Spectrum Road Map
Sri Lanka

2024 – 2029

SPECTRUM MANAGEMENT DIVISION
TELECOMMUNICATIONS REGULATORY COMMISSION

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1 Introduction

The telecommunications industry is constantly evolving, and the fifth-generation mobile technology (commonly known as 5G) is now taking the centre stage. Whilst 4G delivers mobile broadband services, 5G is creating new opportunities beyond faster consumer mobile broadband. The characteristics of 5G can enable many use cases benefiting the society and various industries. This is happening whilst the overall demand for mobile services continue to grow globally. This puts pressure on spectrum management organisation to ensure that spectrum – a key resource needed to enable mobile services – is available.

The deployment of 5G requires new spectrum allocations in different bands – the low, mid and mmWave – for different coverage and speed considerations. At the same time, technology vendors and service providers are actively looking for new ways to maximise their existing spectrum assets. This includes the use of enhanced antenna technology, spectrum refarming, spectrum aggregation, dynamic spectrum sharing, etc. It is required to make available the spectrum in a timely manner and to adjust any regulations to meet changing needs. This makes it important to put in place a framework to coordinate spectrum management activities in a structured and transparent manner. This is the main goal of the Spectrum Master Plan.

The Spectrum Master Plan provides a future roadmap for spectrum allocation as well as spectrum-related policy reviews that are anticipated to take place between 2023 and 2028. This report is developed by incorporating international best practices that are applicable to Sri Lanka. The publication of the spectrum roadmap helps spectrum users to understand the usage of spectrum and the availability of spectrum and also helps commercial operators with their network investment planning. It is crucial to recognise that the pace of change of industry is rapid and whilst the aim is to provide transparency and certainty to the industry, there is a need to review the plan (every 3 years) to ensure that the plan continues to be relevant.

2 Global Trends for Wireless Communications

According to ITU statistics, there were more than 8.4 billion mobile telephone subscriptions in 2021, exceeding the world population. There were more than 6.5 billion active mobile broadband subscriptions in 2021 – a CAGR of 47 % since 2007. The growth in mobile broadband has been driven by the 4G/LTE mobile technology supported by a wide range of smart devices and applications bringing convenience to the general population.

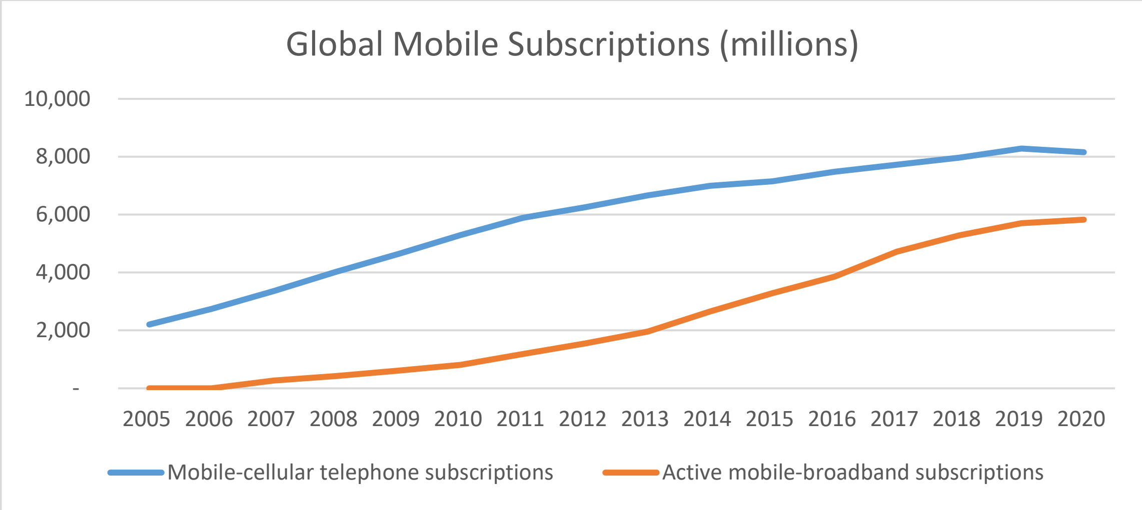

Figure 1: Global Mobile Subscriptions

There are signs of saturation for mobile subscriber growth, especially in developed markets. However, there remain opportunities to use wireless access for Internet services to underserved areas and to connect machines and 'things' to enhance productivity. 5G and Internet of things (IoT) technologies will play a critical role in supporting the transformation of various industries.

2.1 5G Development

The radio interfaces that is being used in full-scale commercial deployment of fifth generation mobile communication networks have achieved global validation with the successful evaluation by ITU of three new technologies that conform with the International Mobile Telecommunications 2020 (IMT-2020) vision and stringent performance requirement. The technologies are: 3GPP 5G-SRIT and 3GPP 5G-RIT, with standard published by Recommendation ITU-R M.2150-1[1]The deployment of 5G is gathering pace. More than 229 communications service providers have launched 5G services and over 700 5G-enabled smartphone models have been launched[2]. According to Ericsson, 5G subscriptions are expected to reach 1 billion by the end of 2022 and this number is expected to reach 5 billion by the end of 2028[3].

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[1] ITU-R M.2150-1, (ITU, 2022) https://www.itu.int/rec/R-REC-M.2150/en
[2] 'Second wave of 5G: 30 countries to launch services in 2023', GSMA, Feb 2022. https://www.gsma.com/newsroom/press-release/second-wave-of-5g-30-countries-to-launch-services-in-2023/
[3] Ibid.

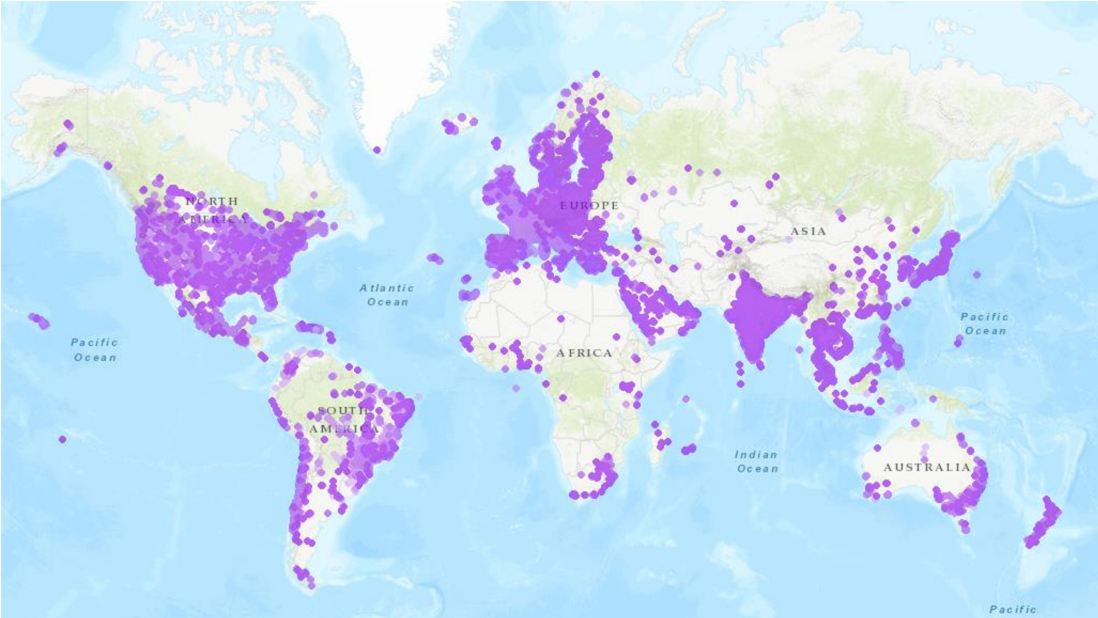


Figure 2: Global 5G Deployment (source: nPerf)

Besides North America, Europe and North Asia, deployment has also been active in the Middle East and South East Asia. Major phone makers have introduced products that are 5G-capable but the device ecosystem for 5G will go beyond smartphones. Vendors are now developing 5G-enabled hardware for augmented reality (AR), virtual reality (VR) and mixed realty (MR). There are also various partnerships globally to create content and applications for these devices. Some examples include the Global XR Content Telco Alliance led by LGplus, Qualcomm and operators (Bell Canada, Chunghwa Telecom, China Telecom, KDDI, Orange and Verizon). Other wearables are also being developed especially amongst start-ups which can enable new applications, for example, smart helmet for cyclist safety, smart earbuds for providing information via audio, and smart glasses for various use cases from healthcare to public safety.

At this point, 5G adoption is still low, a relatively small market penetration considering the 8 billion mobile subscriptions, but there are interesting insights from these early adopters. According to a GSMA report, 5G home broadband and enhanced video calling are the two most appealing use cases for 5G users[4]. Fixed wireless access (FWA) is a key service that mobile operators are keen to offer to capture new revenue opportunities. According to the Ericsson Mobility Report 2021, 70% of all service providers are now offering FWA services. This is even higher amongst operators that have launched 5G – about 90% of them have an FWA offering (4G and/or 5G).

2.2 Impact of COVID-19

The pandemic has resulted in a significant increase in mobile traffic, and this has been a global phenomenon. In many places, mobile is the main conduit to the Internet which makes it crucial for supporting many COVID-related needs such as online learning, remote working, and telehealth. Governments around the world are also leveraging mobile communications for contact tracing;

[4] 'The Mobile Economy 2021', GSMA Intelligence, 2021. https://www.gsma.com/mobileeconomy/wp-content/uploads/2021/06/GSMA_MobileEconomy2021.pdf

providing COVID-related information to the general population; sending alerts for COVID-19 testing and vaccination program; and distribution of social welfare to people.

More importantly, the pandemic has accelerated the adoption of digital services for the public sector, businesses across different industries, and for individuals. This trend is expected to continue as the world recovers from the pandemic. The society will become more connected digitally, and industries will leverage technologies to engage customers and become more productive. 5G together with IoT technologies will play a crucial role in driving digital initiatives either driven by the government or by businesses.

2.3 Digital Economy, Society and the 5G Contribution

Even before the pandemic, policy makers have been undertaking digital economy initiatives to drive economic growth. These efforts are having a boost as governments see investment in these initiatives as crucial for economic recovery as the w3orld emerges from the pandemic. A digital economy strategy will typically include the enhancement of infrastructure; the development of digital skills, driving adoption including amongst small and medium-sized businesses (SMBs), implementing digital government services, and ensuring cybersecurity and safety.

In order to ensure robust security measures for 5G networks, it is crucial for a country's 5G security policy to align with international standards. The GSMA, through its comprehensive threat analysis and collaboration with industry experts, including organizations like 3GPP, ENISA, and NIST, has developed a valuable 5G Cybersecurity Knowledge Base[5] and Network Equipment Security Assurance Scheme[6]. By incorporating these international standards, countries can effectively mitigate risks, foster trust in their 5G networks, and contribute to a more secure interconnected world.5G will play a key part in the digital strategy, not just from the infrastructure perspective but also the services it can enable. From the economic standpoints, there are various estimates that point to very significant economic impact 5G can deliver. For example, PWC predicts that by 2023, the efficiency and productivity brought by 5G could be around $1.3 trillion to global GDP[7]. PWC argues that the impact of 5G will be across different sectors including healthcare, utilities, media, industrial manufacturing and financial services.

[5] 5G Cybersecurity Knowledge Base, (GSMA 2023) https://www.gsma.com/security/5g-cybersecurity-knowledge-base/

[6] GSMA Network Equipment Security Assurance Scheme (NESAS), (GSMA 2022) https://www.gsma.com/security/network-equipment-security-assurance-scheme/

[7] 'The global economic impact of 5G', PWC, 2021. Retrieved from: https://www.digitalpulse.pwc.com.au/5g-economic-impact/

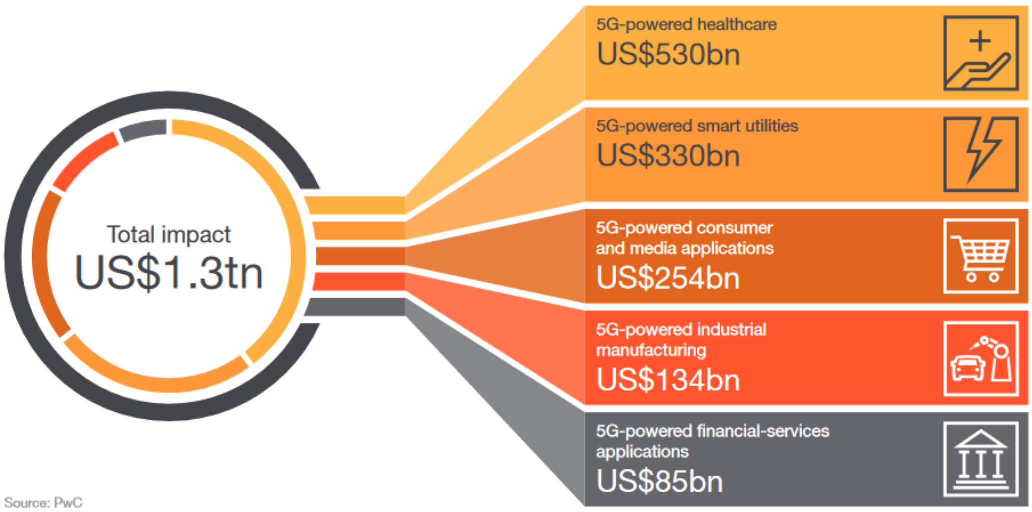


Figure 3: 5G Economic Impact

The economic impact of 5G is substantial but it depends on individual country's readiness to unleash the benefits of 5G. Moreover, 5G is not just about providing faster speeds than 4G. Its ultra reliable low latency communications (URLLC) and massive machine type communications (mMTC) are opening up new possibilities; especially in the enterprise and industrial sectors. A technology ecosystem is also flourishing which include traditional telecom providers and vendors, as well as application developers, platform providers and hyperscale cloud providers such as Amazon Web Services, Microsoft Azure and Google Cloud. When combined with network slicing and multi-access edge computing (MEC), there are various use cases and problems 5G can solve. Looking beyond the economic impact, there are positive social outcomes that the new 5G-enable applications can bring.

Healthcare	Telemedicine has become a reality amidst the pandemic and 5G helps to deliver remote health services including remote surgery. In China, a doctor in the city of Sanya inserted a stimulation device in the brain of a Parkinson's patient 1,900 miles away in Beijing. There are ways 5G can help to improve productivity within health care facilities. For example, Siriraj Hospital in Thailand has trialled unmanned vehicle to offer contactless delivery of medical supplies. Other possibilities include using drones for delivery of medicines and blood samples, and automated drug dispensing systems.
Power & Utilities	As consumers and power generators adopt renewable energy, there is an opportunity to leverage 5G for enabling a distributed energy system. Consumers with solar panels can offer to share their excess with the grid or amongst households. With 5G-enabled meters and probes with high reliability and low latency, an energy management system can be in place to manage energy sources between the grid and homes. The system can also predict energy demand and detect outages. Moreover, whilst 5G is a more energy-efficient technology, it is expected to consume more energy due to the number of sites and higher data transmission. Huawei's 5G Power for example uses intelligent technologies like peak shaving, voltage

	boosting, and energy storage to enable 5G sites to be deployed without the need to change the grid and power distribution. Besides energy grid, 5G can in the same manner improve water management and waste management through real-time data that can help to prevent wastage and improve efficiency.
 **Manufacturing**	The move to Industry 4.0 and smart factory is underway. The use of robotics, automation, IoT, AI, AR/VR and 5G are transforming manufacturing processes, enabling greater efficiency and improving work safety. Whilst a smart factory is being powered by real-time data, it is crucial for the connectivity to various devices to be reliable, security and with ultra-low latency. Car manufacturers have been amongst the early adopters of 5G and some plants have deployed 5G private networks to achieve the desired performance. For example, Ford uses a mobile private network for its electric vehicle plant in the UK to analyse and control laser welding machines. AR for troubleshooting, workforce safety insights, defects detection and preventive maintenance are some of many potential use cases.
 **Retail**	The retail sector has seen a considerable impact due to the pandemic and companies have been embracing digital solutions to move their businesses online. At the same time, retailers are also looking at ways to optimise their stores and create new digital experiences. Operators such as Singtel for example has started to deploy indoor 5G at major shopping malls in Singapore, partly to enable retailers to transform their outlets. Some potential use cases include real-time inventory management, theft detection, digital signages, and real-time store activity for contextual and targeted promotions.
 **Agriculture**	Even in agriculture, 5G and IoT solutions can help to improve yield and farmer productivity through precision agriculture and smart farming. In the Philippines, the Cauayan city looks to transform itself from an agricultural town to a smart city through setting up 5G network and rolling out a Digital Farmers Programme. In the UK, 5G Rural First launched a mobile app to allow farmers to track cows to receive real-time information about their health and behaviour. Other potential areas include remote water and energy monitoring, real-time weather information, soil measurements, vehicle tracking, etc.

Figure 4: 5G Industry-Specific Use Cases

2.4 Competition and Consolidation

Competition in the telecommunications sector has in general benefited the consumers since competitive forces have driven down pricing and motivated service providers to improve quality of service. Consumers also have more options and a wider range of services and service packages. In a competitive environment, mobile operators have to maintain cost efficiency and stay innovative to win customers and minimise churn.

However, in many countries the mobile services market is reaching saturation, and operators have not been able to make much headway in offering value-added content and services due to the rise of the over-the-top (OTT) services. Meanwhile, mobile operators have to lower their expenditure to offer more data at the same price, or face a reduction in operating margins. 5G offers the opportunity for mobile operators to improve cost efficiency and develop new revenue streams (e.g., from enterprise solutions); but it requires significant capital investments. As a result, there has been market consolidation in many countries. For example, Sprint and T-Mobile in the US merged in 2020, leaving the country with three mobile operators; the merger of Vodafone and TPG in Australia in 2020; and the Celcom and Digi merger in Malaysia in 2021.

In Sri Lanka , there are instances that operators have merged their businesses in the past. There are currently seven mobile and fixed operators and as the market becomes more saturated, there is a likelihood that mergers could be proposed. Besides considering the impact on market competition, it has to be ensured that merger does not give the merged entity unfair advantages due to enlarged spectrum holding. Spectrum caps is an ex-ante means to implement competition policy to avoid the creation of positions of large spectrum holdings. There are different types of spectrum caps:

Characteristics of Spectrum Caps	
Hard Spectrum Cap	An absolute limit on the amount of spectrum any one operator can hold.
Soft Spectrum Cap	If the cap is exceeded, other conditions may be applied to the spectrum licence, such as a different initial licence period.
Specific Band Spectrum Cap	A band-specific spectrum cap with no reference to other spectrum holdings.
Multi-band Spectrum Cap	A spectrum cap that considers spectrum holdings across multiple bands – may be cumulative only and/or include cumulative and band-specific elements.
Durable Spectrum Cap	Durable caps set at the time of the award, and applicable to subsequent spectrum trades and acquisitions.

Table 1: Types of Spectrum Cap

Country Example	Spectrum Cap
India – multi-band	TRAI imposes a cap of 35% (increased from 25% in 2018); and 50% cap on combined airwaves holdings below 1GHz bands (i.e., 700MHz, 800MHz and 900MHz).
Ireland – specific bands	For its spectrum auction announced in December 2020, ComReg would release spectrum in the 700MHz, 2.1GHz, 2.3GHz and 2.6GHz

	bands. ComReg is imposing a cap of 70MHz for sub-1GHz and a 375MHz overall cap.

Table 2: Spectrum Cap Examples

2.5 Infrastructure Sharing – Asset Light Approach

Taking cost out is one of the imperatives for mobile operators particularly with the rollout of 5G since more sites are expected to achieve the necessary coverage. Whilst most operators were reluctant to share infrastructure in the past, this has changed over the years as they look to reduce capital expenditure. In recent years, passive infrastructure sharing – the sharing of non-electronic infrastructure such as physical tower space and power supply – are becoming common. Some operators have also begun to sell their tower assets to free up capital for investments in new areas. Some telecommunications operators are going further to become asset light, and offloading a range of infrastructure from towers, through to data centres and fibre assets. AT&T in the US has recently announced the shift of existing 5G mobile core network to Microsoft's Azure cloud infrastructure.

However, with the development of 5G, sharing beyond passive infrastructure is now being explored by operators to reduce cost further. Sharing of active infrastructure means lowering of equipment costs as well as ongoing operational costs (e.g., manpower, hardware maintenance, and lower energy consumption). Active infrastructure sharing is in part enabled by the development of multi-operator core network (MOCN) and multi-operator radio access network (MORAN). MORAN allows the sharing of the radio access network (RAN) whilst each operator uses its own dedicated spectrum. MOCN allows both RAN and spectrum to be shared whilst each operator continues to maintain its own core network.

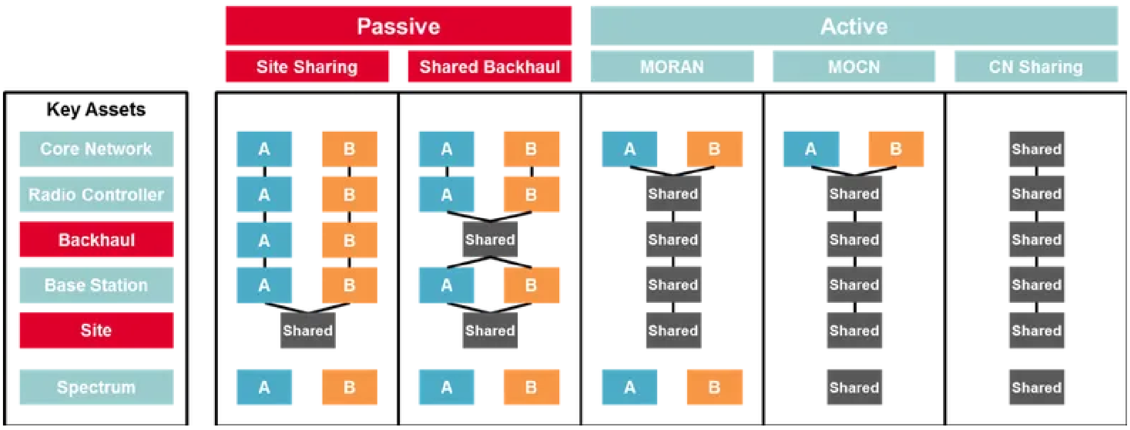


Figure 5: Infrastructure Sharing (source: GSMA)

Sharing beyond passive infrastructure is vigorously being explored by operators to reduce cost further with the development of 5G. Sharing of active infrastructure means lowering of equipment costs as well as ongoing operational costs (e.g., manpower, hardware maintenance, and lower energy consumption) while providing better customer experiences through combined resources[8,9]. Active infrastructure sharing is in part enabled by the development of multi-operator core network (MOCN) and multi-operator radio access network (MORAN). MORAN allows the sharing of the radio access network (RAN) whilst each operator uses its own dedicated spectrum. MOCN allows both RAN and spectrum to be shared whilst each operator continues to maintain its own core network[10,11] This is critical in countries where there is a lack of spectrum to satisfy all network operators. Regulatory intervention, either directly or indirectly, can also drive operators to team up to share infrastructure and spectrum. Below are some examples highlighting the potential scenarios:

TT-Netværket	TT-Network is a joint venture between Telenor and Telia to share 2G, 3G and 4G, thus creating one shared network. This is a commercial agreement formed in 2013 to create a network that can match market leader TDC's network coverage. The cooperation is continuing into 5G and the company has already trialled MOCN and picked up additional spectrum in the 5G auction concluded in April 2021. TT-Network won 140MHz of 3.5GHz spectrum (including 60MHz with rental obligation private networks), 45MHz in the 1,500MHz band, 40MHz in the 2100MHz band, and 600MHz in the 26GHz band. *Source:* *https://www.telenor.com/denmark-in-the-media-spot/ight/* *https://Sgobservatory.eu/Sg-auction-in-denmark-raised-2-1- billion-dkk-279-1-million-eur/*
M1 StarHub	IMDA the regulator in Singapore awarded two nationwide licences in the 3.5GHz band, with each allocated 100MHz of spectrum. With only 200MHz available in the band (3450 – 3650 MHz), and four mobile network operators, there is a lack of spectrum to go around. This has motivated M1 and StarHub to form a joint venture (Antina Pte Ltd) to bid for the spectrum; and was successful in obtaining one of the two licences. Antina has chosen Nokia's CloudRAN technology to deploy a 5G standalone RAN sharing network. The JV will support M1, StarHub as well as other mobile service providers on wholesale arrangements. *Source:* *https://www.imda.gov.sg/regu/ations-and-/icensing-listing/spectrum-management-and-coordination/spectrum-rights-auctions-and-assignment/SG-CFP-2020*

[8] Cortez, P., Silva, H., & Valente, A. (2018). Cost efficiency of active infrastructures in telecommunication networks. Journal of Telecommunications and Information Technology, 4, 50-57

[9] Gavrilovska, L., et al. (2019). 5G - The Convergence of Active and Passive Infrastructures for the Network of the Future. In 2019 14th International Symposium on Wireless Communication Systems (ISWCS) (pp. 351-357). IEEE

[10] GSMA - Infrastructure Sharing: An Overview, https://www.gsma.com/futurenetworks/wiki/infrastructure-sharing-an-overview/

[11] GSMA - Mobile Infrastructure Sharing, https://www.gsma.com/publicpolicy/wp-content/uploads/2012/09/Mobile-Infrastructure-sharing.pdf

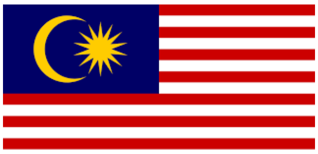
	https://www.nokia.com/about- us/news/releases/2021/03/22/nokia-dep/oys-first-5g-standalone- ran-sharing-network-for-ml-starhub-joint-venture-in-singapore/
	Malaysia is planning to form a “special purpose vehicle” (SPV) to build, operate and lease 5G infrastructure to new and existing telcos. The SPV will be fully owned by Malaysia’s Ministry of Finance. Under this arrangement, the SPV will be given the necessary 5G spectrum such as 700MHz, 3.5GHz and 28GHz. This decision was made in consideration of (1) the dramatic increase in traffic due to COVID-19 which underscores the importance of connectivity including the speeds and coverage; (2) the high investment needed for 5G, which could be between 25% and 75% more than 4G; and (3) the ability to rollout 5G more rapidly. The SPV will only offer wholesale services to ensure level playing field for all retail service providers. In 3rd May 2023, the Malaysian government has finally decided on its next steps for 5G network rollout. Communications and Digital Minister Fahmi Fadzil has announced that Malaysia will transition from a Single Wholesale Network (SWN) to a Dual Network model next year.*Source:* *https://www.mcmc.gov.my/en/media/press-releases/syarikat- tujuan-khas-untuk-memacu-pe/aksanaan-Sg-m* *https://soyacincau.com/2023/05/03/malaysia-to-transition-to-dual-wholesale-network-in-2024-after-dnb-hits-80-5g-population-coverage*
SoftBank KDDI	KDDI and SoftBank have appointed Ericsson to deploy Japan’s first MORAN. The aim is to accelerate the deployment of 5G. The two companies have also announced a joint venture to build out 5G in rural areas more quickly using shared infrastructure. *Source:* *https://www.ericsson.com/en/press-releases/2021/6/ericsson- sets-up-japans-first-multi-operator-ran-with-kddi-and-softbank*

Table 3: Infrastructure Sharing Examples

Sharing of active network will become more prevalent and there are many other examples around the world. These are typically due to reasons such as cost of investment, speed of rollout, competitive reasons (e.g., closing the gap with the market leader), and regulatory reasons (e.g., the lack of spectrum). However, existing regulations in some countries can prohibit the implementation of MOCN-based network sharing. There is a likelihood of spectrum shortages for 5G deployment and there are benefits for operators to share their network particular in rural areas. In Germany for example, operators including Telefonica Deutschland, Vodafone and Deutsche Telekom have teamed up to deliver 4G coverage across rural areas through active network sharing across several hundreds of sites.

2.6 Converged License (Unified License)

Converged Licensing Framework allows competing operators to offer any or multiple services (i.e Service Neutrality) using any technology (i.e Technology Neutrality) without having to apply for a separate license for each service. Convergence can lead to following:

- Promotes competition: allows operators and users to get all benefits of technology directly without regulatory restrictions
- Encourages the development of technologies and increasingly efficient services;
- Reduced costs
- Allows packages or custom services to meet the needs of users[12]

A comprehensive outlook with multiple aspects to be considered for implementation in Sri Lanka

2.7 Technology Neutrality Regulation

Flexibility in spectrum management and access to spectrum can be increased through technology- and service-neutral authorisations to let spectrum users choose the best technologies and services for a particular frequency band. ITU emphasizes technology neutrality in spectrum management to accommodate diverse technologies and evolving communication needs. It encourages countries to adopt technology-neutral approaches in allocating spectrum, allowing different technologies to coexist and utilize spectrum efficiently[13]. This is becoming common and administrative determination of technologies and services should become the exception and should be clearly justified. In some countries, technology neutrality is often applied to spectrum bands that are auctioned (or under spectrum rights framework) to commercial operators.

The technology-neutral approach incentivises network operators to adopt the most spectrally efficient technology. In Sri Lanka, mobile operators are keen to refarm their 2G and 3G spectrum for LTE, and potentially free up spectrum for 4G and subsequently for 5G. Having a technology and service neutral approach allows operators to refarm their spectrum more flexibly without going through additional regulatory hurdles.

2.8 Service Neutrality

Service neutrality refers to a regulatory principle operator is authorized to provide various services in demand by the end user. This ensures that licensing framework is flexible enough to enable operators to be more creative in developing communication services

2.9 Spectrum Sharing

Different techniques and approaches have emerged over the years to enable more efficient use of spectrum, either limiting the power to avoid interference to primary users; or tapping into spectrum that are unused at a given time and location.

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[12] https://www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/Documents/Events/2015/March-DigitalEconomy/Session1-2_Gustova_Pe%C3%B1a-Qui%C3%B1ones.pdf

[13] International Telecommunication Union: https://www.itu.int/en/ITU-D/Regional-Presence/Americas/Documents/events/2015/SSR-Arq-1516-10/Regulatory-policies-for-technology-neutrality.pdf

Dynamic Spectrum Access (DSA) allows for opportunistic access to underutilized spectrum bands. Cognitive radio technology is often employed to detect and exploit spectrum white spaces (unused frequency bands) dynamically. DSA enables secondary users to access the spectrum while ensuring minimal interference with primary users[14]. The Citizens Broadband Radio Service (CBRS) in the United States utilizes a Spectrum Access System (SAS) for dynamic spectrum sharing in the 3.5 GHz band that enable efficient sharing of the spectrum among different users, including commercial wireless carriers, private enterprises, and public entities[15]. U.S. Army has implemented dynamic spectrum sharing techniques in the Tactical Radio Relay (TRR) system, allowing multiple military radios to share spectrum resources dynamically and adaptively in real-time[16].

Licensed Share Access or Shared Spectrum is a way to allow users to access underutilised spectrum whilst protecting existing primary users from harmful interference. This is usually achieved with minimal regulatory intervention, without the need for the regulator to coordinate frequency assignment. Instead, an automated application and registering process is set up to provide faster access to spectrum. An online system is typically used and potentially managed by commercial organisations to perform a basic assessment and inform the user whether the registration is successful or not.

In the US for example, the FCC has enabled shared access to the 3.5GHz CBRS (Citizen Broadband Radio Service) spectrum band. This is through a Spectrum Access System (SAS) which mediates access to spectrum by licensees in two priorities, whilst protecting the primary user – the Department of Defence for shipborne radar systems. The Priority Access Licensed (PAL) provides access to up to 70MHz of licensed spectrum (through an auction in mid-2020) in blocks of 10MHz. The Generally Authorised Access (GAA) licences are accorded no interference protection and may become crowded, relying on the SAS to maintain some level of order. SAS administrators such as CommScope, Federated Wireless, Google and Sony are approved to operate commercial services in the band. The CBRS shared spectrum will enable private mobile networks to be deployed, which are often location-specific. Whilst it is likely to see 4G private networks utilising the band initially, the band can also be used for 5G when the technology and ecosystem become mature. The FCC move has also resulted in industry players coming together to maximise the benefits of the CBRS spectrum. CBRS Alliance (now rebranded at OnGo Alliance) has close to 200 members (e.g., Ericsson, Google, Intel, Motorola and Nokia) and it is looking to take on global mid-band opportunities.

Dynamic Spectrum Sharing (DSS) enables an operator to use the same spectrum bands for different radio access technologies; and dynamically allocates spectrum resources between different technologies based on user demand. This is a promising solution for mobile operators looking at maximising the use of their spectrum as customers migrate from 4G to 5G; without having dedicated spectrum for both technologies. This is also crucial for allowing 5G to tap into low-band for coverage requirements. DSS is already being implemented in countries such as Germany and the US to achieve broader 5G coverage. However, there are still some technical challenges with DSS which affect the performance but this remains a viable option for some operators due to the need for spectrum in the lower band for coverage. More importantly, the implementation of DSS will require technology neutrality across mobile operators' spectrum bands.

[14] Akyildiz, I. F., et al. (2006). Next generation/dynamic spectrum access/cognitive radio wireless networks: A survey. Computer Networks, 50(13), 2127-2159.
[15] Citizens Broadband Radio Service (CBRS): https://www.fcc.gov/wireless/bureau-divisions/mobility-division/citizens-broadband-radio-service-cbrs
[16] Dynamic Spectrum Sharing for Tactical Radio Relay: https://ieeexplore.ieee.org/document/9273386

2.10 Ran Sharing

RAN sharing is a subset of infrastructure sharing that promotes resource optimization by better utilization of assets, avoiding duplication of network, saves time and cost in network and service rollouts. Telecom network deployment involves heavy CAPEX and OPEX liabilities for operators and is considered as a major deterrent for network rollouts. Furthermore, delays in rolling out new network infrastructure, which are attributed to procuring rights of ways, pose great challenges to licensed operators in terms of time relevance to market for telco and ICT services. There are multiple types of sharing RAN.

MORAN (Multi-Operator RAN)	sharing of active (i.e., electronic) infrastructure in a RAN such as the BTS/BSC, Node B/RNC, eNode-B, etc
MOCN (Multi-Operator Core Network)	similar as "MORAN" but the spectrum is also shared.
MVNO (Mobile Virtual Network Operator)	an operator licensed to use the RAN and spectrum of another operator; the MVNO does not hold a spectrum license and may or may not own a core network.
Roaming	users from one Telecom Operator are able to access the network of a second Telecom Operator within the same country; usually limited to a geographical area
Transmission sharing	Sharing of the backhaul or backbone transmission network including equipment such as: microwave, fiber optic cable, terminating equipment, routers, etc.
GWCN (Gateway Core Network) sharing	Sharing of a mobile core network including equipment such as MSCs and SGSNs.

Table 4 Types of RAN Sharing[17]

RAN sharing has been incorporated in to regulatory framework of multiple countries. Following are few global references:

India 	Telecom Regulatory Authority of India (TRAI) issued a consultation paper on the "Review of Scope of Infrastructure Providers Category-I (IP-I) Registration" in August 2019. To discuss infrastructure sharing, TRAI invited stakeholders' comments and conducted an open house discussion. Based on stakeholders' written submissions, issues discussed in the open house and its own analysis, TRAI has released its recommendations on enhancing the scope of IP-Is. TRAI stopped recommending spectrum sharing, and Active infrastructure sharing has been permitted amongst Telecom Service Providers (TSP) licensees only. Active sharing is limited to sharing of antennas, feeder cables, Node B, Radio Access Network (RAN) and transmission system, excluding sharing/trading of radio spectrum. IP-Is can also install all these active elements but only on behalf of TSPs.

[17] ITU. (2013). Infrastructure Sharing for Telecommunications: Approaches to Efficient and Effective Investment in Backbone Networks. Retrieved from https://www.itu.int/en/ITU-D/Regulatory-Market/Documents/Infrastructure%20Sharing%20Study%202013.pdf

	However, sharing of active infrastructure among TSPs has not been very effective. As TSPs operating in the same geographical area and providing similar telecom services are competitors as well, some TSPs are not willing to share their resources with competitors, if it leads to a competitive disadvantage. Therefore, mutual agreements between TSPs are not successful. Alternatively, TSPs are reportedly more comfortable in leasing telecom infrastructure from a non-competing entity such as an IP-I. This has dual benefits of enabling TSPs to concentrate on their core competency of providing telecom services and allowing IP-Is to invest and create active as well as a passive telecom infrastructure.
Bangladesh 	In Bangladesh, at present passive sharing is promoted through the 'Guidelines for Infrastructure Sharing'. These guidelines were issued in 2008 and amended in 2011. They only allow Passive infrastructure sharing for now. Active infrastructure sharing is not yet approved. Bangladesh Telecom regulatory Authority (BTRC) is working to prepare the guideline for active sharing. Permission on active sharing of spectrum is not being issued at the moment in order to verify the feasibility of sharing an active infrastructure first. Apart from the spectrum, all other frameworks can be shared. Under this, mobile phone tower (BTS), equipment required to receive and deliver calls and for data transfer, such as Node B, Node E, antenna, feeder cable, RAN and microwave radio equipment, will be permitted to be shared. BTRC is also considering to allow Distributed Antenna System (DAS) from the active components separately, among the operators, considering the demand of the industry. BTRC is considering to allow active sharing in case to case and phase by phase basis, redefine the definition of active infrastructure and scrutinizing all active components for all stakeholders. Consultation process with every layer from the value chain of the industry is still in process [from submarine cable / ITC operators to mobile operators]
European Union 	Sharing is a feature in many European mobile markets and is often but not always concluded on a voluntary basis (i.e. "commercially driven"), and not as a result of regulatory intervention. In some of the countries where mobile infrastructure sharing is already a factor in the market or under active consideration, National Rental Affordability Scheme (NRAS) have adopted guidelines trying to achieve a reasonable balance between incentivizing investment and ensuring a fair and competitive market development through infrastructure-based competition. There are also differences in terms of providing guidelines or rules with respect to infrastructure sharing with some countries providing detailed guidelines and some providing none at all. There is some degree of passive infrastructure sharing, but the ways in which

	infrastructure sharing is managed or assessed differs from country to country. Differences arise from how information about infrastructure sharing agreements is treated and shared between the parties and the authorities and how disputes are dealt with. There are also differences in the approaches regarding the inclusion of rules in spectrum awards that may foster, mandate or prohibit network sharing. In Denmark, an active sharing agreement on Radio Access Network (RAN) is seen to work fine, although the parties involved are in fierce competition. In France, also RAN sharing is efficient and resulted in better 2G / 3G coverage, as it was a prerequisite for authorization, as defined in the NRA sharing guidelines. Furthermore, Norway describes infrastructure sharing as a prerequisite for newcomers to enter the mobile retail market. With a view to the 5G rollout, it is expected that a much larger number of sites will be needed. As the number of sites increases, also the number of sharing agreements is expected to increase or at least the complexity of such agreements to become higher. Operators are obliged to publish information on passive infrastructure sharing opportunities in advance, in a public forum, in nine countries (Belgium, Bulgaria, Croatia, Greece, Italy, Latvia, Liechtenstein, Montenegro and Serbia). In Norway, the obligation applies only to the SMP operator. The obligations can take the form of online publication, notifying the NRA I Ministry or publication via a third-party platform.
United Kingdom 	Ofcom has powers under the Communications Act 2003 to impose access conditions on electronic communications networks, as well as powers to impose specific access conditions where it finds a provider has significant market power (SMP), known as SMP conditions. The most common form of infrastructure sharing used to deploy telecoms networks in the UK is regulated access to Openreach's passive infrastructure network. At regular intervals, Ofcom conducts reviews of telecoms markets to determine how competitive they are. If it finds that an operator has SMP in one of these markets, it can impose SMP obligations or conditions on that specific operator to address this. There are two providers in the UK with SMP, Openreach and KCOM. Openreach has a near ubiquitous network across the UK excluding the Hull area, where KCOM has SMP. Ofcom issued Access to Infrastructure (ATI) Regulations 2016, enable sharing of information about access to physical infrastructure (e.g. ducts and poles) across utility, transport and communications sectors, including the exchange of information about existing infrastructure, and the right to access that infrastructure on fair and reasonable terms and conditions. Under the ATI Regulations, network providers and infrastructure owners to make commercial arrangements to grant access to their passive infrastructure and publish reference offers, publicly available documents that would set out the terms under which access would be granted to their networks. Under the ATI Regulations, a network provider can request information about another operator's physical infrastructure and can submit requests to undertake a survey of that infrastructure. Network operators are also required to give access to their physical infrastructure,

	including access to in-building physical infrastructure, on fair and reasonable terms and conditions. Further, the ATI Regulations require enhanced transparency of civil engineering works and reasonable coordination of works which use public funds. There are a number of grounds upon which a network operator can refuse requests under the ATI Regulations. For instance, requests can be refused if: • They are likely to be prejudicial to national security or to put the security or integrity of a network, or public safety or health at risk • They are not reasonable or are technically unsuitable. • There is not sufficient space, also taking account of the host operator's future needs • Granting them would breach confidentiality to a third party, or where a telecoms network would seriously interfere with the provision of other services. Requests to coordinate civil works can also be refused if, they have not been made early enough, and if they would impede the infrastructure operator's control over its works or give rise to additional costs. In case of disputes, Ofcom has powers to include the terms of transactions and impose rights and obligations on the parties to a dispute. The regulations require Ofcom to decide about disputes relating to access to physical infrastructure within four months, and to issue a decision on any other dispute within two months. However, this is purely a dispute resolution regime. Ofcom does not have any powers to impose financial penalties under the ATI Regulations. Ofcom's decisions can be appealed to the Competition Appeals Tribunal. To date, Ofcom has not received any formal dispute cases under the ATI Regulations.

Table 5 RAN Sharing References

2.11 The 6GHz Band – Demand from Mobile & RLAN

There is ongoing discussion globally over the potential changes to the allocation of the 6GHz band (5925 – 7125MHz as shown in the figure below). This band is currently being studied by ITU study groups in preparation for WRC-23 (agenda 1.2). More specifically, under Agenda Item 1.2, amongst other bands, 6425 – 7025 MHz is being considered for IMT in Region 1, and 7025 – 7125 MHz is being considered for IMT on a global basis[18,19].

[18] https://www.fee.gov/35-ghz-band-overview
[19] https://ongoalliance.org/news/cbrs-alliance-rebrands-to-ongo-alliance-to-support-global-shared-spectrum- initiatives/

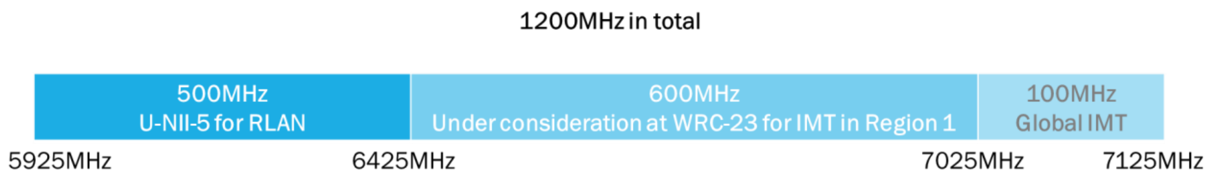

Figure 6: The 6 GHz Band

Studies have been done are being conducted to assess the impact on existing services including fixed satellite service, Space Research Service, Radio astronomy service, and standard frequency and time signal-satellite service Fixed Service, etc., and the results have shown that the sharing is feasible. Whilst the larger portion of spectrum is being considered for Region 1, other countries outside the region are watching this development. Countries such as China have expressed support to use the full 6GHz band for licensed 5G services.

One aspect to be noted is that, R1 has 1200MHz and R2 has 1100MHz mid-band under discussion for IMT use, but R3 has only 300MHz mid-band under discussion for IMT use. The candidate spectrum for R3 is fairly not enough. 6425-7025MHz is essential for R3.

In parallel, the radio local access network (RLAN) community is promoting the use of the full 6GHz band for RLAN purposes. The RLAN technology is also evolving with Wi-Fi 6 offering faster speeds and better performance. The proliferation of Wi-Fi for home and office use have driven the demand for more spectrum. In countries such as Canada, the US, and South Korea, the full 6GHz band has already been made available for unlicensed use, paving the way for RLAN equipment.

Meanwhile, the UK has made available the lower portion of the 6GHz band (i.e., 5925 – 6425MHz) for Wi-Fi and other RLAN technologies. Other countries in Europe are looking at adopting a similar approach as well as countries such as Australia. Whilst it is still at the early stage for the use of 6GHz, and before equipment becomes readily available, this will be a crucial band for both mobile and RLAN technologies. Therefore, it is required to consider the impact on existing services, and work with other countries in Region 3 to ensure there is some level of harmonisation for the use of the band.

3 Mobile Broadband Services

With the convergence of services, the demand for spectrum has been driven predominantly by mobile broadband services. The amount of spectrum required is closely correlated to the growth in mobile data traffic. Globally, mobile network data traffic grew 38 percent between Q3 2021 and Q3 2022[20]. According to Ericsson,

the global average data usage per smartphone now exceeds 15GB; and video traffic accounts for 71 percent of all mobile data traffic. Ericsson's forecast indicates that the global average data usage will reach 46GB by the end of 2028, more than three times the current level. In Sri Lanka a spike in data traffic has been noted nearly doubled due to the pandemic. The proposed rollout of 5G, and the

[20] 'Ericsson Mobility Report', Ericsson,November 2022. https://www.ericsson.com/4ae28d/assets/local/reports-papers/mobility-report/documents/2022/ericsson-mobility-report-november-2022.pdf

increasing demand for video applications (e.g., conferencing and streaming) will continue to drive the increase in mobile data traffic.

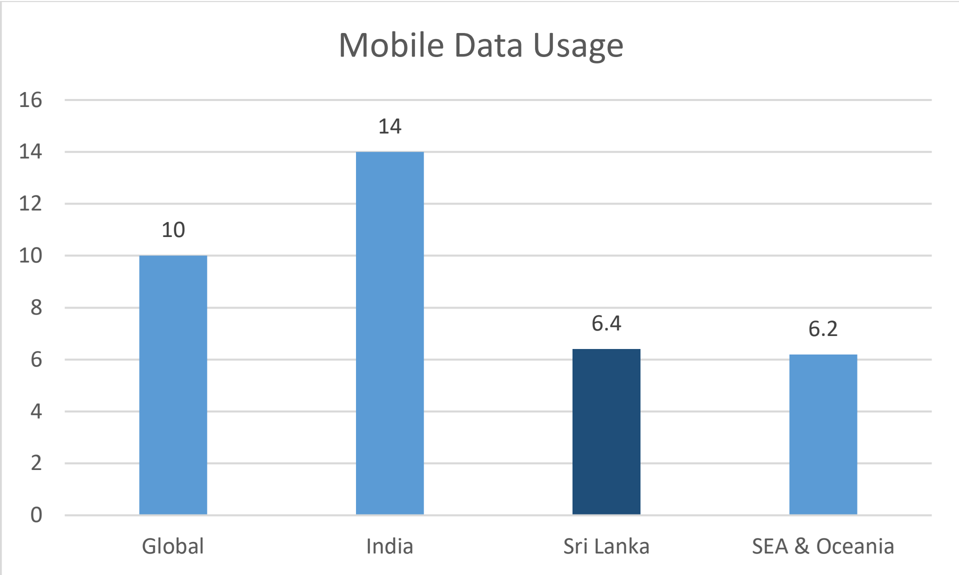

Figure 7: Mobile Data Usage Benchmark[21]

Based on the data from operators in Sri Lanka, the mobile data usage is estimated to be about 6.4GB per user. Overall data traffic will continue to grow rapidly in Sri Lanka because there are still many people who do not own a smartphone, and Airtel has just introduced 4G to its customers. Data consumption over 4G is significantly higher than 3G.

The current focus on spectrum allocation amongst regulators is to facilitate 5G deployment. This is typically through awarding available spectrum in existing bands, refarming of 3.5GHz, and allocating mmWave spectrum. Most 5G allocation exercises are in the mid-band and/or mmWave spectrum since most of the sub-1GHz bands are already used for existing 3G or 4G services. Some countries have also awarded mmWave spectrum to operators looking to offer high-capacity connectivity for targeted areas. Below are some examples of countries that have awarded 5G spectrum:

Country	**Spectrum**	**Comments**
Denmark	1.5GHz (1427 – 1517MHz); 2.1GHz (1970 – 2170MHz); 2.3GHz (2360 – 2400MHz); and 3.5GHz (2410 – 3800MHz)26GHz (24.65 – 26.5GHz) 700 MHz640MHz in the low/mid-band; 1850MHz mmWave	Spectrum was awarded via an auction in April 2021. This provides the three entities – TDC, Hi3G and TT-Network (Telia & Telenor JV) – ample of spectrum to implement 5G services

[21] Source: Ericsson Mobility Report 2021 and data from mobile operators

Hong Kong	4.9GHz (4840 – 4920MHz); 3.3GHz (3300 – 3400MHz); and 3.5GHz (3400 – 3600MHz) 26GHz (24.25 – 27GHz) and 28GHz (27.5 – 28.35GHz) shared spectrum 380MHz of mid-band and 400MHz for mmWave 700MHz (703-738MHz paired with 758-793MHz)	Three separate 5G auctions were carried out between 2019 and 2020. The use of 3.3GHz is limited to indoor use limited to low transmitting power; to mitigate interference to the incumbent radiolocation services and fixed satellite services in the adjacent 3.4 – 4.2GHz band. With four MNOs in Hong Kong (China Mobile HK, HKT, SmarTone and Hutchison), each operator has between 40MHz and 60MHz in the 3.5GHz; and between 20MHz and 30MHz in the 3.3GHz band. The mmWave 26/28GHz bands are designated shared spectrum to be administratively assigned by OFCA for localised wireless broadband services (e.g., in university campuses, industrial estates, the airport, and technology parks).
New Zealand	3.5 GHz (3590 – 3750MHz); 160MHz allocated for short-term rights ending 31 October 2022. The regulator is currently planning the mmWave spectrum allocation in the 24 – 30GHz. 700MHz (703-748MHz paired with 758-803MHz)	The planned auction was cancelled due to the COVID-19 outbreak and the spectrum was administratively awarded in mid-2020 to Spark (formerly Telecom New Zealand), 2Degree and Dense Air (spectrum leasing company with 40MHz). Vodafone NZ already has 60MHz of 3.5GHz spectrum and was not allocated additional spectrum. Spark and 2Degree was awarded 60MHz each; below the recommended 80 – 100MHz. However, this is part of the unallocated spectrum within the entire 3410 – 3800MHz band which is partly under spectrum rights that will expire in November 2022. The allocation in mid-2020 was for short-term rights (ending in 31 October 2022). The regulator is expected to auction off the entire band for long-term rights before November 2022. 700MHz (703-748MHz paired with 758-803MHz) was completed in 2014. It is technical neutral for 4G+5G now.
Singapore	3.5 GHz (3450 – 3650MHz) and 26/28GHz. 200MHz mid-band; 3200MHz mmWave	Instead of the usual auction mechanism, the 5G spectrum was awarded via a beauty contest with two nationwide packages – 100MHz of 3.5GHz plus 800MHz of mmWave. Singtel and M1-StarHub JV were the

		successful bidders. TPG, another MNO, was awarded 800MHz of mmWave for localised coverage.
Thailand	700MHz (3 blocks of 2 x 5MHz); 2.6GHz (2500 – 2690MHz); and 26GHz mmWave. 220MHz low/mid band; 2600MHz mmWave Note: 3.5GHz band is still being refarmed and will be available at a later stage.	The spectrum was awarded in February 2020 through an auction. Five operators AIS, True, DTAC, CAT and TOT picked up different amount of spectrum. AIS won 100MHz in the 2.6GHz band whilst True won the remaining 90MHz in the band. There was limited amount of 700MHz spectrum offered. It is noted that DTAC the third largest mobile operator by subscriber base only secure 26GHz spectrum. The 700MHz spectrum was assigned 2X10MHz each to 3 of mobile operators in advance in June 2019. The balance 2X15MHz was awarded in February 2020 through an auction. In Apr 2023, Thailand National Telecom's (NT) plan to develop a service on the 700MHz. The cabinet approved NT starting project development of 4G and 5G service on the spectrum with a budget of 61.6 billion baht (approx. 1.8 billion USD)[22].

Table 6: Examples of 5G Spectrum Allocation

Many countries have allocated spectrum for 5G deployment but the above examples are chosen to illustrate a few key points:

- Whilst it is ideal to have contiguous 80 – 100MHz of spectrum for 5G, this may not always be possible, especially if demand exceeds supply. The use of carrier aggregation and DSS will also help mobile operators to kick-start 5G rollout without additional 80 – 100MHz contiguous spectrum.
- Spectrum sharing and infrastructure sharing is another way to enable operators to reduce the number of spectrum licences; and increase the amount of spectrum per licensee.
- Besides 3.5GHz, other bands (e.g., 700MHz, 2300MHz, 2600MHz, 4.9GHz and 26/28GHz) can also be considered as part of the 5G allocation exercise. More importantly, need to provide an indication of the next wave of 5G spectrum availability.
- There is a demand for shared spectrum, including for localised operations (private mobile networks). This can be in the mid-band or mmWave.

Current Utilisation

The table below shows the spectrum bands allocated for mobile services in Sri Lanka. These are also spectrum bands widely used for mobile services globally. In Sri Lanka however, these bands

[22] https://www.bangkokpost.com/business/2544445/nt-bullish-on-700mhz-prospects

accommodate both mobile services as well as fixed wireless access (FWA) services. This has resulted in greater demand for spectrum with seven networks competing for spectrum – four mobile operators (Airtel, Dialog Axiata, Hutch and Mobitel) and three FWA operators (Dialog Broadband Network, Lanka Bell, and SLT).

Spectrum Band	Total Bandwidth	Spectrum Assigned	Spectrum Available
450 MHz	20 MHz	Currently for PPDR and CDMA	Fully Assigned
700 MHz	N/A	Currently for broadcasting services	Not available
850 MHz	33 MHz	Assigned for 4G	Fully assigned
900 MHz	55 MHz	Assigned for 2G/4G	Fully assigned
1800 MHz	150 MHz	Assigned for 2G/4G	Fully assigned
2100 MHz	120 MHz	Assigned for 3G/4G	Fully assigned
2300 MHz	100 MHz	Assigned for 4G	Fully assigned
2600 MHz	190 MHz	Assigned for 4G	30 MHz remaining
3500 MHz	200 MHz	being re-farmed	being re-farmed
Total Available	668 MHz	635 MHz assigned	Excluding 700MHz and 3.5GHz

Table 7: Current Mobile Spectrum Allocation in Sri Lanka

Whilst TRCSL has made available 668MHz of spectrum, 410MHz of spectrum (or 68 percent) is used for mobile services. The table below shows the distribution of the spectrum. By including the FWA spectrum used by the operators, the total spectrum held by the four operators increases to 620MHz.

Operator	Type of License	Spectrum Holding	Subscriber Base
Airtel	Mobile	75 MHz	3.2 million
Dialog Axiata	Mobile	140 MHz	14.7 million
Dialog Broadband /Suntel	FWA	80 MHz	2 million
Hutchison/Etisalat	Mobile	90 MHz	3.5 million
SLT	FWA	100 MHz	1.5 million
Mobitel	Mobile	105 MHz	7.2 million

Lanka Bell	FWA	30 MHz	0.1 million
Unallocated		30 MHz	-

Table 8: Spectrum Distribution Amongst Operators in Sri Lanka

IUT-R Report M.2109-0 (2007) [23]provides a summary of the sharing studies between IMT Advanced systems and geostationary satellite networks in the fixed-satellite service (FSS) in the 3 400-4 200 and 4 500 4 800 MHz frequency bands. It was conducted by ITU-R in the framework of Agenda item 1.4 of WRC-07, in accordance with resolves 5 to Resolution 228 (Rev.WRC-03), as these bands were identified as candidate bands for future development of IMT-2000 and IMT-Advanced systems

To provide protection of the FSS receive earth stations, some separation distance relative to the stations of the mobile terrestrial network is required. The magnitude of this separation distance depends on the parameters of the networks and the deployment of the two services. The magnitudes of these required separation distances to protect the FSS receive earth stations have been studied, taking account of the need to meet both short-term and long-term interference criteria requirements, with respect to the three following interference mechanisms:

- **In-band, co-channel operations**
  The minimum required separation distances from IMT-Advanced base stations, when using the long-term interference criterion derived in the studies to date, are at least in the tens of kilometres.
  The minimum separation distances associated with short-term interference criterion, generally, but not in all cases, exceed one hundred kilometers in the considered cases with similar assumptions as the ones used for the long-term.
- **Adjacent band operations**
  Concerning interference from unwanted emissions arising from out-of-band and spurious domains of IMT-Advanced base station transmitters and falling within the band used by the FSS receiver, the minimum required separation distances, when using the long-term interference criterion derived in the studies to date, are up to tens of kilometers (with no guard band) and decreasing as the guard band increases.
- **Overdrive of the FSS receiver**
  One study has shown that emissions from one IMT-Advanced station can overdrive the FSS receiver LNA, or bring it into non-linear operation, if the separation distance is less than some kilometers or some hundreds meters with respect to base stations and user terminals respectively.

With the convergence of services, the mobile networks are supporting more applications and services, therefore carrying more traffic. This is resulting in greater demand for spectrum for mobile services than other services. This is also a global phenomenon. With the mobile technology moving into 5G, mobile operators also need additional spectrum to implement the technology and deliver new services to customers. Allocating spectrum for 5G has also been a priority for many countries.

[23] ITU-R M.2109-0, (ITU, 2007) https://www.itu.int/pub/R-REP-M.2109-2007

Technology can bring significant economic and social benefits to each country. Hence, most governments and regulators are keen to facilitate the investment in 5G, including making the spectrum available, and in some cases encouraging businesses, universities, research organisations and government departments to collaboratively develop 5G-enabled solutions and use cases.

The immediate challenge is to fairly provide the necessary amount of spectrum so that operators can proceed to implement 5G. All mobile operators may intend to rollout 5G but there is limited net new spectrum that is available in the 3.5GHz band. Nevertheless, as highlighted in Section 3 of the report, By allowing the convergence of mobile and FWA in the long run with strict regulatory safeguards, sharing of infrastructure, and enabling operators to more freely refarm their spectrum for newer technologies will further improve the utilisation of spectrum, and allow 5G implementation using existing spectrum.

The new spectrum identified in the 3.5GHz band (3400 – 3600 MHz) will not meet the needs of all four mobile/fixed operators; each looking to have 80 – 100MHz in the band. On the positive side, there is existing spectrum that is currently underutilised and can be used for 5G implementation. It is required to consider the total spectrum assets and create the environment for these assets to be more effectively utilised.

While recognising requirement of technology and service neutrality while ensuring level playing field, to allow existing spectrum to be used for any mobile/fixed technology, and this is in line with international best practice. Whilst operators can currently do so, they have to seek approval from TRCSL which adds uncertainty and lag time. This approach also allows mobile operators to better manage and plan their spectrum resources without worrying about an additional regulatory hurdle. This will also be crucial for operators as customers migrate from 4G to 5G, and allow operators to implement DSS to better manage spectrum usage.

Another key consideration is the introduction of unified licence system to combine spectrum assets for both mobile and FWA services – converging into one licence after ensuring equal spectrum holding and other regulatory safeguards in place. This will improve the efficiency of spectrum as well as cost structures without the need to duplicate infrastructure. As highlighted in the earlier part of this report, many mobile operators also implemented FWA; and FWA is seen as a way to create a new revenue stream. This also means allowing mobile operators to introduce FWA and offer customers more service options for their home broadband. With convergence, operators will also be able to offer better bundled services and give better values to consumers. Crucially, the 2600MHz is a potential band for 5G deployment and there is sizeable amount of spectrum that can offer the bandwidth required for 5G.

Also highlighted in the global trends, operators are looking at offloading their infrastructure assets to free up capital for other investments including 5G. There is also a greater appetite to share infrastructure amongst operators. This trend could play out in Sri Lanka as the market becomes mature and operators look to improve cost management. Operators could potentially share infrastructure as well as spectrum to improve efficiency; and TRCSL is in the process of facilitating such aspects by issuing guidelines under existing regulations and facilitating industry cooperation.

For the 5G spectrum allocation, below are some options for consideration:

(a) Allocating 100MHz for two licenses operators in 3500 MHz band
(b) Considering other spectrum bands including 2300 MHz and 2600 MHz as part of the 5G spectrum allocation.

In the longer-term, it is required to make available more spectrum for mobile services. The 700MHz is a crucial band for mobile services but it is contingent on the completion of analogue TV switch-off. Broadcasters need to make the shift to digital broadcasting.

In addition, it is also required to consider allocating mmWave bands for 5G in the 26Hz/28GHz. There is growing momentum in using mmWave spectrum for localised coverage (e.g., indoor and stadium). There may also be a demand for private mobile networks, possibly in the form of shared spectrum.

Whilst some of the spectrum can only be available in the longer timeframe, it is required to plans and provide and indicative timeline to help manage operators' expectation and facilitate network investment and planning.

Future Outlook

The demand for mobile broadband services in Sri Lanka remains strong, consistent with global trends. The demand is due to both the increasing usage of mobile services in Sri Lanka, and the need to support capacity expansion and new services (e.g., 5G) amongst multiple operators. The following work items are crucial to meet the ongoing and future demand for mobile broadband services:

700MHz: The 700MHz band (703 – 803MHz) is harmonised globally for IMT services. This band has already been made available in many countries for 4G and/or 5G services to achieve better coverage. The band is currently used for broadcasting services and it can only be made available after digital broadcasting is implemented and analogue systems have been shut down. TRCSL will work closely with the Ministry of Mass Media and the broadcasters to determine the timeline, and identify possible ways to speed up the process. However, the digitising of the TV broadcast typically takes a few years from planning to analogue switch-off. After decision has been made, there is a need to design the digital network, implementation, as well as public communications for consumer awareness and adoption.

Rearrangement of 1800 MHz and 2100 MHz: In response to mobile operators' requests to rearrange these spectrum bands so that they have contiguous spectrum to improve spectrum efficiency. In Australia for example, Telstra and TPG Telecom had recently gone through a similar exercise (also in the 1800MHz and 2100MHz bands) and claimed an increase of network capacity by 10 to 20 percent. It is required to consult the industry and facilitate the rearrangement of these two bands.

3500 MHz: The 3400 - 3600 MHz is being refarmed, specifically to enable operators to roll out 5G networks. This band is expected to become available by the end of 2023.

3.3GHz: 3300 – 3400 MHz is being considered for 5G services. In Sri Lanka, this band is used for fixed services with many links in the band. Whilst TRCSL is considering the refarming of this spectrum band, the process is likely to take two to three years.

3.7GHz: The 3600 – 3800 MHz bands is also a potential band for mobile services. The band is current used for fixed satellite services (space-to-Earth). Whilst operators have been assigned frequencies in this band on a temporary basis for conducting 5G trials, there is a need for a compatibility study between mobile and satellite services for future allocation.

mmWave (above 24/26 GHz): The mmWave technology offers faster speeds, despite shorter range than the mid- band 5G spectrum. It can be used for small cells, with compact equipment. This is particularly useful for dense area, localised deployment such as in-building coverage, in sports arenas, and subway systems. This can also be deployed in factories and shopping malls for either for public or private mobile networks. Whilst there are fewer mmWave deployments globally, technology development and trials are gaining pace. It is required to consult the industry and release the spectrum in a timely manner.

Technology Neutrality: TRCSL intends to evaluate the regulatory changes required to facilitate the mobile spectrum to be technology. This will provide mobile/fixed operators greater flexibility to refarm their 2G and 3G spectrum for 4G and/or 5G services; potentially looking at using DSS to facilitate the migration of customers from 4G to 5G.

Converged Licences: TRCSL will consider the convergence of spectrum licences for mobile services and FWA with minimal impact to the industry. This is to give mobile operators the flexibility to introduce FWA services leveraging their mobile networks. It also enables convergence of mobile and FWA services for existing operators offering both services via two separate networks with dedicated frequencies for each network. However, equal spectrum holding has to be ensured with regulatory safeguards to prevent anti-competitive practices.

Infrastructure and Spectrum Sharing: Today, sharing of passive infrastructure has given operators in Sri Lanka access to more sites for improving coverage and capacity. TRCSL will consider enabling operators to share active elements within the networks, including the implementation of MORAN and MOCN with/without spectrum pooling. This will help operators to maximise their resources and deliver better outcomes for consumers. while interests of industry and public while be addressed with fair competition consideration.

Unlicensed Band: Some countries have allowed mobile operators to tap into the unlicensed band for mobile services including 4G and 5G, through technologies such as LAA, LWA and MuLTEfire as explained in Section 2.7. TRCSL will evaluate the feasibility of allowing unlicensed bands (e.g., 5GHz) for mobile services on a non-interference and non-protected basis.

WRC-23: The global community is considering additional spectrum for IMT services through the WRC process. Agenda 1.2 of WRC-23 will consider 7025 – 7125 MHz for IMT on a global basis. and 6425-7025 for IMT on Region 1 and Region 3 basis.

4 Broadcasting Services

Terrestrial broadcasting services have been transitioning from analogue to digital for over a decade and digital TV equipment is now mainstream. Globally, terrestrial TV broadcasting uses prime spectrum in the VHF band (173 – 230 MHz) and UHF band (470 – 862 MHz). Digital terrestrial TV broadcasting (DTTB) allows for more efficient use of spectrum, enabling multiple programmes to be broadcast over a single frequency. For the consumers, digital TV provides better picture quality (high-definition TV, or HDTV), and potentially more programmes that can be supported over the same spectrum. With the additional bandwidth, broadcasters are able introduce new services to retain viewership, for example catch-up TV and electronic program guide (EPG).

Regulators around the world have freed up valuable 700MHz spectrum with the switchover to digital, also known as the digital dividend. According to ITU's database, 74 countries have already completed the transition to DTTB, whilst another 63 countries are in the process of doing so and have not switched off analogue TV[24]. It should also be noted that the majority of the countries (71 percent) have chosen DVB (either DVB-T or DVB-T2) for the digital TV standard. This is important for broadcasters to consider, particularly from the availability and cost of system and equipment.

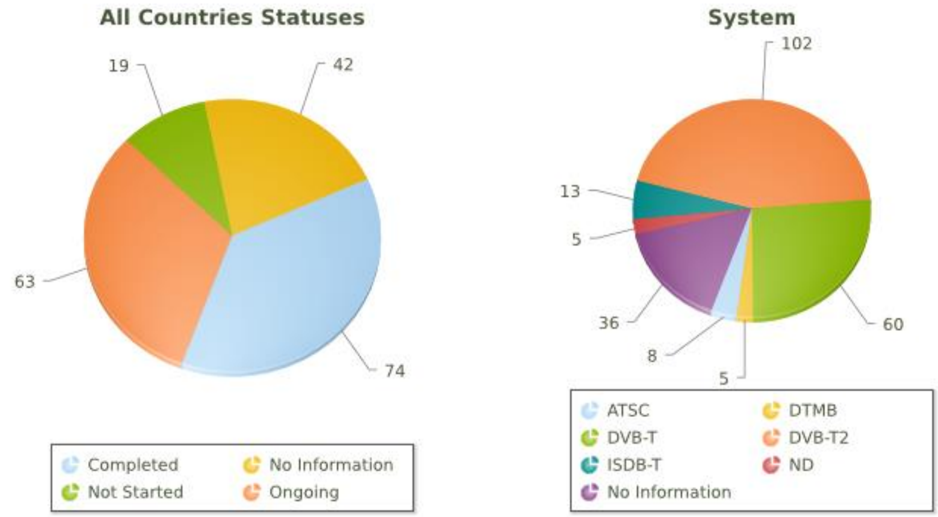

Figure 8: DTTB Status and System

[24] Status of the Tansition to Digital Terrestrial Television, ITU. Retrieved from: https://www.itu.int/en/ITU-D/Spectrum-Broadcasting/DSO/Pages/default.aspx

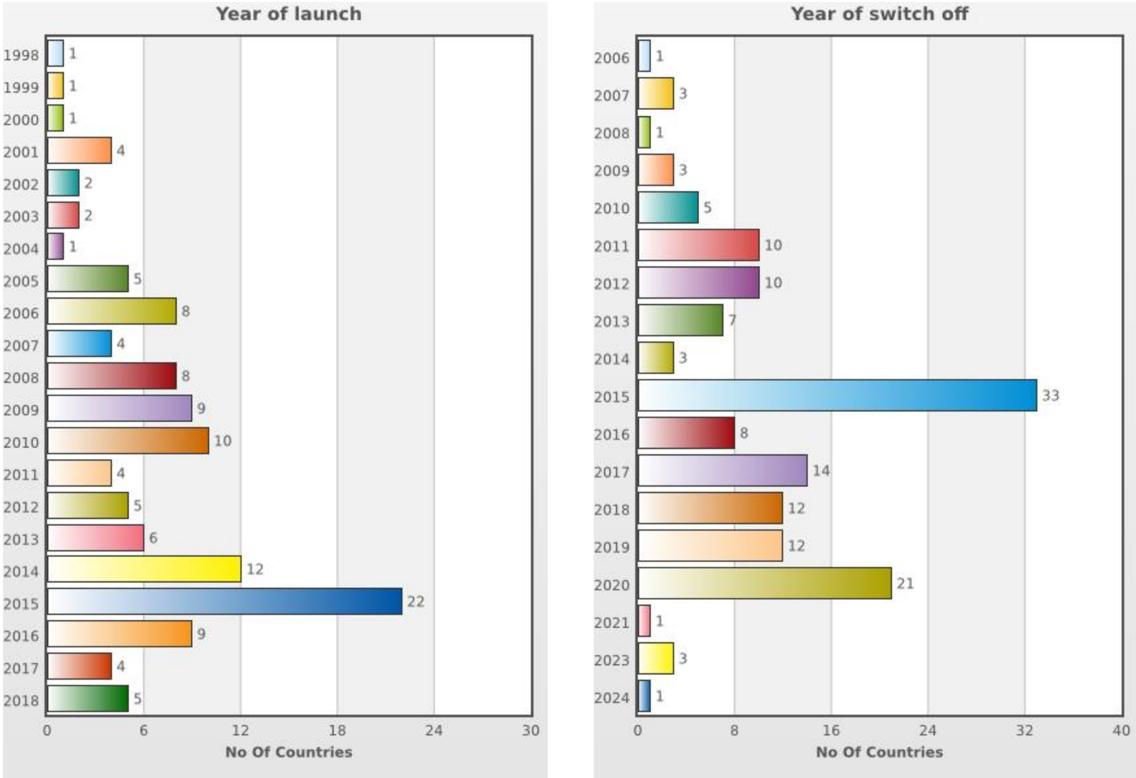

Figure 9: Digital TV Switchover Timeline

It is crucial for terrestrial broadcasters to move quickly to digital which includes the transmission as well as the production of content in digital. Globally, viewers are attracted to digital streaming platform for content on-demand, and national broadcasters are producing content in HD format, and making available their content via digital platform for on-demand streaming. In Sri Lanka, people are also buying digital TV equipment for content over the Internet, digital satellite TV both paid and free to view and cable TV. This could result in terrestrial broadcasters losing viewership. Moving to digital also helps terrestrial broadcasters to reduce their cost of operations in broadcast transmission through to production, managing content, and storage/archiving,

With the migration to digital terrestrial broadcasting, it also allows licences to be issued to new broadcasters. In Sri Lanka, to offer broadcasting services, a company needs to obtain from the Ministry of Mass Media a broadcasting licence. Once the licence has been granted, the company needs to submit an application to TRCSL for the necessary frequencies. In practice, the Ministry of Mass Media would consult TRCSL in advance to ensure spectrum availability before issuing the licence. There was a terrestrial digital TV trial conducted a few years ago but they are no longer operational.

In terms of audio broadcasting, FM analogue radio broadcasting has also existed for a long time and in many countries FM radio services remain popular. With limited bandwidth (88 – 108 MHz), some countries have introduced digital audio broadcasting to support new programmes and to offer better sound quality. However, on a global basis, there is mixed level of success. Several European countries have deployed DAB+ but besides Norway which had switched off FM radio in 2017, most countries have delayed the decision. The UK for example, has put off the switch off of AM and FM stations until 2032. Digital radios offer better sound quality and potentially more programmes, but consumers will need to purchase a digital radio device which costs more than the analogue radio. On the contrary, FM radio services offer extensive coverage and FM receivers are relatively low cost, often integrated to mobile devices. There is no urgency to shut down FM radio services since they are expected to be in demand for the foreseeable future but digital audio broadcasting should still be explored for more programmes.

The majority of countries have either completed their migration to DTTB or are in the process of doing so. Sri Lanka needs to keep pace with global trend and offer digital TV experience to the general population. As highlighted in the Mobile Broadband Services section, the 700MHz spectrum is valuable for mobile services. In particular, 700MHz will play a key role in delivering 5G coverage to rural areas. In China, there are still 600 million people living in the rural areas and China Mobile recently announced its plans to acquire more than 400,000 700MHz base stations. Most of these will go towards delivering coverage in rural areas since 700MHz spectrum can provide a much larger coverage area compared to the mid-band spectrum such as 3.5GHz.

However, the DTTB migration is a multi-year effort and TRCSL supports the Ministry of Mass Media in identifying the frequencies required for digital TV stations. This can include requirements for new services. There will be a period of simulcast until a high percentage of Sri Lankans have switched to digital TV reception (i.e., they have the equipment). The spectrum requirement will also depend on whether the broadcasters are planning based on a single frequency network (SFN) or multi-frequency network (MFN) scenario.

Current Utilisation

The TV frequency assignments are usually based on areas, not island-wide. UHF is more popular due to the reception antenna. There are currently 26 TV channels in Sri Lanka operated by 14 broadcasters including two government-owned entities – Sri Lanka Broadcasting Corporation and Independent Television Network Ltd. These channels are in VHF and UHF bands.

There are currently 36 FM channels in the FM band. These are operated by 16 radio broadcasters. All except one FM channel are island-wide; one frequency is assigned to each FM station. TRCSL needs to evaluate the feasibility of coexistence between DAB in Channel 6 and high-power analogue broadcast stations in Channel 5 and 7.

Spectrum Band	Frequency Range	Utilisation
VHF Band II	87 – 108 MHz	43 FM radio stations, all nationwide and 10 regional stations FM channel spacing is 200kHz
VHF Band I	47 – 68 MHz	26 TV channels operated by 18 broadcasters. VHF bands are based on 7MHz channelling plan and UHF band is based on 8MHz
VHF Band III	174 – 230 MHz	
UHF Band	470 – 806 MHz	

Table 9: Current Broadcasting Spectrum Allocation

Future Outlook

TV Broadcasting: TRCSL will work closely with the Ministry of Mass Media to facilitate the implementation of digital TV implementation. This will include the allocation of frequencies for existing digital broadcasting and potentially for new services.

Audio Broadcasting: There is spectrum available in the VHF Band III for the introduction of digital audio broadcasting services. TRCSL will explore the possibility of deploying DAB+ system within the territory of Sri Lanka.

5 Fixed Services

Fixed services operate in various radio spectrum bands from very high frequency (VHF) and ultra-high frequency (UHF) to extremely high frequency (EHF). The VHF and UHF bands are typically used for narrowband applications; for point-to-point links between land mobile base stations or point-to-multipoint in the case of wireless local loop. Fixed point-to-point links are used for backbone connections for telecommunications network as well as for commercial and industrial operations (e.g., for oil & gas or mining companies in areas where fixed line network is not available). Fixed services also cater to the needs of government agencies (Defence and public safety agencies), telecommunications providers and broadcasters.

Fixed point-to-point links are in demand including for corporate data connectivity and backhaul for telecommunications networks. Whilst the development of fibre network will substitute some microwave links and provide higher capacity (e.g., 1GHz and above) and higher reliability. However, fibre can be expensive, may not always be available, and takes longer to deploy. For these reasons, wireless backhaul will remain crucial to support 5G deployment. Mobile operators in Sri Lanka are keen to deploy more microwave links for mobile backhaul and this will become crucial particularly for 5G small cells deployed for high traffic areas. Forecasts from GSMA[25] and Ericsson[26] point to microwave and mmWave links accounting for about 60 percent of mobile backhaul over the next five to seven years.

However, existing frequency pricing and licensing approach in Sri Lanka can hinder the use of wireless backhaul. The current licensing framework requires each link to be licensed individually. Frequency charges are calculated and applied accordingly for each link and the current fee structure. It is required to study whether current fee structure is prohibitive for operators to deploy a large number of high bandwidth links for their mobile backhaul requirements.

Fixed point-to-multipoint services are offered by companies (eg. Data operators) but this is through 5GHz spectrum which is shared with other systems such as RLAN. There is demand for these services as an alternative to fibre/copper-based services. The wireless option can also be faster to deploy and

[25] Spectrum for Wireless Backhaul, GSMA, February 2021. Retrieved from: https://www.gsma.com/spectrum/wp-content/uploads/2021/02/wireless-backhaul-spectrum-positions.pdf
[26] Get your 5G going with microwave backhaul, Ericsson, November 2020. Retrieved from: https://www.ericsson.com/en/blog/2020/11/get-your-5g-going-with-microwave-backhaul

more affordable in some cases. However, the increase use of the unlicensed spectrum for different applications and services will result in service degradation and create demand for more spectrum.

Fixed wireless access (FWA) is offered by companies to deliver wireless broadband Internet access. These services operate mainly in 2.3GHz and 2.6GHz bands. As highlighted in the Mobile Broadband Services section, these services are increasingly being offered through mobile networks, which is part of the broader service convergence trend globally. The expansion of fibre access can also replace some of the demand for households that require high speed access with high data allowances.

There are different types of licensing framework for point-to-point links and it is required to consider a different approach depending on the bands and requirements. The types of licensing include:

Link-by-link licensing: This is the current TRCSL arrangement which is suitable for preserving long haul microwave links especially for frequency bands below 12GHz. However, It is required to make the assignment criteria public for transparency and help operators (existing and new) with their planning.

Exclusive license: This provides exclusive rights to a particular frequency pair typically for licensees that require the deployment of links in multiple locations (e.g., for mobile backhaul).

Light licensing: This is non-exclusive licences that are provided through simple registration typically through an online system. This can be applied in higher frequency bands (e.g., V-band and E-band) where the reuse factor is high, and the links are highly directional (i.e., lower possibility of interference).

It is required to review the spectrum fee structure for microwave and mmWave frequencies. This will encourage operators to deploy these technologies to achieve faster deployment of 5G and lower their backhaul costs.

Current Utilisation

Fixed services are typically deployed by organisations for the following functions:

Point-to-Point Fixed Links: TRCSL assigns microwave links in frequency bands ranging from 4GHz to 23GHz. Frequencies are assigned based on hop length to reserve the lower bands for longer microwave links. TRCSL current licenses each link individually and the channelling plans are based on the relevant ITU-R recommendations.

Point-to-Multipoint: Operators currently use 5GHz unlicensed spectrum for providing Internet services.

Fixed Wireless Access: The 2.3GHz and 2.6GHz bands are currently allocated for FWA. Operators have been awarded spectrum in these bands for their FWA services using TDD-LTE technology.

Future Outlook

Licensing and Assignment: TRCSL will review the current licensing framework for fixed services as well as the spectrum pricing. The review will take into consideration the need for greater transparency in terms of frequency assignment, the requirements for mobile backhaul, and the need faster access to spectrum.

2300MHz and 2600MHz: In light of the convergence of services, TRCSL will review the feasibility of allowing these bands to be used for both FWA and mobile services. This will give operators greater flexibility to manage their spectrum based on their business models and maximise spectrum utilisation.

E-Band: TRCSL has considered opening up higher bands in the 80GHz (76 - 84GHz) and allocated the spectrum band for testing. TRCSL will consult the industry to estimate the level of interest in using this band, and develop the licensing framework to make this band available.

6 Land Mobile

ITU Radio Regulations define land mobile service as a mobile service between base stations and land mobile stations, or between land mobile stations. Organisations deploy land mobile systems for different operation needs including push-to-talk voice communications, telemetry and narrowband data. Land mobile system is crucial for organisations in different industries construction, logistics, manufacturing, energy/mining, tourism, and public safety. A land mobile network can consist of base stations, repeaters and portable units. A basic set up can be a short-range radio between two walkie talkie units.

Many companies including construction firms, warehouses, and security firms use private mobile radios (PMR) within localised environment. Whilst PMR is still in use, they are gradually replaced by mobile services including GSM, SIM-based systems. There are also public trunked radio services offered by an operator serving multiple customers across different industries such as transportation (e.g., ports and airports), industrial (manufacturing plans), utilities, and resources (e.g., mining, oil & gas).

Land mobile plays a critical part in public safety and emergency services. This includes law enforcement, fire departments, ambulance services, and other emergency and rescue services. Agencies involved in public safety require radio networks that are secure, reliable and support closed group communications. Besides trunked radio, public safety operations require mobile broadband systems to improve their effectiveness in the field. For example, live video streaming between the ground operations and the central command centre provides situational awareness and helps to improve decision making and more efficient deployment of resources.

Public protection and disaster relief (PPDR) systems and applications will continue to modernise to leverage digital technologies (e.g., AR/VR and drone) to improve real-time decision-making. There is also an emphasis on the harmonisation of spectrum for PPDR globally to enable economies of scale and lower costs for PPDR systems; as well as interoperability for cross-border operations in emergency situations. At WRC-2015, the band 694 – 894 MHz was identified to facilitate mobile broadband communications for mission critical emergency services in PPDR, such as police, fire, ambulances and disaster response teams. Whilst some countries have allocated spectrum dedicated to public safety (e.g., FirstNet in the US), it is also possible to implement a public safety network through a mobile operator (e.g., Telstra LANES in Australia).

Current Utilisation

There are currently about 400 private mobile radio (PMR) licensees including construction and security firms. The channel spacing has been reduced from 25kHz to 12.5kHz, and the assignments are mostly island-wide. Three are three main categories – Western Province, Outside Western Province (mostly factories) and Island-wide (e.g., construction and security). The main requirement for PMR frequency application is to have at least ten handsets for each frequency.

For trunked radios, one operator is currently the only operator in Sri Lanka and the company offers its services to companies with vehicle fleets as well as factories. Some other public & private entities also operate trunked radio systems for their internal, operational use.

In terms of public protection and disaster relief (PPDR) requirements, Sri Lanka Police started planning for a new system for crime and emergency services two years ago. The planned system is based on LTE technology, operating in the UHF band. Existing users in the band have already been compensated and vacated. The deployment has not started but is expected to commence soon. There was also a railway project that had considered the implementation of GSM-R but there has been no further progress. There has not been request to open up new land mobile spectrum bands at this stage.

Future Outlook

PPDR and other Government: TRCSL intend to assess the demand for PPDR and other government-related land mobile requirements (e.g., transportation) through regular dialogue. The longer-term planning of the 700MHz will also include the consideration of public safety requirements.

7 Other Services

Satellite Services

Satellite remains a vital means of communications particularly in hard-to-reach places. For example, maritime, mining, oil and gas exploration industries rely heavily on satellite communications. In addition, satellite is also widely used for broadcasting content over a large geographical area; supporting direct-to-home (DTH) TV services. Moreover, satellite technology has made significant progress and there are now higher-speed broadband services being offered at more competitive pricing. Satellite is more effective in delivering services to rural and remote areas where fibre and even mobile access can be uneconomical to provision. The national broadband network (NBN) in Australia uses satellite to provide broadband services to community where it is not feasible to deploy fibre or FWA. Kacific satellite has been able to provide better broadband connectivity to island nations in the Pacific region.

A new breed of satellite services is also emerging, offered by low Earth orbit (LEO) satellite operators such as Starlink, OneWeb and Telesat. These operators have either launched or plan to launch a large number of satellites to achieve higher capacity and global coverage. For example, as of late May 2023, Starlink had already launch more than 3,580 satellites. The service is commercially available in some markets and will become available globally in the not-too-distant future. It offers speeds ranging from 50Mbps to 150Mbps and latency from 20ms to 40ms, which is comparable to some high speed fixed and mobile broadband services. Whilst it is still early days, these services can bring high quality broadband services to rural community and it is an area which could benefit Sri Lanka in the long run, as the services become more widely adopted and the pricing becomes more affordable.

Aeronautical Services

Civil and military aviation are key users of spectrum and the radio systems on board aircraft as well as for air-traffic control are generally harmonised globally through international bodies such as the ITU and the International Civil Aviation Organization (ICAO, also a specialised agency of the United Nations). ICAO has been developing standards for aeronautical radio communication, navigation and surveillance systems and equipment, installed on aircraft or on the ground. In this regard, ICAO is actively involved in the ITU processes to secure the radio-frequency spectrum required for aviation purposes. TRCSL works with the relevant authorities of Sri Lanka to jointly ensure that the aviation industry have access to spectrum that is globally harmonised through ITU and ICAO.

The international community is considering, under WRC-23 agenda 1.7, a new aeronautical mobile-satellite (R) service allocation in the 117.975 – 137 MHz band to enhance the efficiency and capacity of aircraft operations. Under agenda item 1.9, studies are being conducted to allow the implementation of digital technologies for commercial aviation safety-of-life applications in existing HF bands allocated to aeronautical mobile (route) service. Finally, under agenda item 1.10, new allocations for the aeronautical mobile service for non-safety aeronautical mobile applications are being considered.

Maritime Services

The maritime mobile services are used by vessels operating in international waters, coastal areas and inland waterways. Maritime systems are also used in onshore facilities for ensuring safety and security purposes. To ensure safety of life as vessels move across international waters, the maritime systems and frequency requirements are also coordinated internationally through the ITU and the International Maritime Organisation (IMO). For example, the Global Maritime Distress and Safety System (GMDSS) and emergency position indicating radio beacons (EPIRBs) are globally harmonised systems. Similarly, TRCSL works with relevant Authorities to ensure that the maritime industry has access to spectrum that is globally harmonised through ITU and IMO.

WRC-23 will also deliberate on issues pertaining to maritime services. Agenda item 1.11 considers the possible regulatory actions to support the modernisation of the Global Maritime Distress and Safety System (GMDSS) and the implementation of e-navigation.

Future Outlook

WRC-23: There are various issues related to satellite, aeronautical and maritime services being considered at WRC-23. TRCSL will be monitoring the development of relevant studies being conducted by various ITU Study Groups. TRCSL will consult relevant stakeholders to form its national positions in a timely manner.

8 Unlicensed Bands for Short-Range Devices

Short range devices (SRDs) are low power devices that have low capability of causing interference to other radio equipment. SRDs are not considered a radio service under the ITU Radio Regulations. The use of SRDs are typically exempted from licensing but the devices need to meet the standards stipulated by the regulators. Only equipment that meets the standards are permitted to be imported through a type approval process. SRDs are used in many areas including remote control, RFID, Bluetooth devices, wireless microphones, health monitoring devices, wireless LAN, and more.
Today, wireless LAN is perhaps one of the most widely used application in the unlicensed band. The technology continues to enhance through the development of IEEE 802.11 technical standards. The IEEE 802.11ax version which was approved in February 2021 supports over 1Gbps and also enables high-density scenarios such as corporate offices, shopping malls and dense apartments – i.e., providing high-speed connectivity to many devices connected to the network. This version is more commonly referred to as Wi-Fi 6 and it supports license-exempt bands between 1 and 7.125GHz band. As the 2.4GHz and 5GHz are becoming congested, the additional spectrum in 6GHz will provide much needed bandwidth and offer better performance. The standard will continue to evolve and for example, 802.11ay will operate in the 60GHz mmWave spectrum to boost the transmission rate to multiple Gbps.

Current Frequency Bands Designated for SRDs

TRCSL has made available bands across the spectrum for various types of SRDs. The approach is to provide rules around each type of SRD including the frequencies and power allowed, as well as the standards to be referenced for type approval (see TRCSL’s Radio and Telecommunications Terminal Equipment [RTTE] Type Approval Rules 2020).

Applications	Frequency Band	Allowed Power	Radio Interface Standards
Wideband Data Transmission (Wireless LAN i.e., Wi-Fi)	2400 - 2483.5 MHz	200 mW	EN 300 328
	5150-5350 MHz	200 mW	EN 300 328
	5470 – 5725 MHz	1000 mW	EN 301 893
	5725 – 5875 MHz	1000 mW	EN 301 893
Bluetooth Equipment	2400 - 2483.5 MHz	100 mW	EN 300 328 EN 300 440
Inductive Applications	9 – 59.75 kHz	72 dBμA/m@10m	EN300 330-2
	60.250 – 70.000 kHz	69 dBμA/m@10m	
	70 – 119 kHz	42 dBμA/m@10m	
	119 – 135 kHz	66 dBμA/m@10m	
	135 – 140 kHz	42 dBμA/m@10m	
	140 – 148.5 kHz	37.7dBμA/m@10m	
	315 – 340 MHz	37.7dBμA/m@10m	
	6765 – 6795 kHz	42 dBμA/m@10m	
	7400 – 8800 kHz	9 dBμA/m@10m	
	13.553 – 13.567 MHz	42 dBμA/m@10m	EN 302 291-2
	26.957 – 27.283 MHz	42 dBμA/m@10m	EN 300 330-2
Wireless Microphone	29.7 - 47.0 MHz	10 mW	EN 300 422
	173.7 -175.1 MHz		EN 300 422

Applications	Frequency Band	Allowed Power	Radio Interface Standards
	863 - 865 MHz		EN 300 422 EN 301 357
Hearing Audio Assistance Aids	169.40 – 175.00 MHz	500 mW	EN 300 220-1
	180 – 200 MHz	112dBµV/m @10m	
	230-234.75MHz		
	487 – 507 MHz		
Alarms	169.475-169.4875MHz	10 mW	EN 300 220-2
	169.587-169.600MHz		
	869.30 -869.40 MHz		
	868.600-868.70 MHz		
Active Medical Implant Devices	9 – 315kHz	30dBµA/m @10m	EN 302 195
	30– 37.5 MHz	1 mW	EN 302 510
	401 – 402 MHz	25 µW	EN 302 537
	402 – 405 MHz		EN 302 839
	405 – 406 MHz EN		EN 302 537
Radio Frequency Identification (RFID) Equipment	125 kHz	1000mW	EN 300 330 EN 302 291
	13.553-13.567 MHz	60 dBµA/m @10m	
	2446-2454 MHz	500mW	EN 300 440
	865.0-865.6 MHz	100mW	EN 302 208
	865.6-867.6 MHz	2000mW	
	867.6-869.0 MHz	1000mW	
Radio Determination (Detection of Movement Equipment) Systems	2400 – 2483.5 MHz	25 mW	EN 300 440-2
	9200 – 9500 MHz		
	9500 - 9975 MHz		
	10.5 – 10.6 GHz	500 mW	
	13.4 – 14.0 GHz	25 mW	
	24.05 – 24.25 GHz	100 mW	
Animals Implantable Devices	315-600 kHz	-5dBµA/m @ 10m	EN 302 536-2
	12.5-20.0 MHz	-7dBµA/m @10m	EN 300 330-2
Car Smart Key Systems	433 MHz – 435 MHz	10 mW	EN 300 220
Car Immobilizers and Alarm Systems	9 kHz – 148.5 kHz	72dBµA/m @ 10m	EN 302 291 EN 300 330
	3155 kHz – 400 kHz	13.5dBµA/m@10m	
	6765 – 6795 kHz	42dBµA/m @10 m	
	7400 – 8800 kHz	9dBµA/m @ 10 m	
	13.553 – 13.567 MHz	60dBµA/m@ 10 m	
	26.957 – 27.283 MHz	42dBµA/m @10 m	
	433MHz – 435MHz	10 mW	EN 300 220
Road Transport and Traffic Telematics	5795 – 5805 MHz	2000 mW	EN 300 674-2
	5805 – 5815 MHz	2000 mW	
	24050 – 24250 MHz	100 mW	EN 302 288-2
Remote Controls of Aircraft and Glider Models	26.96 – 27.28 MHz	500 mW	EN 300 220-1
	29.70 – 30.00 MHz		
Zigbee Equipment	902- 928 MHz	100 mW	EN 300 220-2

Applications	Frequency Band	Allowed Power	Radio Interface Standards
	2400 -2483.5 MHz		EN 300 328
Ultra Wide Band (UWB) Technology Applications	1600 - 2700 MHz	-85dBm/MHz	EN 302 066-2
	2700 - 3400MHz	-70dBm/MHz	EN 302 066-2 EN 302 065
	3400 -4800 MHz	-70dBm/MHz	
	4800 - 6000 MHz	-70dBm/MHz	EN 302 066-2
	6000 - 8500 MHz	-41.3dBm/MHz	EN 302 065 EN 302 066-2 EN 302 500-2
	8500– 10600 MHz	-65dBm/MHz	
	Above 10600 MHz	-85dBm/MHz	
Short Range Radar	10500 -10600 MHz	500 mW	EN 300 440-2
	24050– 24250 MHz	100 mW	EN 300 440-2 EN 302 288-2
	57000 – 64000 MHz	-41.3dBm/MHz	EN 302 372-2
	75000 – 85000 MHz		
Non-Specific SRDs	6765 – 6795 kHz	42dBμA/m@10m	EN 300 330-2
	13.535 – 13,567 MHz	42dBμA/m@10m	EN 300 330-2
	26.957 - 27.283 MHz	42dBμA/m@10m	EN 300 330-2
	40.660 - 40.700 MHz	10 mW	EN 300 220-2
	434.040 -434.790 MHz	10 mW	EN 300 220-2
	863.000 -870.000 MHz	25mW	EN 300 220-2
	869.400 -869.650 MHz	500mW	EN 300 220-2
	2400 - 2483.5 MHz	10 mW	EN 300 440-2
	5725 - 5875 MHz	25mW	EN 300 440-2
	24000 - 25000 MHz	100mW	EN 300 440-2

Table 10: Frequency Bands for SRDs

Future Outlook

5925 – 7125 MHz: Some countries have made available either the entire band or part of the band for wireless LAN (e.g., 802.11ax or Wi-Fi 6) and more equipment supporting this band will be brought to market. However, part of the band is currently under consideration for IMT through the WRC-23 process. TRCSL will perform a technical evaluation to assess any potential interference to existing services if wireless LAN equipment operates in this band.

9 Spectrum Outlook and Work Plan

The Spectrum Outlook table provides an indication of TRCSL's plan over the next five years. The table also provides an indication of the demand and difficulty to change the allocation.

	Demand	Difficulty
High	Multiple parties asking for the spectrum; expressing urgency in using the spectrum	Many existing users; technical studies need to be conducted; or potential legal issues need to be considered

Medium	One or two parties enquiring the availability of spectrum, but the need is not immediate	Some existing users, simple technical analysis required
Low	Future demand based on industry feedback and/or international trends	Very few users and system migration is straightforward

Timeline	The timeline in the table below refers to the timeframe anticipated for each work item to be completed.

Table 11: Level of Demand for Spectrum, Difficulty and Timeline

Spectrum Outlook Table

Work Item	Plan	Demand	Difficulty	Timeline
700 MHz	To inform the Media Ministry to implement the Analogue switch off (ASO) by 2027, after establishing island wide Digital Broadcasting Network	High	High	Beyond 2028
Implementation of Spectrum contiguity in all IMT bands	TRCSL will facilitate the rearrangement of these bands to enable contiguous spectrum for mobile operators.	High	Medium	2024 – 2025
3500 MHz (3400 – 3600 MHz)	Allocation of the band for mobile services, to support 5G implementation.	Medium	Medium	2024 – 2025
3300 MHz (3300 – 3400 MHz)	To conduct a feasibility study and a compatibility analysis/ refarm this band for allocation of the spectrum for mobile services.	Medium	High	2026 – 2027
3700 MHz Band (3600 – 3800 MHz)	To conduct a feasibility study and a compatibility analysis/ refarm this band for allocation of the spectrum for mobile services.	Medium	High	2025 – 2026
26/28 GHz (mmWave)	To conduct a feasibility study and allocate the bands for mobile services, particularly for 5G technology	Low	Low	2024 – 2026
Technology/Service Neutrality	To conduct a feasibility study and ensure proper regulatory safeguards to enable technology and service neutrality for spectrum allocated for commercial services.	High	Medium	2024 – 2027
Converged Licensing	To allow the convergence of mobile and FWA so that operators can offer both services with a single licence,	High	Medium	2026 - 2027

Work Item	Plan	Demand	Difficulty	Timeline
	one network and with the same spectrum.			
Infrastructure and Spectrum Sharing	TRCSL will facilitate the sharing of infrastructure and spectrum amongst operators.	Medium	Medium	2024 – 2025
Unlicensed Band (e.g., 5 GHz) for Mobile Services	TRCSL will evaluate the feasibility of allowing unlicensed bands for mobile services on a non-interference and non-protected basis	Medium	Medium	2026 – 2027
7025 – 7125 MHz	TRCSL will evaluate the impact on existing services and formulate the national plan for deployment of IMT as per WRC23 outcome	Low	Medium	Beyond 2025
Digital TV Broadcasting	Facilitate the transition of TV terrestrial broadcasting from analogue to digital by developing the transition spectrum plan.	High	Medium	2024 – 2027
Digital Audio Broadcasting	To conduct a feasibility study and deploy Digital Audio Broadcasting Network.	Low	Low	2024 – 2025
Fixed Services Licensing and Assignment Review	TRCSL will review the current licensing framework for fixed services as well as the spectrum pricing to encourage use off microwave frequencies	Medium	Medium	2025 - 2027
E-Band (76 – 84 GHz)	Allocation of the band for fixed services, through a light licensing framework.	Medium	Low	2027 – 2029
5925 – 7125 MHz	To conduct feasibility study and as per WRC 23 outcome, allow radio LAN (RLAN) to operate in part or the entire band in compliance with WRC 23	Medium	High	2024 – 2025

Table 12: Spectrum Roadmap

10 Conclusions

Innovation continues to bring about new technologies, business models and methods to enhance spectrum management. Spectrum management practices need to keep up with times to deliver the best outcomes for the telecommunications industry, as well as for the overall society and economy. With rapid changes in technology and customer demand, it is imperative that regulators has a framework and a systematic approach to plan and manage radio frequency spectrum resources. This is the main objective of this spectrum master plan document.

10.1 Spectrum Master Plan & Roadmap

It is required to provide transparency in spectrum management and visibility into spectrum availability. This Spectrum Master Plan document lays the foundation in developing the spectrum strategy and allocation roadmap. Section 3 to 8 highlight key trends in various radio services and capture potential demand for spectrum. TRCSL intends to review this document every three years to incorporate international trends and check its relevancy based on input of the stakeholders as well.