aircel Group | All India |
| 3 | Reliance  | All India |
| 4 | IDEA | All India |
| 5 | Vodafone | All India |
| 6 | Tata Teleservices | 19 Service Areas |
| 7 | Sistema Shyam  | Only 8 Service Areas |
| 8 | BSNL | All India (except Delhi & Mumbai) |
| 9 | MTNL | Delhi & Mumbai |
| 10 | Quadrant  | Only Punjab |
| 11 | Telewings Communications  | 6 Service Areas |

* 1. From the above table it is clear that not all the TSPs have access to all the LSAs. Therefore, in order to provide services outside its Service Area, some arrangement of sharing of network is a must. Inter-Circle Roaming could be one such arrangement.
1. **Limited Spectrum Resources:**
	1. The table given below provides the quantum of spectrum assigned for commercial telecom operations and spectrum holding per TSP in various countries. It is clear that in India, both spectrum assignments for commercial purposes as well as spectrum holdings with each operator are very low. The primary reason for lesser spectrum per TSP is the number of TSPs operating in India which is very large as compared to other countries. So, in order to improve their service across country, TSPs may go for of telecom infrastructure, including spectrum.

**Table 3.3: Spectrum Assignment & TSPs Holdings**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sl. No.** | **Country** | **Spectrum (< 3 GHz) assigned for commercial telecom operations****(MHz)** | **Spectrum holding per TSP****(MHz)** |
| 1 | India | 100 -125 MHz in each LSA | Typically 12-14 MHz |
| 2 | Germany | 290 | 72.5 MHz |
| 3 | UK | 291 | 58.2 MHz |
| 4 | Ireland | 200 | 50 MHz |
| 5 | Denmark | 294 | 73.5 MHz |
| 6 | Malaysia | 275 | 37 MHz |
| 7 | New Zealand | 287.5 | 57.5 MHz |
| 8 | Singapore | 260 | 87 MHz |
| 9 | China | 256 | 86 MHz |

1. **Lower broadband Penetration:**
	1. As on 31st March 2016, Total Broadband subscribers in India are 149.75 million i.e. approximately 11.4% of total India’s population. Wireless broadband subscribers are around 10% and wireline broadband subscribers are only around 1.2% of total population. As per ITU-UN report ‘*The state of broadband report 2015’*, India ranked 131 out of 189 countries on fixed-broadband subscriptions in 2014. On active mobile-broadband subscriptions, India ranked 155. Therefore, In India, infrastructure sharing can help in minimizing the resources needed for communication and by freeing up resources required for network construction, broadband can be made affordable for the users. That will, in turn, help in increasing the penetration of broadband across country.
2. **Data Growth Projections and emerging M2M technologies**
	1. Data growth in the recent years has been extremely high. It is likely to continue in the future also. It may not result in the proportionate increase in the revenue, although the TSPs will be in constant requirement to upgrade their networks. With the increasing deployment of Machine–to-Machine (M2M) communication and Internet of Things (IoT), spectrum and network capacity requirement are expected to go up.
3. **Need to introduce Virtual Network Operator:**
	1. There are around 50,000 villages in India which do not have any telecom services. To provide telecom services in the rural areas, which are economically unviable, sharing of resources is essential. As the reach of telecom operators is still limited, VNOs can play a crucial by laying incremental infrastructure to remote/inaccessible service areas where the telecom operators do not have a reach or do not want to invest due to commercial reasons.
4. **To support ambitious Government Plans**
	1. Under Digital India programme, Indian Government has identified three key areas viz. ‘Digital Infrastructure as a Utility to Every Citizen’, ‘Governance & Services on Demand’ and ‘Digital Empowerment of Citizens’. It also aims to create infrastructure including public Wi-Fi hotspots for citizens and Wi-Fi in 250 thousand schools and all universities.
	2. Above all, there is urgent need to utilise available infrastructure efficiently and to move towards Green telecom i.e. to reduce power consumption and carbon emissions, to maintain city aesthetic, to overcome the RoW issues etc.

## Existing Regulatory framework for sharing the infrastructure in India

* 1. In India most of the access service licensees are integrated TSPs providing access, long distance and internet/broadband services. They provide services either by using their own infrastructure or by sharing infrastructure of other TSPs. Over a period of time, restriction on sharing the telecom infrastructure has been removed in India and greater degree of freedom has been given to the TSPs on the issue. The existing regulatory framework for sharing of infrastructure has been evolved and discussed under the heads of **(a)** **Sharing of Passive Infrastructure (b) Sharing of Passive Infrastructure created through USO Fund (c) Sharing of Active Infrastructure without Shared Spectrum (d) Spectrum Sharing (e) Roaming i.e. Complete RAN and Core Network Sharing and (f) Virtual Network Operators**
1. **Sharing of Passive Infrastructure:**
	1. Sharing of passive infrastructure like sharing of physical sites, buildings, shelters, towers/masts, dark fibre, etc is permitted amongst TSPs in India since long time. In order to develop an independent business model to encourage creation of towers, Department of Telecommunication (DoT) introduced a new class of service providers called Infrastructure Provider Category – I (IP-I) in the year 2000.
	2. For IP-I the applicant company is required to be registered only. No license is issued for IP-I. Companies registered as IP-I can provide passive infrastructure such as dark fibres, Right of Way, duct space, towers on lease/rent out/sale basis to the licensees of telecom services on mutually agreed terms and conditions. All Indian registered companies are eligible to apply. There is no restriction on foreign equity and number of entrants. There is no entry fee and no bank guarantee. The applicant company is required to pay Rs. 5000/- as processing fee along with the application. In 2008, the scope of IP-I was enhanced to provide active infrastructure if this active infrastructure is provided on behalf of the licensees. The margin pressure for telecom operators and the need for faster rollouts have led to the entry of many IP-1 companies. As on 31.05.2016, there are 634 infrastructure service providers companies into the Indian Market.
	3. Amongst IP-I companies, prominent are the tower companies. Followings are the various models of Tower sharing deployed in Indian telecom industry.
	4. **Telecos owned Tower companies:** This category consists of companies created by hiving off the tower portfolios of telcos into subsidiaries. For example- Reliance Infratel and Bharti Infratel.
	5. **Independent Telecom Tower Companies jointly owned**: This category consists of companies that are not owned or managed by telcos. These companies build, own and lease telecom towers to telcos. This is a fragmented segment with a large number of players. For example: the joint venture, Indus Towers Limited (ITL), the shareholding in which is held by three telcos: Bharti Airtel Limited, the Vodafone group, and the Idea Cellular group.
	6. **Inter-operator tower sharing**: Operators generally use bilateral arrangements to execute Inter-operator sharing of passive infrastructure. The two parties may agree to install BTSs on each other’s towers.
	7. **Third-party tower companies:** Independent companies assume responsibility for tower deployment and maintenance, entering agreements with operators that allow them to install their BTSs on the towers. In this model, the ownership of passive infrastructure equipment lies with the tower company. The decision to outsource tower operations to third-party tower companies typically involves a strategic shift to focus on service innovation and improving customer experiences. This aspect becomes critical in highly competitive telecom markets.
2. **Sharing of Passive Infrastructure created through USO Fund**
	1. Creation of infrastructure for provision of telecom Services in rural and remote areas and provision of fibre connectivity to villages in a phased manner is supported by the Government through the use of USO Fund (USOF). The New Telecom Policy - 1999 (NTP’99) provided that the resources for meeting the Universal Service Obligation (USO) would be raised through a ‘Universal Access Levy (UAL)’, which would be a certain percentage of the revenue earned by the operators under various licenses. The Universal Service Support Policy came into effect from 01.04.2002. Under Universal Service Obligation Fund (USOF), schemes are planned from time to time to extend financial support for provisioning of mobile communication services in uncovered villages of the country in a phased manner. In 2007, USOF launched a Shared Mobile Infrastructure Scheme to provide subsidy support for setting up and managing 7,353 infrastructure sites/towers in 500 districts spread over 27 states for provision of mobile services in the specified rural and remote areas, where there was no existing fixed wireless or mobile coverage. It aims to provide mobile services to approximately 0.2 million villages.
	2. It was a unique initiative as it is based on sharing of subsidized passive infrastructure (tower, boundary wall, electric connection, power backup etc) by three telecom service providers who will put up their own active infrastructure and roll out wireless services. Service providers shall not pay any rental to infrastructure provider for using it till five years except sharing operational cost.
	3. To bridge the rural coverage gap both for broadband penetration and voice, Government has undertaken to establish the National Optical Fibre Network (NOFN) laying incremental optical fibre to connect all 2,50,000 Gram Panchayats in the country. The project is being funded by USOF and is being executed by a Special Purpose Vehicle (SPV) namely Bharat Broadband Network Limited (BBNL), which has been incorporated on 25.02.2012. Non-discriminatory access to the network will be provided to all the telecom service providers. These access providers like mobile operators, Internet Service Providers (ISPs), cable TV operators, content providers can launch various services in rural areas. Various applications for e-health, e-education, e-governance etc. will be provided.
3. **Sharing of Active Infrastructure**
	1. In 2008, DoT, had issued ‘Guidelines on Active Infrastructure sharing”. Active infrastructure sharing limited to antenna, feeder cable, Node B, Radio Access Network (RAN) and transmission system only, was permitted amongst TSPs with the view that Sharing of active infrastructure would help new telecom operators that have not yet set up infrastructure for telecom services as it would also bring down capital expenditure in setting up the projects and make their operations viable in view of intense competition.
4. **Spectrum Sharing**
	1. Traditional mobile network operation strategy includes high degree of vertical integration where Telecom Service Providers (TSPs) acquires and develops the sites that are needed for rolling out the network and then plans about the architecture of network required, its topology etc. However, with the introduction of new generations of wireless technologies technology migration has become rapid and complex. The Telecom Regulatory Authority of India (TRAI) has released its recommendations on ‘Guidelines on Spectrum Sharing’ (Proposed Guidelines) in 2014, suggesting that sharing of spectrum between operators should be permitted, as long as certain minimum conditions are fulfilled. The Government has given its approval to the guidelines on spectrum sharing in 2015, arising from the recommendations of the Telecom Regulatory Authority of India (TRAI).
	2. The salient features of the norms for spectrum sharing, among other things, shall include:
	3. Spectrum sharing would be allowed only for the access service providers in a Licensed Service Area (LSA), where both the licensees are having spectrum in the same band.

**Illustration**: It is assumed that two Licensees ‘A’ and ‘B’ have spectrum holding in 900 MHz, 1800 MHz and 2100 MHz band as shown in Table below:

|  |  |  |
| --- | --- | --- |
| Licensee | Licensee A | Licensee B |
| Spectrum Band | 900 MHz | 1800 MHz | 2100 MHz | 900 MHz | 1800 MHz | 2100 MHz |
| Spectrum holding (MHz) | 6.2 | 3 | 0 | 0 | 4.4 | 5 |

In such a scenario, the bands, in which spectrum sharing is permitted are shown in the Table below:

|  |  |  |  |
| --- | --- | --- | --- |
| Spectrum Band | 900 MHz | 1800 MHz | 2100 MHz |
| Can Licensee A and B share their spectrum? | No, because B does not have spectrum in 900 MHz Band | Yes, Because both A and B have spectrum spectrum in 1800 MHz band | No, Because A does not have spectrum in 900 MHz Band |

* 1. Sharing will be permitted when sharing entities possess spectrum which is either acquired through auctions or for which market price has been paid.
	2. All access spectrum will be sharable.
	3. Leasing of spectrum will not be permitted.
	4. For the purpose of charging Spectrum Usage Charges (SUC), licensees shall be considered as sharing their entire spectrum holding in the particular band in the entire LSA.
	5. The right to share spectrum shall be subject to fulfillment of relevant license conditions and any other conditions that may be specified by the licensor/Government from time to time.
	6. A licensee shall not be eligible to share its spectrum, if it has been established that it is in breach of terms and conditions of the licence, and the licensor has ordered for revocation/termination of its licence.
	7. The use of technology shall be governed by the terms and conditions of respective Notice Inviting Application (NIA)/license.
	8. Both licensees will be individually and collectively responsible for complying with sharing guidelines, including interference norms.
	9. Spectrum sharing will be restricted to sharing by only two licensees subject to the condition that there will be at least two independent networks provided in the same band.

**Illustration**

|  |  |  |
| --- | --- | --- |
|  | No. of Operators  | Whether Sharing of spectrum Permitted?  |
| In 1800 MHz band  | 6  | YES  |
| In 2300 MHz Band  | 2  | NO  |

* 1. Spectrum Usage Charges (SUC) rate of each of the licensees post-sharing shall increase by 0.5 percent of Aggregate Gross Revenue (AGR).

**Illustration:** Annual Spectrum charges is payable as % of adjusted Revenue of Operator. The % share depends upon the time when the spectrum was acquired by the licensee as illustrated below:

|  |  |
| --- | --- |
| Spectrum Acquired through auction of 2014 and 2015  | 5%  |
| Administratively Held Spectrum and Spectrum Acquired through auction of 2012 and 2013  | 3% to 8% depending upon quantum of spectrum possessed by the TSP |
| Spectrum in 2300 MHz band acquired through 2010 auctions  | 1%  |

In case of combination of spectrum acquired through different auctions/administrative assignments- Weighted average approach is adopted to determine the applicable SUC rate.

Post Sharing, Annual Spectrum Charges rate of each of the licensees post-sharing shall increase by 0.5% of AGR.

**Illustration**: In the following example, if Licensee ‘A’ and ‘B’ decide to share their spectrum; post-sharing they will be subjected to the following SUC rates.

|  |  |  |
| --- | --- | --- |
|  | Spectrum Usage Charges rate before sharing | Spectrum Usage Charges rate after sharing  |
| Licensee ‘A’ | 4% of AGR  | 4.5% of AGR  |
| Licensee ‘B’ | 5% of AGR  | 5.5% of AGR  |

* 1. The prescribed limits for spectrum cap shall be applicable for both licensees individually. Further, spectrum holding of any licensee post-sharing shall be counted after adding 50 percent of the spectrum held by the other licensee in the band being shared, being added as additional spectrum to the original spectrum, held by the licensee in the band.

**Illustration:** As per the prevailing regulations, Spectrum Cap is imposed on the spectrum holding of each operators in India on TWO Counts.

1. Band-Specific Spectrum Cap- 50% of the Total Spectrum assigned to Operators in that band.
2. Over-all Spectrum Cap- 25% of the Total Spectrum assigned to Operators in all bands.

Impact of sharing on the applicable spectrum cap has been shown in the following table.

|  |  |  |
| --- | --- | --- |
|  | Quantum of spectrum in a band before sharing | Quantum of spectrum after sharing that will be counted for the purpose of applying the stipulated spectrum cap  |
| Licensee ‘A’ | 10 MHz  | 10 MHz + half of 20 MHz i.e. 20 MHz  |
| Licensee ‘B’ | 20 MHz  | 20 MHz + half of 10 MHz i.e. 25 MHz  |

* 1. Both licensees sharing the spectrum shall jointly give a prior intimation for sharing the right to use the spectrum at least 45 days before the proposed effective date of the sharing. Both the licensees shall also give an undertaking that they are in compliance with all terms and conditions of the guidelines for spectrum sharing and licence conditions, and will agree that in the event it is established at any stage in the future, that either of the licensee was not in conformance with the terms and conditions of the guidelines for spectrum sharing or/and of the licence, at the time of giving intimation for sharing of right to use the spectrum, the Government will have the right to take appropriate action which among other things may include annulment of sharing arrangement. A processing fee, of Rs. 50,000/- which could be modified from time to time, shall be payable individually by each licensee for each service area at the time of intimation.
1. **Roaming**
	1. India, being a large country, has been divided into 22 Service Areas. Spectrum rights are awarded Service Area-wise. Some of the TSPs don’t have pan-India spectrum rights. Therefore, subscribers of such TSPs are required to ride the networks of other TSPs in those Service Areas where their operator does not have telecom network. Therefore, inter-Circle roaming has been permitted in India. Another arrangement is intra-Circle roaming, which permits two licensees having spectrum in the same band, to have intra-Circle roaming pact between them. Each of these has been discussed below:

**Inter-Circle Roaming**

* 1. Inter-Circle roaming service allows a mobile subscriber travelling outside the network of his/her wireless access service provider (mobile operator) to use his/her mobile connection on the networks of other wireless access service providers. The Licensees are permitted to enter into agreements with other Licensees to allow their subscribers roaming services. A roaming agreement is a commercial agreement between the two mobile operators. However, this is not mandatory and depends on the operators’ mutual agreement.
	2. . Selection of a different network by the subscriber while roaming will be limited to those mobile operators with whom his home mobile operator has a roaming agreement.
	3. Section 11(2) of the Telecom Regulatory Authority of India Act, 1997 empowers TRAI to notify rates for various telecommunication services. In exercise of these powers, TRAI has been notifying tariff for telecommunication services including national inter-circle roaming services. The approach of TRAI for regulating the tariff for national roaming service has been to prescribe a ceiling tariff below which the wireless service providers are allowed to charge from their subscribers. These ceilings are arrived at by factoring in various cost-components for providing national roaming service. At present, roaming subscribers are subjected to additional charges while roaming, subject to ceiling prescribed by TRAI.

**Intra-Circle Roaming**:

* 1. It enables a subscriber of a given Home Public Land Mobile Network (HPLMN) to obtain services from a Visited PLMN (VPLMN) in the same service area with automatic return to the HPLMN when possible. In other words, when a service provider does not have adequate coverage in its circle, then it may tie-up with some other operator within the same circle which would allow the subscriber to use its network in the areas of low coverage. Thus, a subscriber of a particular operator would be latched onto the network of another operator within the same circle. Like Inter-circle roaming, intra-circle roaming agreement is a commercial agreement between the two mobile operators. This is not mandatory and depends on the operators’ mutual agreement.
	2. Intra-circle roaming is permitted by DoT in June 2008. It does not absolve operators from meeting their mandatory roll-out obligations linked with the spectrum. This is akin to RAN sharing. It leads to delay or reduction in CAPEX and OPEX that helps in increasing network utilization and related revenue. In Intra-circle roaming, several core network operators can be connected to the same RAN resources.
1. **Virtual Network Operators**
	1. On 1st May 2015, TRAI issued its recommendations on ‘Introducing Virtual Network Operators in telecom sector’. The salient features of the recommendations are:
* VNO be introduced through proper “licensing framework” in the Indian Telecom Sector.
* The VNOs should be permitted for all segments of Voice, Data and Video as well as in all services notified in the Unified Licence.
* VNO to be introduced in the network based on the basis of mutually accepted terms and conditions between NSO and the VNO. The terms and conditions of sharing the infrastructure between the NSO and VNO are left to the market to determine.
* VNOs are permitted to set up their own network equipment(s). However, they are not permitted an interconnection with other NSO.
* Local Cable Operators (LCOs) and Multi Service Operators (MSOs) can become VNO and/or are permitted to share infrastructure with VNOs.
* For introduction of VNO in the sector, there should be a separate category of license namely UL (VNO). Like UL authorization, only pan-India or service area-wise authorizations may be granted under a UL (VNO) license.
* Duration for VNO licenses should be 10 years, extendable by 10 years at a time.
* There should not be a restriction on the number of VNO licensees per service area. Also there should be no restriction on the number of VNOs parented by an NSO.
* Customer verification and number activation shall be the responsibility of a VNO for its own customers.
	1. Based on these recommendations, DoT issued the guidelines for the grant of Unified Licence (Virtual Network Operators) on 31st May 2016. The basic features of thee guidelines are:
* Applicant can apply for UL (VNO) along with VNO authorisation for any one or more services listed below:
1. Unified License VNO (All Services)
2. Access Service (Service Area-wise)
3. Internet Service (Category-A with All India Jurisdiction)
4. Internet service (Category-B with Jurisdiction in a Service Area)
5. Internet Service (Category C with Jurisdiction in a SSA)
6. National Long distance (NLD) Service
7. International Long Distance (ILD) Service
8. Global Mobile Personal Communication by Satellite (GMPCS) Service
9. Public Mobile Radio Trunking Service (PMRTS) Service
10. Very Small Aperture Terminal (VSAT) Closed User Group (CUG) Service
11. INSAT MSS-Reporting (MSS-R) Service
12. Resale of international Private Leased Circuit (IPLC) Service.
* Authorisation for UL VNO (All Service) would however cover all services listed above in all service areas.
* The terms and conditions of sharing of infrastructure between the NSO and VNO shall be on the basis of mutually accepted terms and conditions between the NSO and the VNO.
* VNOs are permitted to install various equipments such as BTS/BSC. However, they are not allowed to own/install equipments which are required for interconnection.
* VNOs shall also be allowed to create their own service delivery platforms in respect of customer service, billing and VAS.
* An operator who wishes to provide telecom services to its customers utilizing the underlying network and/or access spectrum of an existing NSO will have to obtain UL (VNO) license.
* There would not be a restriction on the number of VNO licensees per service area.
* There shall be no restriction on the number of VNOs parented by an NSO
* VNOs will be allowed to have agreements with more than one NSO for all services other than access services and such services which need numbering and unique identity of the customers.
* An NSO shall allocate a numbering range to their VNO(s) from the numbering range allocated to it by the licensor. VNOs shall also utilise the LRN and network codes of the parent NSO for the purpose of routing of calls.
* There would not be any mandate to an NSO for providing time bound access to its VNO; rather, it shall be left to the mutual agreement between NSO and VNO. However DoT/TRAI shall have right to intervene in the matter as and when required to protect the interest of consumers and telecom sector
* CAF verification and number activation shall be the responsibility of a VNO.
* No spectrum shall be assigned to the VNOs.
* The Unified License (VNO) shall be issued on non-exclusive basis, for a period of 10 years.
	1.

# CONCLUSIONS

1. Human and machine driven demand for information capacity and data exchange is perpetually increasing, presenting challenges to telecom industry. This reality is based on the simple fact that end users have developed an insatiable appetite for advanced applications, services and infotainment that can be accessed anywhere and at any time. This appetite is enabled by the ongoing proliferation of mobile devices that make accessing anything and everything an easier process while on the go. With a steep increase in the demand for mobile connectivity comes the inevitable pressure on the supply side of the resource. Radio spectrum being the most precious supply side component, pressure of its supply is nothing but a natural phenomenon.
2. There is another dimension of the issue. Although the data is increasing rapidly in each region, the data realization (i.e. revenue earned per MB data) is witnessing a downward trend. It puts pressure on the Telecom Service Providers to find out innovative ways to use their resources in a most optimum manner and also to reduce their cost of operations. In such a situation, sharing of Passive as well as active infrastructure becomes part of the solution to this issue.
3. Spectrum sharing provides an effective key to problem of shortage of access spectrum. The sharing of spectrum could be between two or more telecom service providers, which make it possible to use the same spectrum more optimally. Another way of sharing the spectrum the unlicenced use within defined etiquettes. There are many innovative concepts about sharing the spectrum as a secondary user like White Spaces, Licence Shared Access etc.
4. The goal of each and every country is the same i.e. to have access to greater amount of spectrum for commercial use. To identify additional harmonized spectrum band is a task in hand on which continuous efforts are being made world over. Additional spectrum band which can be assigned for delinked use are also being explored. As far sharing of spectrum is concerned, innovative approached are being tried by various countries. Some countries such as India have defined spectrum sharing guidelines for the telecom service providers. Some European countries and USA have evolved the framework for the use of spectrum in TV White Space and LSA.
5. The levels of spectrum demand are likely to vary across SATRC countries depending on factors such as population density and scale of development of broadband fixed networks, the adoption of advanced consumer mobile devices and newer applications. However, it is high time that all SATRC member countries explore the possibilities of sharing the active telecom infrastructure including spectrum and also explore the possibility of using innovative spectrum sharing techniques discussed in this report.

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**Annexure-I: Infrastructure Sharing Framework in Bangladesh**

* 1. **Exploring the need and justification for infrastructure sharing.**
1. **No. of Mobile Telecom Service Providers (TSPs) in each spectrum band.**

|  |  |
| --- | --- |
| **Band** | **Number of Operators** |
|  800 MHz | 1 |
| 900 MHz & E-GSM | 5 |
| 1800 MHz | 5 |
| 2100 MHz | 5 |

1. **Technology deployed in each spectrum band.**

|  |  |
| --- | --- |
| **Band** | **Technology Deployed** |
| 800 MHz | CDMA |
| 900 MHz & E-GSM | GSM |
| 1800 MHz | GSM |
| 2100 MHz | WCDMA |

1. **Geographical jurisdiction of the licence of each TSP.**

All of the TSPs have the permission to operate all over the country.

1. **Quantum of Band wise spectrum assigned in the country for commercial telecom service.**

|  |  |
| --- | --- |
| **Band** | **Assigned Frequency** |
| 800 MHz | 10 MHz |
| 900 MHz &E-GSM | 25 MHz |
| 1800 MHz  | 59.4 MHz |
| 2100 MHz | 35 MHz |

1. **Average spectrum holding of a TSP.**

Average spectrum holding of a TSP is approximately 20MHz.

1. **Geographical coverage of mobile services. Uncovered areas till date.**

Although, all of the six cellular mobile phone operators have the permission to operate all over the country, they are not allowed to deploy their network in some areas of the Chittagong hill tracks and in the Sudarbans.

1. **Any other information that may be relevant to examine the need of infrastructure sharing including spectrum sharing.**

At present, in Bangladesh only ‘Passive Infrastructure Sharing’ is permitted. The guideline attached with this document is applicable for aforesaid sharing.

* 1. **Existing Regulatory Framework of infrastructure sharing.**
1. **Details of infrastructure sharing framework.**

At present ‘Active Infrastructure Sharing’ is not allowed in Bangladesh.

Please see ‘Guidelines for Infrastructure Sharing’ for Bangladesh in Annex 1.

1. **Details of any back bone network or project like National Optical Fiber Network (NOFN) Project which is being/will be shared by all TSPs.**

There are two National Telecommunication Transmission Network (NTTN) operators in Bangladesh. These two operators provide optical fiber back bone network throughout the country.

1. **Any other information that may be relevant.**
	1. **Details on unlicensed spectrum being used in the country.**

2.4 GHz and 5.7 GHz.

* 1. **Spectrum utilization in UHF 3 and UHF 4 bands to examine the feasibility of TV White Spaces.**

Bangladesh Television (BTV) is being transmitted using terrestrial television broadcasting technology in VHF band 3 and UHF band 4 is reserved for Digital Terrestrial Television Broadcasting (DTTB)Service in Bangladesh.

* 1. **Current utilization of 2300 MHz band in the country. Is there any plan to refarm it from current users to use it for IMT services? This information is required to examine the feasibility of LSA concept in this band.**

A wireless Internet Service Provider is occupying 18 MHz of frequency whereas a Broadband Wireless Access operator has 35 MHz of frequency in 2300MHz band. Remaining portion of this band is unoccupied at the moment.

In the National Frequency Allocation Plan (NFAP) of Bangladesh 2300 MHz band is already identified for IMT service.

**Annexure-II: Infrastructure Sharing Framework in Bhutan**

* 1. **Exploring the need and justification for infrastructure sharing.**

**Response:**

The Infrastructure sharing is a subject widely discussed and highly encouraged in Bhutan. To expedite this implementation, both the Ministry of Information and Communications (Ministry) and the Bhutan InfoComm and Media Authority (Regulator) are vigorously working on formulating the required policies, frameworks and the rules to enable the effective and efficient sharing of infrastructure and other resources within TSPs, ISPs, and other users.

With respect to the Bhutan’s perspective, the infrastructure sharing is must and important due to the following reasons;

1. **Preserving the Environment**

Governed by the developmental philosophy of Gross National Happiness (GNH), the preservation and conservation of the natural environment is one of its elements. Enshrined in the constitution to maintain the minimum of 60% forests cover throughout the country, the TSPs and ICT providers can participate in conservation of forests by establishing their network towers and stations as minimum as possible. Thus the Infrastructure sharing particularly by sharing the passive infrastructure will minimize the unnecessary establishment of individual infrastructure which would otherwise lead to destruction of certain forests. This is one reason for promoting the infrastructure sharing in the country.

1. **Geographical Terrain**

Owing to the mountainous geographical landscape of the country, it requires more BTS and backhaul stations to provide the network coverage throughout the country. Moreover, the establishment of towers is very difficult due to terrain. Therefore, it is efficient and effective to share the infrastructure by the TSPs rather than establishing their own infrastructure.

1. **Multiple Spectrum bands/technologies**

Although there are only two existing TSPs in the country, they provide different services with different technologies requiring multiple spectrum bands. These will further require placing of multiple base stations and associated antennas. The infrastructure sharing is important in this case too.

1. **Financial Resources**

Bhutan is dependent on foreign manufacturers. The need to establish network infrastructure requires import of equipments from foreign nations. Involving enormous financial capacity, it is important for the TSPs and other ISPs to share the existing infrastructure thus minimizing the capital and operational expenditure.

1. **Spectrum Demand by the TSPs and ISPs for enhanced technologies**

Although, at the moment we have only two TSPs (Bhutan Telecom Limited, Tashi InfoComm Private Limited) in the country however there are increase in the demand of spectrum.

|  |  |  |  |
| --- | --- | --- | --- |
| **Sl. No.** | **Spectrum Band** | **No. of TSPs having spectrum rights**  | **Remark** |
| 1 | 850 MHz Band | Both the TSPs | Both the TSPs deployed for 3G services initially in the capital and expanding its network gradually |
| 2 | 900 MHz Band | Both the TSPs | Both TSPs deployed for GSM services |
| 3 | 1800 MHz Band | Both the TSPs | One TSP has already launched 4G-LTE services and expands its network. And other applied for spectrum and soon going to launch. |
| 4 | 2100 MHz Band | 1 TSPs | The UMTS is deployed in this band by one TSP. |
| 5 | 2500 to 2700 MHz Band | Not allocated | However, there are many applications and proposals from the ISPs in deploying this band for MMDS and other Wireless broadband services.  |

1. **Availability of government resources (National Optic Fiber Backbone)**

The government has laid down the Optic Fiber Backbone connecting all the 205 blocks in the country. There is a need for proper frameworks for this infrastructure sharing so that the industries and private firms can avail the resources effectively.

1. **Efficient usage of spectrum**

Owing to the limited spectrum resources, there is a need for spectrum sharing.

1. **There are around 500 villages in Bhutan which do not have any telecom services**

To provide telecom services in the rural areas, which are economically unviable, sharing of resources is a must.

* 1. **Existing Regulatory Framework of infrastructure sharing.**

**Response:**

The Royal Government of Bhutan has recognized Information and Communications Technology (ICT) as important tool for the socioeconomic development of the country and thus envisioned to ensure universal availability and accessibility of ICT services by all Bhutanese, irrespective of where they dwell. In 2014, the Ministry of Information and Communications launched Bhutan Telecommunications and Broadband Policy 2014 which also ensures that the Royal Government will make available all infrastructures belonging to it and its corporations for sharing to enable and promote ICT services throughout the country.

The Bhutan Information, Communications and Media Act 2006 also promote and encourage infrastructure sharing amongst all licensed ICT operators.

1. **Sharing of Passive Infrastructure**
* Although sharing of passive infrastructure is permitted in Bhutan, there is no proper framework on Sharing of passive infrastructure. Therefore, the Rules titled “Infrastructure Sharing Rule” is formulated, consulted and submitted to the Ministry for approval.
* The above Rule is mostly focused on an administrative approach towards sharing of such infrastructure and it covers;
* Costing of sharing infrastructure
* Reference offer
* Procedure for infrastructure sharing
* Refusal of access
* Reservation of capacity
* Obligations with sharing infrastructure
* Dispute resolution
1. **Sharing of Active Infrastructure**
* Currently the sharing of Active infrastructure is not practiced in the country. However, the aforementioned Rule will also govern the sharing of Active Infrastructure.
1. **Spectrum Sharing**
* Till date spectrum sharing is not permitted. The Bhutan InfoComm and Media Authority may explore in future on the spectrum sharing in the country.
1. **Roaming**
* As there are no Licensed Service Area system in Bhutan, there is no intra/inter LSA regions. Both the TSPs are assigned with license for nationwide service.
1. **VNO (virtual network Operators)**
* Currently, virtual network operators (VNOs) are not permitted in Bhutan.
1. **National Optical Fiber Network (NOFN) Project**

The National project of connecting all 205 blocks (Bhutan has 205 blocks) with National Optical Fiber backbone is now completed and there is numerous demands for the National dark fiber by the ICT service providers and the broadcaster. However, the government is in the process of preparing the framework for infrastructure sharing of dark fiber and its tariff.

* 1. **Details on unlicensed spectrum being used in the country.**

**Response:**

Currently, there is no specific regulation on the unlicensed bands in our country. Nevertheless, we are exploring to develop a Rule on governing the usage of unlicensed bands mainly to prevent the unnecessary interference caused by radio usage in the unlicensed bands.

The mostly deployed radio applications are in ISM bands especially in 2.4 and 2.5GHz.

* 1. **Spectrum utilization in UHF 3 and UHF 4 bands to examine the feasibility of TV White Spaces.**

**Response:**

We have only one Television broadcaster which is called as Bhutan Broadcasting Service Corporation and it is a Public Service Broadcaster. Their terrestrial networks are deployed in VHF bands and not in UHF band. Therefore, the UHF 3 and UHF 4 are not utilized in our country at the moment.

* 1. **Current utilization of 2300 MHz band in the country. Is there any plan to refarm it from current users to use it for IMT services? This information is required to examine the feasibility of LSA concept in this band.**

**Response**:

Currently, the Bhutan Telecom Limited has deployed WIMAX service in this band. We are planning to re-farm it for other Wireless broadband services.

**Annexure-III: Infrastructure Sharing Framework in Maldives**

1. **Exploring the need and justification for infrastructure sharing.**

 **Response:**

At present there are 2 telecom service providers servicing whole country. The service providers are deployed 3G, 3G as well as 4G with average spectrum holding of 133MHz in band 1, band 3 and band 8. Testing is done on APT 700MHz band (band 28). We encourage sharing of towers which is very much needed because of limited land space of the islands. The other reasons behind sharing of the cell towers, is high in cost of constructing and maintenance of towers. Since the islands are very small in land size makes difficult to get a site for towers makes and best option as to share towers.

1. **Existing Regulatory Framework of infrastructure sharing.**

**Response:**

The existing country wide submarine cable which lay by one of the service provider is shared by the other TSP. The international 2 submarine cable is also shared. In the case of newly built tower sharing is a must and is working very well. We have almost 20 Plus tower are shared as of now. At present only passive sharing is practiced. Even we have restricted to build newly big tower that is taller than 30 meters.

1. **Details on unlicensed spectrum being used in the country.**

**Response:**

The unlicensed band is in the 2.4GHz and 5.8GHz and in E band some test are going on to see whether is it usable as all know we are surrounded by sea, refraction hinder such a communication.

* 1. **Spectrum utilization in UHF 3 and UHF 4 bands to examine the feasibility of TV White Spaces.**

**Response:**

The UHF 3 and UHF 4 are used for TV Broadcasting and lower position of the UHF 3 used for fixed mobile.

* 1. **Current utilization of 2300 MHz band in the country. Is there any plan to refarm it from current users to use it for IMT services? This information is required to examine the feasibility of LSA concept in this band.**

Response:

 The 2300MHz is at presently assigned to MMDS service, which provides backhaul Cable TV content to island as to provide cable TV to the islands. We have to refarm

1. These costs on investment are fixed, sunk and irreversible costs. [↑](#footnote-ref-1)
2. Digital Dividend: Insights for Spectrum Decisions: http://www.itu.int/ITU [↑](#footnote-ref-2)
3. The TVWS framework distinguishes master WSDs and slave WSDs. A master WSD is a device that is able to communicate with and obtain operational parameters directly from a WSDB, whereas a slave WSD is a device that is only able to operate in TVWS when under the control of a master WSD. [↑](#footnote-ref-3)
4. http://stakeholders.ofcom.org.uk/spectrum/tv-white-spaces/consultations-statements/tvws-regulations-2015/ [↑](#footnote-ref-4)
5. Sources: Code of Federal Regulations, Title 47, Chapter I, Subchapter A, Part 15, Subpart H; FCC website; FCC NPRM 15-68 [↑](#footnote-ref-5)
6. Sources: IC website; IC SMSE-012-12; IC DBS-1;IC RSS-222 [↑](#footnote-ref-6)
7. IDA REGULATORY FRAMEWORK FOR TV WHITE SPACE OPERATIONS IN THE VHF/UHF BANDS, June 2014 [↑](#footnote-ref-7)
8. ETSI, the European Telecommunications Standards Institute, [produces globally-applicable standards](http://www.etsi.org/about/what-we-do) for Information and Communications Technologies (ICT), including fixed, mobile, radio, converged, broadcast and Internet technologies. [↑](#footnote-ref-8)
9. European Conference of Postal and Telecommunication Administration (CEPT) is an organization where experts’ policy makers and regulators from 48 countries across the whole Europe collaborate to create a stronger and more dynamic market in the electronic communication and postal sector. [↑](#footnote-ref-9)
10. The ECC is the leading expert group within CEPT responsible for developing common policies and regulations in electronic communications and related applications for Europe and harmonising spectrum use. [↑](#footnote-ref-10)
11. ECC Reports are the results of its studies normally developed in support of ECC decisions, higher level deliverables, i.e. as part of preparation of an ECC decisions or recommendations. [↑](#footnote-ref-11)
12. <http://www.erodocdb.dk/Docs/doc98/official/pdf/ECCREP205.PDF> [↑](#footnote-ref-12)
13. ETSI TS 103 235. [↑](#footnote-ref-13)
14. #  Established in 1996, the Wireless Innovation Forum™ is an non-profit “mutual benefit corporation” dedicated to advocating for the innovative use of spectrum, and advancing radio technologies that support essential or critical communications worldwide. Its members include wireless service providers, network operators, component and equipment manufacturers, hardware and software developers, regulatory agencies, and academia.

 [↑](#footnote-ref-14)