Consultative Document

on the

Spectrum Management Framework

(2nd Round of Two Rounds)

(Version 1.3)

July 2022

TATT Ref: 2/1/1/1/6

Maintenance History		
Date	**Change Details**	**Version**
31st March 2005	First draft	0.1
1st June 2005	Includes comments from McCarthy Tétrault	0.2
14th June 2005	First consultative document for the first round of public consultation	0.3
27th September 2005	First consultative document for the second round of public consultation	0.4
21st November 2005	Approved version	1.0
25th May 2021	Revised version – plan updated based on changes in the industry, to allow for the introduction of new spectrum management policies for public telecommunications services.	1.1
11th October 2021	Revised consultative document published for the first round of two rounds of public consultation	1.2
1st July 2022	Revised consultative document published for the second round of two rounds of public consultation	1.3

This document may be cited as: Telecommunications Authority of Trinidad and Tobago (TATT 2022). *Spectrum Management Framework* (June 2022). Barataria, Trinidad and Tobago.

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Abbreviations

ACMA	Australian Communications and Media Authority
BWA	broadband wireless access
DTT	digital terrestrial television
GHz	gigahertz
IMT	International Mobile Telecommunications
ITU	International Telecommunication Union
kHz	kilohertz
MHz	megahertz
NSP	National Spectrum Plan
TATT	Telecommunications Authority of Trinidad and Tobago

1 Introduction

1.1 Background

The *National Development Strategy (NDS) 2016–2030,* also known as Vision 2030, outlines the country's aspiration to attain first world nation status by 2030. As the country's principal strategic planning document, it defines the priorities and overarching thrust of government policy, which is focused on achieving sustainable economic growth. To realise Vision 2030, the Government of the Republic of Trinidad and Tobago (GORTT) has implemented a series of initiatives that, collectively, seek to further develop and transform the national economy, leading to the development of an information society and the attainment of developed country status.

One of the major initiatives undertaken was the drafting of a *National Information and Communications Technology Plan* (NICT) for the period 2018 to 2022, branded as the ICT Blueprint, in which several programmes aimed at the development of the information and communications technology (ICT) sector were identified.

The pertinent thematic area of the ICT Blueprint, "Improving Connectivity", focuses on advancing the deployment of ICT infrastructure to support securely connected people, businesses and government. The management of the radio frequency spectrum (spectrum) efficiently and effectively, consistent with the objects of the Telecommunications Act, Chap. 47:31 (the Act), supports this thematic area.

Under the Act, spectrum is defined as "the continuous range of electromagnetic wave frequencies used for telecommunications". The allocated radio spectrum, as defined in the International Telecommunication Union (ITU) Radio Regulations, covers the frequency range from 8.3 kHz to 3,000 GHz. The radio frequency spectrum (spectrum) is a scarce national resource that is essential to the provision of communications associated with a wide range of activities, including national defence; public safety; air, land and sea transportation; broadcasting; aviation; maritime; weather forecasts and commercial telecommunications services.

It is widely acknowledged that the availability of good telecommunications infrastructure and high quality, cost-effective telecommunications services are essential to the social and economic development of a country. It is therefore imperative that the radio spectrum resource is effectively managed, to optimise the delivery of telecommunications services in Trinidad and Tobago, and facilitate the achievement of the country's social and economic goals.

The ability of the spectrum management activities to facilitate the implementation of radio systems, based on international principles, is vital for maximising the spectrum resource. While

users of the spectrum have immediate needs, future uses must also be accommodated in planning. Therefore, a balance must be achieved between the current and possible future uses.

The *National Spectrum Plan* (NSP) lays out the schema for the spectrum to be regulated in an orderly and efficient manner, in accordance with the Authority's mandate. Figure 1, The National Spectrum Planning Structure, outlines the various services and systems[1], the spectrum plan pertinent to specific services and systems, and the application processing procedures for the respective services and systems, all under the umbrella of the *Trinidad and Tobago Frequency Allocation Table* (TTFAT).

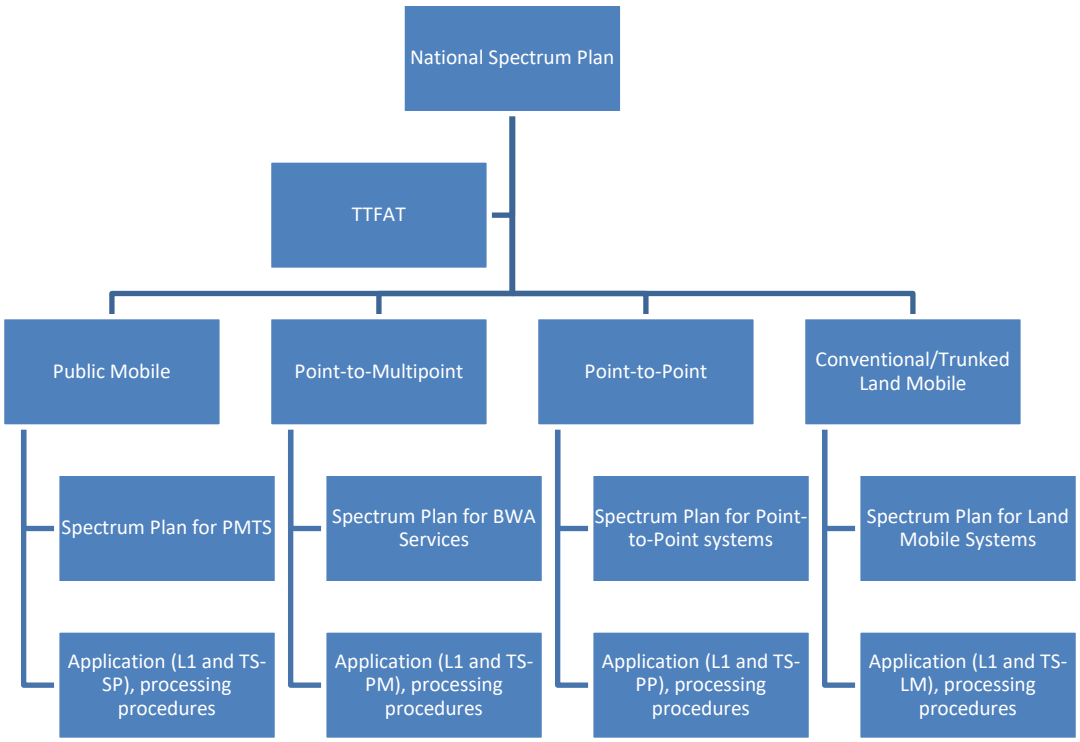

Figure 1: The national spectrum planning structure

1.2 Purpose

Given that the greater demand for spectrum requires its careful management to ensure its effective use without harmful interference, the *Spectrum Management Framework* (the Framework) will be the key regulatory instrument to guide the planning, authorisation and monitoring of the national spectrum resource.

[1] Systems – a collection of organised things used in the provision of a service

This Framework:

1. determines appropriate spectrum policies, rules and regulations for the management of the national spectrum resource.

2. provides the foundation for the NSP.

1.3 Objectives

The primary objectives of this Framework are to:

1. identify the evolving technologies that promote the efficient and effective use of the spectrum.

2. derive an effective mechanism for the management of the spectrum in an era of converged technologies and telecommunications services, so that a wide range of services can be made available to the public.

3. provide a responsive, effective and flexible approach to meeting the needs of users of the spectrum.

4. ensure there is adequate provision of spectrum for national security, law enforcement and emergency services.

5. promote the economic and orderly utilisation of the spectrum for the operation of all means of telecommunications.

6. allocate spectrum resources for the provision of telecommunications and broadcasting services in an effective and efficient manner.

7. recover the cost incurred in the management of the spectrum and increase the economic benefit to the country.

8. provide an efficient, equitable and transparent system for the establishment of the fee regime for the use of the spectrum, taking into account both the commercial and non-commercial use of the spectrum.

1.4 Relevant Legislation

The relevant sections of the Act which were taken into consideration in the drafting of this Framework are stated hereunder.

Section 18(1)(i):

Subject to the provisions of this Act, the Authority may exercise such functions and powers as are imposed on it by this Act and in particular –

(i) plan, supervise, regulate and manage the use of the radio frequency spectrum, including–

(i) the licensing and registration of radio frequencies and call signs to be used by all stations operating in Trinidad and Tobago or on any ship, aircraft, or other vessel or satellite registered in Trinidad and Tobago;

(ii) the allocation, assignment and reallocation or reassignment of frequency bands where necessary.

Section 36(1):

Subject to subsection (2), no person shall –

(a) establish, operate or use a radio-communication service;

(b) install, operate or use any radio transmitting equipment; or

(c) establish, operate or use any radio-communication service on board any ship, aircraft, or other vessel in the territorial waters or territorial airspace of Trinidad and Tobago, other than a ship of war or a military aircraft or satellite registered in Trinidad and Tobago without a licence granted by the Authority.

Section 41:

(1) The Authority shall regulate the use of the spectrum in order to promote the economic and orderly utilisation of frequencies for the operation of all means of telecommunications and to recover the cost incurred in the management of the spectrum.

(2) The Authority shall develop a spectrum plan in order to regulate the use of the spectrum.

(3) The National Spectrum Plan shall be made available to the public in the manner prescribed by the Authority.

(4) The National Spectrum Plan shall state how the spectrum shall be used and the procedures for licensing frequency bands.

(5) The procedures referred to in subsection (4) may include, but are not limited to -

(a) procedures for licensing frequency bands by auction;

(b) procedures for licensing frequency bands by tender;
(c) procedures for licensing frequency bands at a fixed price; or
(d) procedures for licensing frequency bands on stated criteria.

Section 42:

(1) Subject to subsection (2), the Authority may, in accordance with the spectrum plan allocate and re-allocate frequency bands.
(2) In the allocation or assignment and re-allocation or reassignment of frequency bands by the Authority priority shall be given to the needs of the State in respect of matters of national security.

Section 43:

The Authority, in exercising the functions under Sections 36 to 42, shall take into account -

a) the objects of the Act;
b) the impact of the spectrum plan on existing and future use;
c) the efficient use of the spectrum;
d) the Convention;
e) applicable international standards, conventions and other agreements; and
f) any other relevant matters having regard to the circumstances of the case.

1.5 Relevant Documents

This Framework is endorsed alongside other policies, plans and regulations prepared by the Authority, including the following:

1. *Authorisation Framework for the Telecommunications and Broadcasting Sectors of Trinidad and Tobago (TATT, 2005)*

2. *Radio Spectrum Regulations (TATT, 2005)*

3. *Trinidad and Tobago Frequency Allocation Table (TATT, 2019)*

4. *Price Regulation Framework for Telecommunications Services in Trinidad and Tobago (TATT, 2009)*

5. *Telecommunications (Fees) Methodology (TATT, 2017)*

1.6 Review Cycle

This Framework will be reviewed every three to five years to adapt to the evolving needs of the telecommunications industry and changing circumstances. When the need for modification is identified, the Authority will announce its intention to review the Framework and any interested party in the telecommunications sector or any appropriate industry forum may suggest changes to it. Questions or concerns regarding the maintenance of this Framework may be directed to the Authority via e-mail consultation@tatt.org.tt.

1.7 The Consultation Process

In accordance with its *Procedures for Consultation in the Telecommunications and Broadcasting Sectors of Trinidad and Tobago (ver. 7.0, 2021)* (Consultation Procedures), the Authority sought the views of the general public and other stakeholders regarding the proposals made in this Framework.

Versions 0.3 and 0.4 of the Framework were released for public consultation in June 2005 and September 2005, respectively. In revising the document, the comments and recommendations received during both rounds of consultation were considered. In November 2005, the Framework (version 1.0) was approved and published in the form of a recommended spectrum management policy to support spectrum management regulations, and submitted to the Authority's line Ministry at the time – the Ministry of Public Administration and Information.

In May 2021, the Framework was revised based on changes in the industry to introduce new spectrum policies. The revised consultative document (version 1.2) was made available for the first round of public consultation on 11th October 2021, for a period of six weeks.

2 Current Spectrum Management Regime in Trinidad and Tobago

Effective management of the spectrum plays a vital role in the provision of a broad variety of radiocommunications services and is closely associated with national law, policy statements, radio regulations and long-term spectrum planning.

Following the proclamation of the Act, the procedural framework adopted for spectrum management in Trinidad and Tobago was generally in conformity with the Table of Frequency Allocations in Article 5 of the ITU Radio Regulations and, except in certain cases, specifically in accordance with the allocations for Region 2.

2.1 Spectrum Planning

The Authority has developed the NSP as the instrument for regulating the use of the spectrum and ensuring its efficient use in an orderly manner. The NSP serves as an umbrella document for the various spectrum plans, starting with TTFAT that governs the use of the radio spectrum for specific radio services and/or public telecommunications networks and services based on established spectrum management policies[2].

Trinidad and Tobago is classified by ITU under Region 2, which covers the Americas and some of the eastern Pacific Islands. From the Table of Frequency Allocations in Article 5 of the ITU Radio Regulation, the Authority decides for each frequency band which service(s) to adopt based on national requirements and priority.

The spectrum planning process in Trinidad and Tobago, figure 2, is informed by inputs from the ITU Radio Regulations, Region 2 Administrations, Stakeholders and National Policies.

[2] https://tatt.org.tt/AboutTATT/SpectrumManagement/SpectrumPlanning.aspx

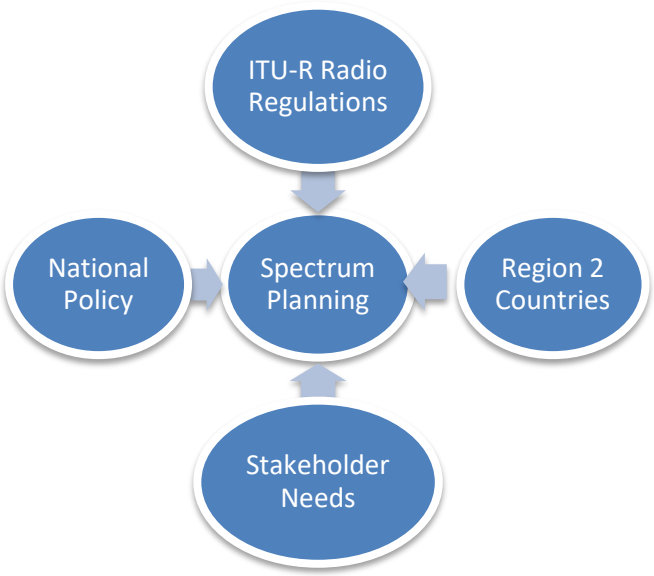

Figure 2: Spectrum planning process in Trinidad and Tobago

Other spectrum plans developed by the Authority to regulate specific radiocommunications services include:

1. *Spectrum Plan for the Accommodation of Point-to-Point Radiocommunications*
2. *Systems Spectrum Plan for the Accommodation of Land Mobile Radiocommunications Systems*
3. *Spectrum Plan for the Accommodation of Broadband Wireless Access Services (BWA)*
4. *Spectrum Plan for the Accommodation of Public Mobile Telecommunications Services (PMTS)*
5. *Spectrum Plan for the Accommodation of Radio and Television Broadcast Auxiliary Services*

For the purpose of assignment, the spectrum bands are further divided into a number of channels to develop the channelling plans. Once the necessary border coordination has been successfully carried out, the frequencies or channels are then assigned to eligible users.

2.2 Spectrum Authorisation

The spectrum assigned to wireless apparatus[3] for the provision of telecommunications and broadcasting services is based generally on the Region 2 allocations, on a "first come, first served" (FCFS) basis.

Since 2004, spectrum authorisation or licensing in Trinidad and Tobago has been traditionally classified according to the following: individual licences and class licences, in accordance with the *Authorisation Framework for the Telecommunications and Broadcasting Sectors of Trinidad and Tobago, 2005*.

2.2.1 Individual Licences

The individual licence assigns a right to the use of the spectrum, via an administrative process (comparative selection) or market mechanisms (auction).

Individual licences are generally customised and detailed, and require that telecommunications and/or broadcasting services be provided in a particular manner by a particular service provider. Individual licences granted by the Authority are station licences and spectrum licences.

A station licence is issued for a particular transmitter for a particular use, typically at a particular location. The licence gives "first in time, first in right" to the holder of the licence against any other entity in relation to any disputes over interference. Station licences are normally acquired "over the counter" and tend to be short term in nature, typically between three and five years. An administrative pricing arrangement usually applies, often in the form of annual fees plus an up-front application fee. Station licences do not confer exclusivity, so they have little intrinsic value (except in providing a right to operate a particular transmitter).

A spectrum licence was created to allow licensees, or in some cases, persons authorised by a licensee, to operate radiocommunications devices within a specified frequency band (and/or time and/or geographic area, as required). There is flexibility with respect to changing equipment, such as antennas. This type of licence is technology neutral, but is subject to compliance with certain technical limits in order to avoid harmful interference. Spectrum licences give the holder of the licence the exclusive right to use and manage the assigned frequency in a pre-determined geographic area – typically for mobile networks. These licences are long term in duration, i.e., 10 to 20 years. They typically correspond with the term of the concession for the operation of the fixed or mobile network for which the licence is issued.

[3] "Wireless apparatus" means any apparatus, appliance or instrument used, or capable of use, in wireless communications.

2.2.2 Class Licences

Class licences allow specific radiocommunications devices to operate in designated spectrum band(s) on a shared basis, subject to specific terms and conditions, and specific technical operating parameters. This type of licensing applies to low-power, mass consumer market devices, such as cordless telephones, cellular mobile handsets and citizens band two-way radios, which do not need to be individually coordinated to minimise the potential for harmful interference to other systems and services.

In some jurisdictions, class-licensed frequency bands may also be referred to as "unlicensed" bands or open authorisation, which is effectively exemption from the need for an individual licence, or "right of use". There is an increasing trend towards global allocations of the spectrum for such systems (e.g., 2.4 GHz and 5 GHz).

Interference is a common problem for class-licensed devices, although many technologies employ digital signal processing which enables coexistence without interference.

In keeping with the Class Licensing Regime, section 3.4, the Authority currently maintains a Register of Category 2 and Category 3 Class Licensed Devices in Trinidad and Tobago. The user of a class licensed radiocommunications device shall adhere to the terms and conditions of the class licence and the technical operating parameters specified for that device in the *Schedule of Devices Eligible for Use Under a Class Licence*.

2.3 Mechanisms for Granting Licences

Different spectrum licensing mechanisms are necessary for dealing with the distinct needs of individual radio users. The following mechanisms are used globally for authorising telecommunications services, networks and resources on the national and international levels:

1. First come, first served (FCFS)
2. Comparative valuation or "beauty contest"
3. Lotteries
4. Auctions
5. Hybrid

2.3.1 First Come, First Served (FCFS)

The first come, first served (FCFS) mechanism is a process by which the first request that is received is served. Spectrum is assigned in the order the applications are received; on the basis of the availability of the frequency; on the appropriate spectrum management functions being completed; and if the applicant meets the application criteria.

The FCFS method is appropriate when there is no shortage of spectrum and it has to be assigned to a potentially large number of users or over a long period. This is most commonly used with national budget financing or spectrum usage fees and is likely to remain the most effective for the foreseeable future, although it may be linked (with or without cost recovery) to methods for regulating demand (e.g., administrative pricing).

Advantages of FCFS:

1. Simple and least burdensome of all methods
2. Fast, practical and inexpensive
3. Little subjectivity is involved, so the opportunity for favouritism is minimised.

Disadvantages of FCFS:

1. Successful applicants may not be the entities that would most value economically the authorisation.
2. Not appropriate for competitive or economically desirable markets

2.3.2 Comparative Evaluations or Beauty Contests

The comparative evaluation or "beauty contest" method of authorisation involves an assessment of competitive applicants, based on predetermined criteria and public objectives. Each criterion is weighted, and the weightings are made known to the applicants prior to selection. Applicants are selected based on their rank after evaluation.

Competing applicants' proposals would typically include information on population coverage, quality of service, speed of implementation, and the operator's business plan. For broadcasting, there would be information on programmes, such as the number of hours of children's programmes, educational programming and news services. Proposals are usually prepared in response to the criteria established and published by the regulatory authority.

The review of the proposals can be time consuming and resource intensive, and the decision-making process may not be transparent. The review might be subjective and, unless the reasons for the rejection of the losing applicants are clear and conform to the published criteria, those applicants may apply for a judicial review. Any legal challenge can have a significant impact on the general timescales for starting the service and may require a repeat of the whole tendering process.

This method of authorisation is suitable when there are a small number of applicants for a limited number of licences.

Advantages of a Beauty Contest:

1. Ensures that the successful applicant will make the best use of the opportunity – socially, financially and technically

2. Keeps spectrum costs low compared to an auction, ensuring lower service prices for consumers

3. Enables policymakers to utilise specific requirements in the evaluation process to achieve social goals

Disadvantages of a Beauty Contest:

1. It can be a slow and costly process if a proper mechanism is not put in place to deal with complex applications and the effort involved in objectively evaluating applications

2. Subjective and may give rise to problems of transparency. The regulator's capacity to identify the best proposal is limited; it is difficult to justify the selection of best proposals; and there is the possibility of political or other interferences.

3. Successful applicants may not be able to fulfil the proposals made in applications.

4. It does not provide a clear way of choosing between two applicants who are equal in quality.

5. Applicants may propose systems that appear appealing or innovative but may not be well suited to the marketplace, resulting in higher prices for consumers.

2.3.3 Lotteries

This method of authorisation involves a very large number of applicants and is based on selecting the winners at random from the competing applicants. In its simplest form, a lottery is quick and transparent but the spectrum may be assigned to someone who does not value it.

As there is no subjective decision required in the assignment of the spectrum and no need to review the applicants, there is little possibility of a legal challenge to the decision.

Regulators may decide to impose a fee for entry to the lottery, and possibly other entry criteria, to ensure the winning applicant is capable of providing the service. These additional constraints may restrict the number of applicants and may also recover some of the value of the spectrum. The mechanism of lotteries has not been used much by regulators.

Advantages of a Lottery:

1. Fast, inexpensive and transparent

2. Fair for selecting among applicants of substantially equal standing

Disadvantage of a Lottery:

1. Will not guarantee that the best service provider is awarded the licence/concession. The regulator can minimise this risk by using a pre-qualification process. However, this adds to the time, complexity and cost of the process, thereby negating the principal advantages of the lottery.

2.3.4 Auctions

Auctions are an authorisation method where, at the end, the applicants determine the amount of money to be paid. In this way, the eventual price of the spectrum is determined by market forces and the frequencies are assigned to the winning bidder.

Allocation of spectrum through auction leads to efficiency, as the spectrum is sold to those who value it the most. It can be an open or closed single-round auction or a multi-round auction that can be held consecutively or simultaneously.

In most cases, the regulatory authority will set criteria for applicants to enter the auction. These criteria may be similar to the types of entry conditions set in comparative bidding or lotteries.

Selection is then made from a list of qualified applicants, based on their willingness and capability to pay for the spectrum resource.

The main advantages of an auction, which explain the widespread adoption of this method, are as follows:

1. Provides an efficient, transparent and objective means of awarding spectrum licences to bidders who most value the resource

2. Can be conducted quickly and efficiently in the assignment of the spectrum compared to traditional tender procedures or comparative bidding

3. Can accommodate large numbers of applicants and can be considered an objective and transparent licensing procedure

4. Provides information on the economic value of the spectrum resource.

5. Excess revenues generated can be used by the government to fulfil universal and other social objectives.

6. Discourages spectrum hoarding

7. Reduces the opportunity for favouritism. Transparency of the process reduces the possibility of a legal challenge.

Disadvantages of an Auction:

1. The more criteria or conditions the process contains, the more the value of the licence is affected (e.g., auction price may go down).

2. Due to the high fees paid, it may be harder to roll out the network as quickly as proposed.

3. Smaller players may be discouraged to enter the market.

4. High costs may be passed on to the consumer, which can result in reduced service penetration.

5. Governments can exploit the process for revenue purposes only, without taking into consideration the policy impacts.

6. Auction designs can be complex, depending on the nature of the award. An improper design can yield results that do not maximise economic benefits.

2.3.5 Hybrid

This is a mixture of one or more of the above.

2.4 Spectrum Monitoring and Enforcement

Spectrum monitoring supports the Authority's spectrum management process, including frequency assignment, spectrum planning, and enforcement of licensed operating conditions such as radio frequency (RF) output power, modulation, and frequency accuracy.

Spectrum monitoring, consisting of spectrum occupancy measurements, enables the Authority, inter alia, to:

1. correlate the actual level of use with the associated assignment register records (e.g., channel occupancy and band congestion).

2. verify proper technical and operational characteristics of transmitted signals and the detection and identification of illegal transmitters.

3. assist in the resolution of electromagnetic spectrum interference, on a local, regional or global scale, so that radio services and stations may coexist.

4. assist in ensuring an acceptable quality of radio and television reception by the general public.

The Authority carries out routine frequency monitoring, spectrum audits and tracing of unauthorised radiocommunications transmissions. The unauthorised use of the spectrum is identified and regularised before stricter enforcement actions are considered.

Interference complaints are treated in accordance with the Authority's guidelines, which ensures an interference-free environment for licensed RF users.

3 Technology Considerations

The development of wireless technologies and the associated services is influencing the way spectrum is allocated and reallocated globally, regionally and within national borders. However, technology is only one element in the complex process of spectrum management. The advancement of technologies and the associated policy and regulatory regimes that govern their use are closely coupled.

Traditional wireless technologies offer several advantages over wired technologies. The primary advantage of wireless technology is mobility. While the underlying core of the Internet remains wired, many access networks utilise wireless technologies like cellular and satellite to connect homes and businesses.

As the increase in the use of personal wireless communications and related data services continues, the demand for spectrum to be used by individuals and devices will increase. To meet this growing demand, spectrum sharing among different services is now a common practice and is implemented by adopting regulations consistent with ITU Radio Regulations and ITU-R Recommendations, and through technical solutions developed in partnership with industry and international standards organisations.

Technologies such as IMT-2020 and agile radios show great promise with respect to enabling more effective use of the spectrum. These evolving technologies are making RF communications much more efficient and spectrum policy will need to be adjusted, so that the benefits from these technologies can be realised.

3.1 Technology Trends

Different wireless services are delivered through a range of technologies which require different spectral bands and bandwidths. Careful spectrum management is necessary to ensure adequate availability of spectrum to meet the demand for various wireless services, as well as to ensure fair access to, and efficient use of, this valuable national resource. Appropriate spectrum allocation and assignment therefore requires the tracking of technology trends and the associated spectral utilisation (bands and bandwidths) and efficiency (data rate per unit Hz of spectral bandwidth).

The following are some of the main trends that are influencing the way spectrum is allocated and reallocated within national borders:

1. Terrestrial cellular networks: higher data rates, lower latencies, massive numbers of devices, accommodation for very high mobility and increased spectral efficiency, as exemplified in evolving generations such as 5G (IMT-2020)

2. Airborne wireless networks: fast, dynamic provisioning of cellular service using unmanned base stations in the stratosphere, as exemplified in high altitude platform systems (HAPS)

3. Local area networks: higher data rates, greater ranges and accommodation for very high mobility, as exemplified in evolving generations of Wi-Fi

4. Internet of Things (IoT): lower cost, longer battery life and lower profile, as exemplified in 5G mMTC

5. Digital television and radio broadcasting: increased spectral efficiency, improved quality, and lower operating costs, as exemplified in digital terrestrial television (DTT)

6. Spectrum sharing:

    a) Shared use of spectral bands in the delivery of public telecommunications service, as exemplified in LTE-U in industrial, scientific and medical (ISM) bands in the US or equivalently class licensed access in Trinidad and Tobago

    b) Dynamic spectrum access (DSA): increased efficiency in the use of shared spectrum by multiple parties, as exemplified in some versions of TV white space (TVWS).

Key underlying technologies that have enabled significant performance improvements include the following:

1. Multiple input multiple output (MIMO) antenna systems as used, for example, in 3G, 4G, 5G, several HAPS, DTT and Wi-Fi technologies, which enable increased data rate through spatial multiplexing, signal power optimisation through beam forming, and greater channel resilience through the use of diversity.

2. Smart antenna systems as used, for example, in radar, LTE and UMTS technologies, to facilitate increased capacity, combat multipath, and reduce radio frequency interference using switched beam and adaptive array antennas techniques.

3. Multicarrier modulation schemes such as orthogonal frequency division multiplexing (OFDM) as used, for example, in 4G (including LTE), 5G and several HAPS, DTT and Wi-Fi technologies, which facilitates flexible transmission bandwidths, high spectral efficiencies, high data rates and increased channel resilience.

4. Software defined radios (SDRs): dynamically and programmatically tunable radio transmission frequencies, as exemplified in the use of cognitive radio and dynamic spectrum sharing, newer versions of Wi-Fi and IoT.

Changes in technology have impacted the spectrum management framework and processes in the following ways:

1. Modification to channel bandwidths for applications including, but not limited to, point-to-point backhaul links, digital radio broadcasting and mobile cellular service

2. Repurposing of bands allocated to other services, as exemplified, in the repurposing of the digital dividend for mobile services, the AM band and class licenses of land mobile frequency for multi-use radio service (MURS) radio

3. Use of spectral bands:

    a) Shared use of specific bands between services, as exemplified in the use of the C-band for IMT and satellite services, and the use of the Ku band for fixed satellite service (FSS) and earth station in motion (ESIM)

    b) Under regulatory sandbox provisions which promote innovation

The above underlying trends are essential in identifying the best possible ways to plan, allocate, and assign spectrum to meet the future needs of operators and consumers, while ensuring efficient use of valuable spectrum resources and fostering competition. As spectrum plays a critical role in realising the full extent of access to broadband capabilities, its efficient use has a direct social and economic impact on multiple sectors of society (ITU 2020).

4 Economic Considerations for Spectrum Management

The overarching aim in the management of any scarce resource is economic efficiency. Economic efficiency, as it relates to national spectrum resources, can be defined as the allocation of frequency bands to specific groups, through the use of various economic and technical assignment mechanisms[4], in such a way as to maximise the benefits to the citizens of Trinidad and Tobago.

The mechanisms used to pursue the economically efficient management of the spectrum resource are generally categorised into three approaches: command and control, flexible rights of use and open access (DCMS Barwise, Cave 2015).

The three subsections below review these economic approaches to spectrum allocation.

4.1 Command and Control

The command and control approach to spectrum management refers to scenarios where regulators allocate non-overlapping frequency bands to specific uses and assigns usage rights to licensees. Historically, the allocation of frequency bands to specific uses has been based primarily on considerations of technical and global harmonisation parameters, with lower priority given to extracting total economic value[5] or maximising total welfare. This approach may be considered suitable where there is significant surplus of the national spectrum resource available, as opportunity cost[6] and marginal value foregone[7] are negligible or may be considered insignificant.

4.1.1 Methodology (Spectrum Usage Rights and Valuation)

Regarding the assignment mechanisms considered under the command and control approach to spectrum management, licensee rights tend to be limited to a predetermined purpose of the use or fixed rights of use, frequency band(s), geographic scope and/or transmission power, and extract minimal economic value or resource rent through the recovery of administrative costs only.

[4] "Assignment mechanism" refers to the combination of legal, technical and pricing parameters conferred to a spectrum licence holder or authorised user of the national spectrum resource.

[5] "Total economic value" refers to the sum of private use value and external value.

[6] "Opportunity cost" refers to the value that would have been generated from the next best alternative foregone.

[7] "Marginal value foregone (MVF) is the unit by which opportunity cost is measured.

It has been observed globally that the command and control approach to spectrum management brings sustained technical advantages. Where well-designed allocative bands have been established, the approach facilitates the supply of diverse services with high service reliability for most users and with minimum interference (NTIA, Brookings 2011). Thus, the command and control approach remains the spectrum management approach of choice for national security purposes (NTIA, Brookings 2011).

4.1.2 Benefits and Applications

In an environment of high spectrum demand, dynamic spectrum access and market-based assignment mechanisms may be used to reduce spectrum idling and increase efficiency in the use of the national resource, even in the case of public interest assignments (DCMS Barwise, Cave 2015). This adaptation refers to a public sector body that is assigned spectrum through the command and control approach but is permitted to release unused spectrum (at least for a reasonable period) to another spectrum access seeker. In this arrangement, a public sector body, for example, national defence, is encouraged to economise on its spectrum usage and thereby reduce spectrum idling and increase its resource utilisation efficiency[8].

The Authority currently employs strict command and control approaches to spectrum management through the allocation of frequency bands to particular end users. Specifically, the Authority has committed to the provision of spectrum and assignment of exclusive fixed usage rights to licensees using an administrative cost recovery methodology, for the following uses:

1. National security, law enforcement, public health and safety, and emergency services
2. Public radio communications services relating to universality requirements
3. Aeronautical radio communications services
4. Amateur radio operations

4.2 Flexible Rights of Use

In the flexible rights of use approach to spectrum management, exclusive rights to specific frequencies and/or geographies are assigned to the primary licence holder. Primary licence holders

[8] In 2012, the USA became one of the first countries to permit surplus public safety spectrum to be sold to other users. The enabling legislation allowed the spectrum allocated to public safety to be used to generate revenue when not in use.

may trade licences in a secondary market, except with those who would cause interferences[9] and, therefore, have broad discretion or flexibility about how they use and share their frequency.

4.2.1 Methodology

In this method, the rights to use specific spectrum bands are administered through market-based auctions, cost-benefit analysis and/or administrative pricing. The primary holder may then determine its spectrum allocation and is motivated to reallocate surplus spectrum or unused frequency bands through secondary trading[10] or spectrum management and/or administrative mechanisms[11], depending on the degree of control held by the licensee.

The advantages of the flexible rights of use approach are derived from its ability to reduce idle bands and increase efficiency in the allocation of spectrum to higher social value services, thereby promoting welfare maximisation. Specifically, a profit-driven primary licence holder may assign idle spectrum to access seekers willing to pay the highest price for the resource, through sale or lease. Additionally, due to the reduction in bureaucracy, spectrum and its dependent service markets are expected to respond more efficiently to changes in demand and technology.

The primary disadvantages of the flexible rights of use approach include "anti-commons" or hold up; the potential for interference; and high transaction costs. In particular, strategic, rent-seeking behaviour by the primary licence holder has been noted to prevent spectrum access by potential competitors (ITU 2004). Additionally, transaction costs relating to the negotiation of spectrum access by a large number of owners and seekers have been prohibitive.

4.2.2 Benefits and Applications

To reduce externalities[12] in this approach, absolute use priority of the primary licence holder and strict interference regulatory constraints[13] must be maintained.

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[9] Interference is, however, controlled by technical rules that govern transmitters' specifications and power limits, which may be set by the regulator.

[10] Secondary trading refers to scenarios whereby the primary licence holder makes surplus spectrum available to other (secondary) access seekers at a price. Secondary trading is not currently allowed in Trinidad and Tobago.

[11] This may include alienation of some users and leasing to other users.

[12] "Externalities" refers to the occurrence of congestion or overconsumption of the resource and interference in the provision of services using said resource.

[13] Regulatory constraints include, inter alia, power level or field intensity, geographic area and authorised operation time.

Furthermore, to reduce the drawbacks of the anti-commons, the "ownership with easement" model, which incorporates the use of new sharing technologies within the flexible rights of use market model, has been developed. In the ownership with easement model especially, the exclusive rights of the primary licence holder are subject to easement, such that unlicensed non-interfering users cannot be excluded from using the spectrum "owned" by the primary holder. The inclusion of an acceptable rate of return can provide additional incentive for the adoption of this augmentation to the flexible rights of use approach; however, this may also increase regulatory involvement in an approach designed to be more market based.

The Authority has not issued exclusive rights of use to spectrum licence holders of any frequency band. Rather, spectrum licences issued by the Authority largely permitted only fixed rights of use to the licensee. Therefore, the potential for spectrum trading and/or spectrum sharing is not provided for within the Authority's regulations.

4.3 Open Access

The open access approach to spectrum management permits spectrum access to all potential users. In this approach, rights may or may not be granted to access seekers and the price for spectrum access may be determined by the market or set administratively by the regulator.

4.3.1 Methodology

The open access mechanism has several known iterations or implementation approaches, one being where a single, variable access fee is determined via electronically supplied demand and supply information services and where operational rules are determined by the regulator. This approach is referred to as "the managed commons" or "modern open access".

Other iterations of the open access approach include the standard commons method and market-based methods. In the former method, the government protects the boundaries of spectrum usage by limiting the group of end users who, in turn, have responsibility for spectrum uses, setting standards and dealing with interference. This method confers some degree of joint ownership but excludes flexible rights of use and secondary markets.

4.3.2 Benefits and Applications

The advantages of the open access approach include low barriers to entry, low lead times from innovation to market, and increased service innovation as a result. The primary drawbacks of the open access or unlicensed approach include congestion and/or interference, also termed "the tragedy of the commons"[14]. These drawbacks hold the potential to significantly outweigh the notable gains of the open access approach when demand for spectrum is high.

To minimise interference and congestion, regulatory oversight (which may take the form of sharing rules, common technical standards and protocols, and resource control), may be adopted to retain some economic efficiency. However, as regulatory controls set in, the adaptation of the open access regime is noted to approach the command and control regime and so too its level of allocation inefficiency.

The Authority currently provides for open authorisation for designated bands of the spectrum, which may be used by persons for specific radio communications services upholding specific technical and operational parameters, in the form of a class licence.

[14] This refers to a situation where open access and excessive demand for rival resources lead to the depletion or extreme scarcity of the resource.

5 Principles for Spectrum Management

The radio spectrum is a finite and vital resource that needs to be managed carefully, appropriately, efficiently and effectively, in the public interest, if its potential is to be realised. It is a vital input into an ever-widening range of new and innovative services.

Sound spectrum management principles guide the management of the radio frequency spectrum in accordance with existing legislative responsibilities and policy settings. Spectrum management in Trinidad and Tobago is consistent with these principles, as follows:

1. Allocate spectrum to the highest value use, to ensure that the maximum benefits to society are realised.

2. Enable and encourage spectrum to move to its highest value use.

3. Use a light-handed approach to achieve policy objectives.

4. Promote both certainty and flexibility, to the extent possible.

5. Balance the cost of interference against the benefits gained from greater spectrum utilisation.

6. Harmonise spectrum use with international and regional allocations and standards.

5.1 Allocate Spectrum to the Highest Value Use

The Authority's decision-making processes are conducted in accordance with legislative requirements and guided by the objectives of the Act. Specific sections of the Act cover, inter alia, radio frequency planning, licensing (including spectrum, apparatus and class licensing), reallocation, technical standards, interference and dispute resolution.

Section 3(c)(ii) of the Act states, "the objects of the Act are to establish conditions for promoting universal access to telecommunications services for all persons in Trinidad and Tobago, to the extent that is reasonably practicable to provide such access". In keeping with the objectives of the Act, the public benefit will be increased where the spectrum is regulated in order to promote the economic and orderly utilisation of frequencies for the operation of all means of telecommunications and to recover the cost incurred in the management of the spectrum.

In assessing the highest value use of the radio spectrum, the Authority considers, inter alia:

1. the objectives of the Act and all relevant legislative requirements.

2. the community benefits derived from the use of the spectrum.

3. the increasing demand for the use of the radio spectrum.

Spectrum Management Framework Policy Statement

1. *Spectrum shall be allocated to the highest value use, to ensure that maximum benefits to society are realised.*

5.2 Enable and Encourage Spectrum to Move to Its Highest Value Use

The highest value use of a portion of spectrum is the use that enables the highest incremental increase in the value of that spectrum, rather than the use for which the services on offer have the highest absolute value (ACMA, 2017).

Market-based mechanisms can ensure that spectrum is awarded to entities that plan to deploy wireless networks and efficiently use the spectrum resource. The overall benefits to the public derived from the use of the radio spectrum can be maximised by allowing the spectrum to move to the highest value use as quickly and as easily as possible following its initial allocation.

To encourage spectrum to move to its highest value use, the Authority will consider, inter alia:

1. a flexible regulatory system that enables licensees to adapt spectrum access and usage to both market requirements and technology advances.

2. promoting mechanisms that enable and encourage spectrum licensees to move spectrum to its highest value use with minimum regulatory burden.

Spectrum Management Framework Policy Statement

2. *Mechanisms shall be put in place to enable and encourage spectrum to move to its highest value use.*

5.3 Use of a Light-Handed Approach to Achieving Policy Objectives

Reducing the cost of spectrum management requires a focus on regulatory effectiveness, taking into account developments in technology and conditions in affected markets. Under good regulatory practice, all benefits and costs of regulations, including compliance costs, are thoroughly assessed.

The light-handed approach reduces regulatory burdens and allows greater freedom for spectrum licensees to optimise their use of the spectrum. The Authority shall seek to operate as efficiently as possible to minimise the total cost of spectrum management.

Spectrum Management Framework Policy Statement

3. *The least cost and least restrictive approach shall be used to achieve spectrum management goals and objectives.*

5.4 Promote Both Certainty and Flexibility Through Procedural Reforms

Licences issued by SMAs need to be flexible, to facilitate the third-party use of a licensee's spectrum. This flexibility requirement may at times conflict with the desire of some licensees for certainty, particularly in relation to interference management. If there is any conflict between these two objectives, the Authority will seek an outcome that provides the greatest net benefits for industry, consumers and the wider community.

A stable and predictable regulatory arrangement and sufficient certainty about spectrum occupancy are also essential, in order for licensees to be confident about investing in equipment and services. This maximises the public benefits from spectrum use by reducing the risk of market failures arising from uncertainty and risk aversion.

To promote both certainty and flexibility through procedural reforms, the Authority will establish, inter alia:

1. a stable and predictable regulatory and spectrum management regime.

2. longer licence terms with flexible conditions to allow for secondary licences, for example, pluralistic licences.

Spectrum Management Framework Policy Statement

4. *The Authority shall promote both certainty and flexibility through procedural reforms.*

5.5 Balance the Cost of Interference Against the Benefits of Greater Spectrum Utilisation

There is no RF environment or operation with a complete absence of potentially interfering signals. As the use of the spectrum for personal, commercial, industrial, government and scientific purposes continues to increase, the number of potentially interfering sources will also increase. Interference can be caused by legitimate users of the spectrum, improperly functioning consumer and commercial equipment, and improper or disallowed use of the spectrum.

In keeping with its Consultation Procedures, the Authority shall consult with stakeholders on subsidiary documents developed in support of the implementation of this spectrum management policy.

Interference mitigation techniques are a limited but critical element in efforts aimed at extracting scientific value from an increasingly difficult RF environment. In balancing the cost of interference against the benefits of greater spectrum utilisation, the Authority shall consider, inter alia:

1. mitigation techniques that enable more flexible access for service providers.

2. promoting higher spectral efficiency in modulations from the point of signal processing.

3. optimisation techniques that contribute greatly to more efficient spectrum usage in wireless communications.

Spectrum Management Framework Policy Statement

5. *The risk and cost of interference shall be balanced against the benefits gained from greater spectrum utilisation, to ensure the most efficient use of the spectrum.*

5.6 Harmonise Spectrum Use with International and Regional Allocations and Standards

Spectrum harmonisation is desirable in regions comprising small economies, as it increases economies of scale for equipment and simplifies assignment procedures. As global marketplace demands continue to enhance the mobility of communications technologies, harmonised spectrum bands and improved technical interoperability among diverse systems will play an increasingly important role in the international communications arena.

The Authority will harmonise spectrum use with international and regional allocations and standards as far as practical, to reap benefits in terms of access and economies of scale. For example, spectrum is allocated for the provision of broadband wireless access (BWA) services, in keeping with the Region 2 Table of Frequency Allocations.

In harmonising spectrum use with international and regional allocations and standards, the Authority shall continue working with, inter alia:

1. regional members of the Caribbean Telecommunications Union (CTU) Spectrum Management Task Force (SMTF).

2. the Inter-American Telecommunication Commission (CITEL) member states.

3. global regulators at the World Radio Conference (WRC).

Spectrum Management Framework Policy Statement

6. *Spectrum use shall be harmonised, as far as practicable, with international and regional allocations and standards, to generate additional benefits in terms of access and economies of scale.*

6 Revised Spectrum Management Regime for Trinidad and Tobago

At the time that policies were put in place to support the traditional spectrum authorisation models outlined in section 2, spectrum management authorities (SMAs) were bound by the limitations of early technologies. Technologies have since advanced significantly but the existing spectrum structure remains. SMAs must proceed carefully in order to make more effective use of the spectrum and ensure that legacy devices retain their functionality.

The technologies outlined in section 3 are changing the way SMAs need to manage the radio spectrum. Technologies such as SDR and IMT-2020 cannot exist legally without changes to spectrum policy. The changes necessary to make use of new technologies with the least amount of disturbance to existing devices and licensees include developing coexistence models, creating new unlicensed spectrum, clearing underused spectrum and allowing multipurpose radios.

The following are the key areas of the revised spectrum management framework:

1. Spectrum planning

2. Spectrum authorisation:
    a) frequency assignment and licensing
    b) mechanism for the granting of licences

3. Spectrum monitoring and enforcement

6.1 Spectrum Planning

Spectrum planning is the process of setting spectrum management goals for the future and establishing the steps for achieving those goals. The planning process precedes the efficient and effective conduct of any activity, be it governmental or business.

According to the ITU-R *Handbook on National Spectrum Management* (ITUR 2015), the purpose of any planning effort is to organise and focus thoughts and actions on the efficient and effective achievement of directed or agreed goals and objectives. This effort is important for any country (and especially important for developing countries) wanting to initiate or improve a national spectrum management process.

Planning activities are classified by time (short term, long term and strategic) and the areas covered (spectrum use and spectrum management systems). Short-term plans are implemented within three

to five years and long-term plans consider issues that need resolutions or systems to be implemented within five to 10 years.

In comparison, strategic planning involves the identification of several key issues that require concentrated spectrum management attention, to create solutions that need more than 10 years to be implemented (ITU-R, 2019).

The Authority's spectrum planning and policy-making process will ensure that an adequate amount of spectrum is provided, over the short and long term, for public service organisations to fulfil their missions, for public correspondence, for private business telecommunications, and for broadcasting. Spectrum usage for research, scientific uses and amateur radio activities will also be considered.

6.1.1 Spectrum to Support National Socioeconomic Development Objectives

Under its NICT Plan, GORTT has launched several programmes aimed at developing the information and communications technology (ICT) sector. These initiatives support Vision 2030, which outlines the country's aspiration to attain "first world nation status" by 2030.

The management of the radio spectrum plays a major role in increasing a country's social and economic well-being, by maximising the use of the spectrum for wireless applications. It is important to note that the economic benefit in this sense must be viewed in a broad context rather than that of merely increasing revenues from licensing.

The output of the spectrum planning effort is the allocation of frequency bands to the various radio services for specific uses. Where there are competing interests for use of the spectrum, the Authority shall determine the use that would best serve public and government interest, including how to share the spectrum.

Spectrum Management Framework Policy Statement

7. *The radio frequency spectrum, as a scarce national resource, shall be used for the benefit of the public and to facilitate the Government of the Republic of Trinidad and Tobago's public policy and socioeconomic objectives.*

6.1.2 Spectrum for National Security, Law Enforcement and Emergency Services

The use of spectrum to provide services for national security and the protection of the sovereignty of Trinidad and Tobago will receive high priority in the allocation of resources. The Authority will work closely with the organisations responsible for providing these services, to ensure that a sufficient amount of radio spectrum is made available to fully satisfy their requirements and that such spectrum is used in the most efficient manner.

Clear capacity dimensioning and frequency reuse plans for the provision of telecommunications services for law enforcement, the safety of life and property, and emergency services are outlined in the various spectrum plans. Any revision to spectrum plans due to changes in the allocation of radio frequency spectrum for national security, law enforcement, public health and safety, and emergency services will be consulted upon, in accordance with the Consultation Procedures .

Government users will be charged for the use of the spectrum.

Spectrum Management Framework Policy Statement

8. *Radio frequency spectrum shall be provided for radiocommunications services for national security, law enforcement, public health and safety, and emergency services, on a priority basis, and such spectrum shall be used efficiently and effectively.*

6.1.3 Spectrum to Facilitate Public Telecommunications (Radiocommunications) Services

The proclamation of the Act and the opening of the market to competition increased the demand for spectrum for the provision of public telecommunications networks and services. This trend has continued with the developments in telecommunications technologies and the demand for data services.

Additionally, increased competition will fuel the demand for "modern" public telecommunications services and the Authority will need to respond to the greater need for spectrum resources for the provision of these services.

Spectrum Management Framework Policy Statement

9. *Radio frequency spectrum shall be provided for public telecommunications services, using a market-based approach, to ensure an equitable return for the use of the spectrum resources.*

6.1.4 Spectrum for Universal Service

Under the Act, provision was made for the establishment of a Universal Service Fund (USF) that is used to assist in the development of the telecommunications infrastructure and the provision of services to underserved and geographically remote areas in Trinidad and Tobago, to bridge the access divide and boost digital inclusion. The USF is funded by certain concessionaires and licensees, e.g., telecommunications networks and service providers.

One of the measures now used to determine the level of penetration of telecommunications services and the overall ability of citizens to access and use these services is the ICT Development Index (IDI). The IDI is a composite index launched by ITU to measure the development of ICTs within and among various countries[15]. In 2021, the Authority embarked on a national digital inclusion survey to collect data to gauge the development of ICTs at the national and community levels. As of 2021, Trinidad and Tobago's IDI has been determined as 7.86.

Several access technologies, mostly wireless, which rely on the availability of spectrum, are deployed in various countries. The Authority will allocate spectrum for the provision of wireless access services, to facilitate the penetration of telecommunications networks and services in Trinidad and Tobago, which ultimately will enhance the growth of the IDI.

Subsidiary documents such as the PMTS Spectrum Plan and the Fees Methodology will be revised as a result of this Framework and will provide details on the allocation of spectrum for universal service and the related fees. The Authority will consult with stakeholders, in accordance with its Consultation Procedures, regarding the revision and development of subsidiary documents in support of the allocation of spectrum for universal service.

Spectrum Management Framework Policy Statements

10. Radio frequency spectrum shall be allocated to public radiocommunications services for the provision of universal service.

11. Consideration shall be given to the use of spectrum to provide direct incentives for the rolling out of telecommunications networks and services and broadcasting services in unserved and underserved areas.

[15] IDI Conceptual Framework: https://www.itu.int/en/ITU-D/Statistics/Pages/publications/mis/methodology.aspx#:~:text=The%20ICT%20Development%20Index%20(IDI)%2C%20which%20has%20been%20published,between%20countries%20and%20over%20time

6.1.5 Spectrum for Commercial Radiocommunications Services

With the rapid and sometimes disruptive advancements in the telecommunications sector, there is increasing reliance on telecommunications to meet private and commercial business needs.

Commercial telecommunications applications have flourished with the liberalisation of the telecommunications sector. An important consideration is the relative economic attractiveness of, and demand for, different parts of the spectrum. Whilst the main cellular mobile and broadcasting bands are likely to be highly sought after, the bands mainly used for private mobile radio are likely to be underutilised and substantially lower fees would be justified. Similarly, if congestion arises in the existing bands for fixed links (below 6 GHz), higher frequency bands could be made available at lower fees to encourage their use.

It would also be appropriate to apply lower fees for fixed links at sites that are not heavily used. Fees charged for spectrum access should reflect the opportunity cost where there is current or potential excess demand for spectrum (i.e., reflect the cost of denying access to spectrum for other users).

Spectrum Management Framework Policy Statement

12. Radio frequency spectrum shall be provided for commercial radiocommunications services, using an appropriate administrative costing methodology or market-based approach, to ensure an economical value for use of the spectrum resources.

6.1.6 Spectrum to Provide Aeronautical Radiocommunications Services

Radiocommunications facilities to enable the work of air traffic controllers, air-to-ground communications and ancillary services are critical to the safety and efficiency of air transportation.

Currently, the allocation of spectrum within agreed bands is co-ordinated with the International Civil Aviation Organization (ICAO), which plays a major role in the international and regional coordination of the use of the allocated frequencies.

The aeronautical spectrum is generally allocated internationally for the exclusive use of the service and, given the safety-critical nature of the service, cannot be shared by other users. The Authority's role in regard to these services is essential to ensuring that the spectrum is protected in accordance with ITU and ICAO regulations, and that effective enforcement action is taken in the case of any interference or other infringement arising.

Spectrum Management Framework Policy Statements

13. Radio frequency spectrum shall be provided for aeronautical radiocommunications services, using an administrative cost recovery methodology.

14. The Authority shall recognise all international and regional radio frequency spectrum allocated to aeronautical services.

6.1.7 Spectrum for Maritime Radiocommunications Services

Maritime radiocommunications services are required for a variety of purposes including:

1. Global Maritime Safety and Distress System (GMDSS) and Safety of Life at Sea (SOLAS)
2. Radio navigation
3. Weather warnings
4. Commercial use
5. Leisure
6. Coast station operations
7. Port operations

A range of frequency bands, including MF, HF, VHF and UHF, and satellite bands are used to provide the above maritime services.

Internationally, the maritime spectrum is generally allocated exclusively for maritime communication and, given the safety-critical nature of the service, the spectrum cannot be shared by other users. The Authority's role with respect to maritime services is essentially to ensure that the spectrum is protected in accordance with ITU and International Maritime Organization (IMO) regulations, and to take effective enforcement action in the case of interference or any other infringements arising.

Spectrum Management Framework Policy Statements

15. Radio frequency spectrum shall be provided for maritime radiocommunications services, using an administrative cost recovery methodology.

16. The Authority shall recognise all international and regional radio frequency spectrum allocated to maritime services.

6.1.8 Spectrum for Amateur Radio and Other Experimental Purposes

Amateur radio operators internationally have been allocated radio spectrum in various frequency bands to undertake non-commercial radiocommunications activities including experimental work. Many of the allocations are on a secondary basis and may be shared with other users.

The benefits of amateur radio include fostering technical radio skills that may be of subsequent value to the commercial or state sectors, as well as in a potential emergency response role. The spectrum shall be made available to radio amateurs consistent with international practice.

Trinidad and Tobago, a Member State of Inter-American Telecommunication Commission (CITEL), became a party to the Inter-American Convention on an International Amateur Radio Permit (IARP Convention) by accession on 16th August 2001. The Authority will adhere to the articles of the IARP Convention and any subsequent revisions or amendments to which Trinidad and Tobago is a party.

The Authority recognises IARPs issued by the other Member States in accordance with the IARP Convention. Visiting amateur radio operators who hold a valid IARP and wish to operate their equipment during their stay in Trinidad and Tobago will be permitted to do so, subject to procedures defined by the Authority in the *Framework for the Authorisation of Amateur Radio Services*.

Spectrum Management Framework Policy Statements

17. Radio frequency spectrum shall be provided for amateur radio operations, using an administrative cost recovery methodology.

18. The Authority shall adhere to the articles of the IARP Convention and any revisions or amendments to which Trinidad and Tobago is a party.

6.1.9 Spectrum for Private Non-commercial Radiocommunications Services

The use of radiocommunications equipment is part of everyday life – from the ubiquitous mobile telephone and the home cordless telephone to the car alarm system. Spectrum resources will need to be made available to facilitate this widespread use of radio technology. Generally, these radio devices operate at relatively low power levels and use the shared spectrum.

The Authority has developed a Class Licensing Regime to allow for the use of low power, low interference potential, and mass-market consumer devices which operate within specific technical and operational parameters.

The class licensing process is a simplified authorisation process that imposes minimal administrative and financial burdens on the Authority and users of devices deemed to be class licensed. A class licence will authorise users of such devices to operate in designated spectrum band(s) on a shared basis.

Spectrum Management Framework Policy Statement

19. Radio frequency spectrum shall be made available for private non-commercial radiocommunications services, in accordance with the Authority's Class Licensing Regime.

6.1.10 Spectrum for Emerging Radiocommunications Services

There are significant developments taking place in the global marketplace with respect to the establishment of new standards and technologies to enable the delivery of wideband telecommunications and broadcasting services via wireless access/delivery systems. In many cases, the provision of these standards and technologies is being fostered by regulatory bodies through a "soft" regulatory regime that facilitates a less costly and easier deployment of systems.

It is anticipated that such systems will greatly assist in the development of the national telecommunications infrastructure and will contribute to the ready access of telecommunications services, thereby contributing to the overall improvement of the country's IDI.

Spectrum Management Framework Policy Statement

20. Radio frequency spectrum shall be made available to enhance the delivery of emerging radiocommunications services within an enabling spectrum licensing framework.

6.2 Spectrum Authorisation

One of the main purposes of managing the spectrum is to increase the social gains from its use while avoiding interference between different users. How this is achieved has changed in recent years, as countries transition from more constrained models to more market-based ones. Instead of a one-size-fits-all solution, most countries are currently implementing a mix of policies that will ensure more efficient use of the spectrum.

The technologies outlined in section 3 show great promise in how more effective use of the spectrum can be made. These technologies can only be implemented if current regulatory models support or allow their use. SMAs, engineers and economists must understand the implications of technologies and how regulatory regimes will have to adapt if new and emerging technologies are going to succeed.

In recent years, the authorisation toolbox used by SMAs has been enriched by the addition of licensing schemes that allow various arrangements and degrees of shared use of the spectrum resources. The authorised shared access/licensed shared access (ASA/LSA) is an example of a framework that is currently being discussed at international forums. It proposes a sharing scheme in which a dedicated spectrum should be assigned by either the incumbent user or by the licensee, in any given place at any given time.

The emergence of these new licensing schemes that promote the various forms and degrees of organised sharing of the spectrum resources has gradually reduced the uncertainty between the traditional polarised approaches of exclusive licensing versus licence exemption.

A critical decision for the Authority and other Region 2 administrations is balancing the trade-offs between the different spectrum authorisation approaches. As a light-touch regulator, the Authority's preference is to adopt a mixed or flexible approach, allowing market forces to prevail to ensure the continued development of wireless communications services and applications.

6.2.1 Frequency Assignment and Licensing

A key to increasing the overall efficiency of spectrum utilisation is through better sharing, enabled by continued international collaboration and innovation in the management of the radio spectrum. The mixed or hybrid assignment framework offers a modern approach for the management of the spectrum and conveys a new trend in which different frameworks are merged.

In applying the mixed or hybrid model, also known as the flexible approach, the Authority shall use market mechanisms for spectrum assignment, accord freedom in the choice of technologies and services, and separate universal service obligations from licence terms.

The Authority is of the view that the spectrum should be free of technology and usage constraints as far as possible. Policy constraints shall only be used where they can be justified. However, although some flexibility will be allowed, that flexibility will be measured to ensure that national policy objectives and international obligations are still maintained. As a result, the Authority intends to adopt licensing practices that are based on a market-oriented system (flexible approach), supported by institutional best practices, such as the following:

1. Setting up an efficient spectrum management system – achieving streamlined and efficient spectrum management on both a short-term and long-term basis. This involves allocating, allotting and assigning spectrum licences in an economical and efficient manner, relying on market forces, economic incentives and technical innovations.

2. Ensuring transparency of the spectrum management operations – promoting transparent, non-discriminatory, economically efficient and effective spectrum management policies, that provide regulatory certainty

3. Adhering to the principle of technological neutrality and flexible spectrum use – promoting wireless innovation by creating conditions for the development of new services, reducing investment risks and stimulating competition among different technologies, including facilitating new competitors' entry into the market

4. Managing the availability and use of spectrum – facilitating the timely introduction of new applications and technology, while protecting existing services from harmful interference, ensuring the most efficient use of radio spectrum

5. Harmonising regional and global spectrum standards – aligning domestic spectrum policies with internationally recommended standards, to achieve faster take-up of new bands and economies of scale

6. Promoting affordable and fair access to the spectrum – reducing financial barriers for new entrants into the wireless market and guiding the development of wireless technologies, especially in less developed areas

7. Ensuring that all wireless players have equitable and fair access to spectrum resources

8. Coordinating shared spectrum use – the key to increasing the efficiency of overall spectrum utilisation is through better sharing, enabled by emerging technologies that promote spectrum sharing, continued international collaboration and innovation in spectrum management.

9. Monitoring and controlling spectrum use – monitoring, market supervision and enforcement are becoming increasingly integrated fields of operation. Most countries have some monitoring facilities at or near their headquarters as well as a set of regional stations spread throughout the country.

Under the mixed or flexible approach, licensing is currently the mainstream spectrum management approach for mobile broadband, providing the certainty of dedicated spectrum to support over 8.1 billion connections and almost 5 billion unique subscribers (ITU 2017).

A licence may be granted to an operator at a particular location or for a defined geographical area (niche, major or national), authorising the operation of a station(s) in this/these location(s) or area(s). The licensee secures rights for the transmission of signals and the protection of their reception from interference for a specified period.

All licences are technology neutral. Frequency coordination enables efficient use of the spectrum between several licensees. It also enables spectrum sharing between different licensed services (e.g., point-to-point links and earth stations).

Figure 3 depicts the hierarchical view of the new spectrum access licensing approach adopted by the Authority for Trinidad and Tobago, allowing for a degree of organised sharing and the efficient management of the radio spectrum resources.

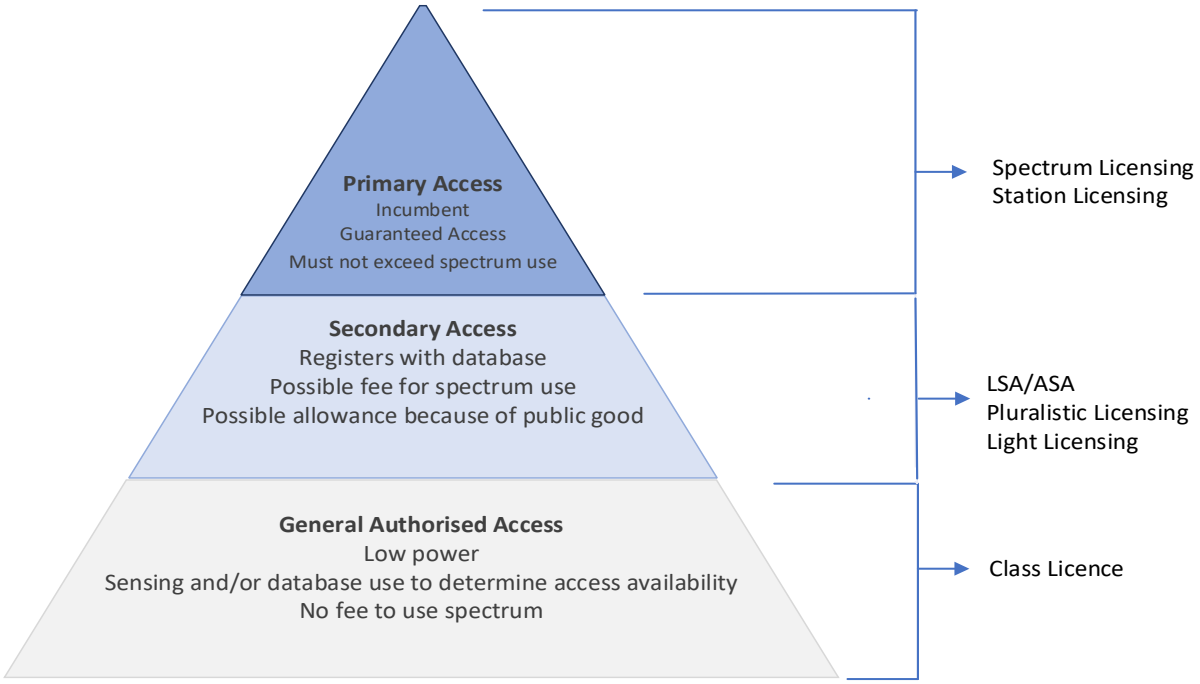

Figure 3: Hierarchical view of the new authorisation approach (Source: US PCAST Report 2012)

Spectrum Management Framework Policy Statement

21. The Authority shall employ the following types of licences for the use of spectrum, in accordance with section 36(1) of the Act:

a. Primary Access Licences:
- *i. Spectrum*
- *ii. Station*

b. Secondary Access Licences:
- *i. Licensed Shared Access (LSA) or Authorised Shared Access (ASA)*
- *ii. Pluralistic*
- *iii. Light*

c. General Authorised Access Licence:
- *i. Licence-exempt (Class Licence)*

Figure 4 summarises the current authorisation regime that consists of the class licence, station licences and spectrum licences and the new authorisation regime that includes the class licence, secondary access licences and primary access licences.

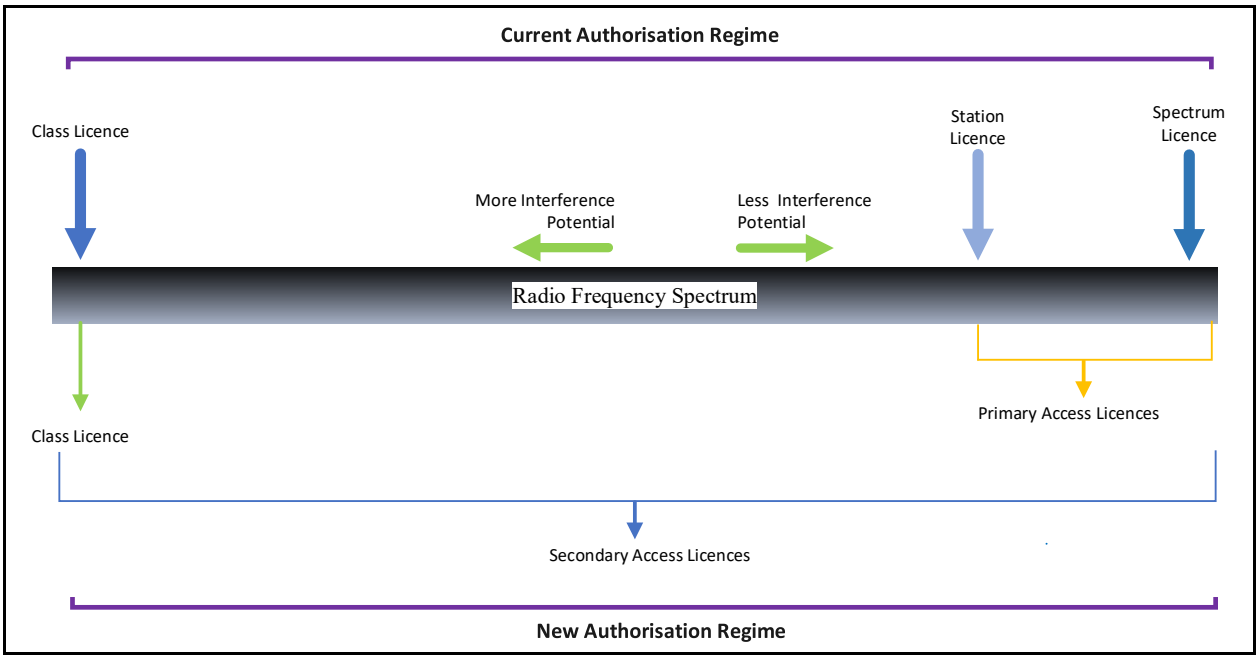

Figure 4: Current authorisation regime vs new authorisation regime

6.2.1.1 Primary Access Licences

6.2.1.1.1 Spectrum Licence

Spectrum licensing, also known as exclusive licensing, is a common model used by most countries in Region 2 in the assignment of spectrum. Under certain minimal conditions, countries like Canada and the United States issue spectrum licences to authorise the use of a specific frequency/frequencies or a frequency block(s) within a defined geographic area(s). Once authorised, licensees are permitted to establish and modify their radiocommunications networks while adhering to the conditions of the spectrum licence.

Exclusive frequency assignments under a spectrum licence should not be interpreted as a reason to preclude other productive uses of spectrum capacity in areas or at times where the primary use is dormant or where underutilised capacity can be shared. The assignment of the spectrum on a secondary exclusive basis shall be accommodated where practical.

The spectrum licence was created to allow licensees or, in some cases, persons authorised by a licensee, to operate radiocommunications devices within a specified frequency band (and/or time and/or geographic area, as required).

The rights and obligations associated with a spectrum licence granted to mobile network operators (MNOs) are included in the concession granted to MNOs by the Authority (e.g., coverage obligations).

The established regulatory environment in Trinidad and Tobago provides the long-term predictability for spectrum licensees and helps incentivise the large investment necessary for network rollout. This is important to enable mobile broadband coverage in rural areas where the business case for service provision can be challenging due to sparse populations.

Additionally, spectrum licences allow for better assurance of interference protection, provide certainty to operators in terms of guaranteed access to spectrum, and enable higher power output, all of which help improve coverage and also incentivise network investment.

Spectrum Management Framework Policy Statements

22. *The Authority shall utilise a primary access licence type (spectrum licence) to authorise the exclusive assignment of spectrum for the operation of radiocommunications systems within a specified frequency band under specific conditions on a technology-neutral basis, i.e., no restrictions will be placed on the type of technology used.*

23. *Spectrum licences shall be used to authorise the offering of public or closed user group telecommunications or broadcasting services*

24. *Exclusive assignment under a spectrum licence shall mean the right to use the spectrum without precluding other productive uses of the spectrum, in areas or at times where the primary use is dormant, or where underutilised capacity can be shared.*

6.2.1.1.2 Station Licence

A station licence applies to a radiocommunications service that requires the use of a specific location, technical standard, piece of equipment and/or frequency to achieve the purpose of the radiocommunications service or to facilitate coexistence with other radiocommunications services.

A station licence authorises the licensee to operate the station(s) specified in the licence, in accordance with the Act, regulations and the conditions of the licence. A station licence may be one of the following:

1. An assigned frequency licence (i.e., frequency is allocated to users)

2. A non-assigned frequency licence (i.e., frequencies are shared with other users; no frequency allocated to users)

A radiocommunications service operating under a station licence cannot be changed or modified with respect to any of the particulars mentioned in the licence, including the radiocommunications equipment, the operating radio frequencies, and the location where the station is installed.

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25. The Authority shall utilise a primary access licence type (station licence) for the assignment of spectrum to authorise the use of one or more specific radio stations in accordance with specific conditions.

26. A station licence shall apply where the radiocommunications service requires the use of a specific location, technical standard, piece of equipment and/or frequency within a frequency band in order to achieve the purpose of the radiocommunications service or to facilitate coexistence with other radiocommunications services.

6.2.1.2 Secondary Access Licences

Figure 5 highlights the secondary access licences that consist of the light licence, pluralistic licence and licensed shared access licence types. As the figure shows, secondary access licence allows for a degree of organised sharing, the efficient management of the radio spectrum resources, and less potential for interference in the direction of the licensed shared access licence type.

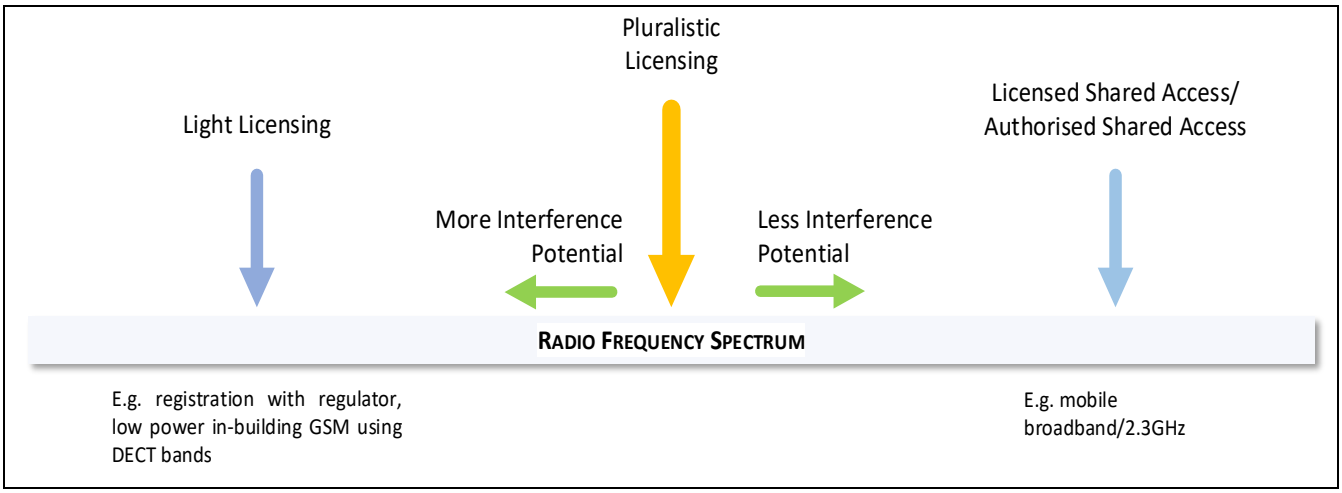

Figure 5: Secondary access licences

6.2.1.2.1 Licensed Shared Access (LSA) Licence

Licensed shared access (LSA), also known as authorised shared access (ASA), is defined as "a regulatory approach aiming to facilitate the introduction of radiocommunication systems operated by a limited number of licensees under an individual licensing regime in a frequency band already assigned or expected to be assigned to one or more incumbent users. Under the LSA approach, the additional users are authorised to use the spectrum (or part of the spectrum) in accordance with sharing rules included in their rights of use of spectrum, thereby allowing all the authorised users, including incumbents, to provide a certain Quality of Service (QoS)" (EC 2013).

LSA allows for the shared use of the spectrum using cognitive radio techniques (i.e., geolocation combined with spectrum databases). Under a specific regulatory framework, the non-mobile incumbent could allow a mobile operator non-interfering use of part of its assigned spectrum, pursuant to a commercial agreement with the incumbent, and subject to the terms defined by the relevant government authority.

In Trinidad and Tobago, a spectrum licence (exclusive licence) lasts for 10 years and applies to a frequency block on a national basis. An example of such licensed use is the 2.5 GHz spectrum for the provision of BWA services. Under the LSA concept, existing BWA spectrum user(s) ("the incumbents") would share spectrum with one or several MNOs licensed as LSA users ("LSA licensees), in accordance with a set of pre-defined conditions. These conditions may be static (e.g., specific exclusion zone or time allowed for operation), or dynamic (e.g., geographic/time sharing, on-demand authorisation by LSA licensees, or on-demand restrictions imposed by incumbents).

A key benefit for MNOs is that the LSA approach enables them to have faster access to new spectrum without having to wait for difficult, costly and lengthy re-farming policies, thus allowing much fewer conflicting scenarios (ANFR 2012).

LSA aims to ensure a certain level of guarantee in terms of spectrum access and protection against harmful interference for both the incumbent(s) and LSA licensee(s). Incumbent(s) and LSA licensee(s) each have exclusive access to the spectrum at a given location at a given time.

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27. The Authority shall adopt the licensed shared access (LSA) type of licence.

28. Licensed shared access licences shall be issued for the frequency bands that qualify, to facilitate the introduction of new users while maintaining incumbent services in the bands.

29. Minimum technical standards and conditions shall be established before the implementation of the licensed shared access licence.

30. The frequency bands to which the licensed shared access licensing type applies shall be determined by the Authority from time to time.

31. A fee may be charged for the licensed shared access licence in keeping with the fee regulations.

6.2.1.2.2 Pluralistic Licence

In line with the emerging technologies outlined in section 3, pluralistic licensing is the latest emerging licensing concept for flexible spectrum management, under which interference is viewed as a tradeable characteristic of the spectrum.

With pluralistic licensing, licences are awarded under the assumption that opportunistic secondary spectrum access will be allowed, and that interference may be caused to the primary spectrum holder based on defined parameters and rules that are known to the primary at the point of obtaining the licence.

Benefits of pluralistic licensing include:

1. encouraging a more robust or better designed primary system that can cope with an increased degree/risk of interference.

2. allowing opportunistic spectrum use while providing any level of protection desired by the primary users.

3. incentivising the primary users to make more efficient use of spectrum, and to make unused spectrum available, i.e., it greatly improves spectrum usage efficiency and fairness.
4. highly scalable to progressive deployment in more spectrum bands.

5. greater flexibility, depending on the case-by-case deployment context (e.g., intended primary service).

6. possible pricing mechanisms for secondary systems (e.g., at the certification stage) that might also lead to the better design of secondary systems, such as incorporating sensing for secondary awareness (i.e., better secondary coexistence).

Pluralistic licensing is a good, adaptable balance between exclusive use and licence-exempt access. Primary interference and licence fees are based on primary/secondary services (Holland, Oliver, et al. 2012).

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32. The Authority shall adopt the pluralistic licensing types to incentivise primary users to make more efficient use of the spectrum.

33. Pluralistic licences shall be issued for the frequency bands that qualify.

34. The relevant technical conditions shall be established before the implementation of the pluralistic licence.

35. The frequency bands to which the pluralistic licensing type applies shall be determined by the Authority from time to time.

36. A fee may be charged for a pluralistic licence in keeping with the fee regulations.

6.2.1.2.3 Light Licence

Light licensing refers to a regulatory framework that combines licence-exempt use and protection of users of the spectrum. With this approach, interference is typically mediated by technical solutions rather than by the local administrator. In a light licensing framework, a user is required to obtain a non-exclusive licence to operate in a particular frequency band.

Light licensed offers another layer of security when compared to unlicensed. In a light licensed approach, the licensee pays a comparatively smaller fee for a non-exclusive license. Benefits of the light licensed approach include:

1. reduced regulatory/administrative burden on the operator.
2. comparatively low licence fee as the licence is not exclusive.
3. fast rollout.
4. some moderate guarantees against interference.

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37. The Authority shall adopt the light licence type to award non-exclusive licences which are either free or have only a nominal fee attached to them.

38. Light licences shall be issued for the frequency bands that qualify.

39. The relevant technical conditions shall be established before the implementation of the light licence type.

40. The Authority shall determine which frequency bands to apply the light licensing to from time to time.

6.2.1.3 General Authorised Access

6.2.1.3.1 Class Licence

"Class licensing spectrum" refers to the spectrum in which access is permitted on the basis of a general licence. In some jurisdictions, class licensed frequency bands may also be referred to as

"unlicensed" or "license-exempt" bands. The class licensed bands are inherently based on spectrum sharing among the various class licence users.

Under a class licence regime, no individual authorisation or coordination is required and no fee is payable for using the spectrum.

Access to the spectrum under a class licence is regulated solely by adherence to pre-defined regulatory parameters. These regulatory parameters are defined to ensure the protection of radio services (vertical sharing) and also to ensure equitable access between class licence radio devices (horizontal sharing).

Short-range devices (SRDs) commonly fall in the class licence category. Effective access to spectrum by SRDs relies heavily on the principle of "frequency re-use" and is enabled by the low-power operation, cluttered environment, and spectrum access mechanisms such as duty cycle limitation. Administrations have a responsibility to ensure sustainable access to SRD bands, and the impact of a change in spectrum regulations has to be duly assessed prior to decision making.

At present, in several countries, mobile network operators utilise Wi-Fi offload of the downlink data over the class licensed spectrum in the 2.4 GHz ISM band to improve network operations and user experience, and are laying the groundwork for supplemental downlink in segments of the 5 GHz band (ITU WDTC Resolution 9, 2017).

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41. The Authority shall maintain its class licence regime for the licensing of short-range radiocommunications devices.

42. The class licence shall set out the requirements regarding the permitted radio frequency emissions and the permitted maximum power of those emissions.

6.2.2 Mechanisms for the Granting of Licences

The radio spectrum is vital to modern communications. Different spectrum licensing mechanisms are required to deal with the distinct needs of individual radio users and the time period in which a frequency band may be open for licensing (ITU-R 2015).

The licensing mechanism adopted by the Authority for the allocation of the spectrum is based on several factors, such as the potential number of applicants; the number of licences to be granted

based on spectrum availability; the type of service linked to the use of the spectrum; universal service requirements; and the economic value of the resource.

The Authority has retained the use of both auctions and comparative evaluation (beauty contests) as the main licensing mechanisms for awarding operating licences.

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43. Where the spectrum is scarce (i.e., demand is greater than supply), the Authority shall utilise competitive licensing mechanisms, such as auctions or beauty contests, as the main tools for awarding licences.

44. Where no scarcity in the spectrum is foreseen, or scarcity can be managed by another mechanism (e.g., spectrum pricing and releasing more spectrum), the first come, first served (FCFS) licensing approach is a simple and administratively straightforward method of individual licence-based assignment that shall be employed.

6.3 Spectrum Monitoring

A key component in effective spectrum management is the capability to monitor the use of spectrum resources and to ensure that users comply with the particular technical and operational parameters included in their licences.

Spectrum monitoring supports the overall spectrum management process, including frequency assignment and spectrum planning functions, by the practical measurements of the channel and band usage taken during the monitoring process, so that channel availability statistics may be derived and the effectiveness of spectrum use can be assessed (ITU-R, Handbook on National Spectrum Management 2015).

The Authority's spectrum monitoring activities fall under two categories: responsive and scheduled.

6.3.1 Responsive Monitoring Activities

Responsive monitoring is unplanned or ad hoc and is based either on internal or external triggers from the Authority's processes, or requests from the Authority's committees and departments. Responsive monitoring consists of the following activities:

1. Interference complaints. In order to accurately determine the location of interference, the Authority's spectrum monitoring system comprises both fixed and mobile units. It has the capability of performing interference analysis for all potential systems as well as monitoring to detect cases of interference among existing systems. Responsive monitoring to investigate interference complaints may span several weeks, consisting of one or more types of spectrum monitoring activities, depending on the complexity of the complaint.

   Additionally, in accordance with its objective to manage the national spectrum resource and act to deter or eliminate any harmful interference, the Authority maintains oversight of all licensed users' sites of operation. This oversight includes reviewing the maintenance of all radio-transmitting equipment facilities.

2. Consumer technical complaints. These responsive monitoring activities, like those undertaken to investigate interference complaints, are focused on the collection of data to investigate complaints, submitted by the public, about the quality of service (QoS) and coverage received from public fixed wireless and mobile telecommunications and broadcasting services that use spectrum.

6.3.2 Scheduled Monitoring Activities

Monitoring activities are planned and take the form of spectrum audits and proactive spectrum monitoring exercises. These activities take considerable time and resources and are critical, both from an operational and planning perspective. Scheduled monitoring consists of the following activities:

1. Spectrum planning and management. Scheduled monitoring is used to determine the level of occupancy of the various frequency bands and the availability of spectrum to potential users, and informs the Authority's spectrum planning process.

2. Licensing. Prior to the assignment of frequencies in the granting of licences, monitoring is conducted to ensure that the frequencies to be assigned to a new system will not create any interference to existing users and that the new system is not subjected to interference from

existing users. Scheduled monitoring also provides data that verify spectrum utilisation for expired and surrendered licences.

3. Compliance with technical parameters. It is mandatory that licensees adhere to the terms and conditions of their licences. The Authority's scheduled monitoring activities are critical in the detection of non-compliance with respect to technical parameters, e.g., power levels and frequency drift.

   One area of particular concern is the level of RF activity, i.e., electromagnetic radiation in the vicinity of radio transmitting equipment which should, at all times, conform to the limits established by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) vis-à-vis exposure to the public.

4. Spectrum audits to identify the unauthorised use of spectrum. The unauthorised use of spectrum poses interference problems for existing users and translates to a loss of revenue for the Authority. Detection of such unauthorised use is of paramount importance. Scheduled monitoring is used to gather information to determine the unauthorised use of the spectrum.

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45. The Authority shall perform both responsive and scheduled monitoring activities, in accordance with its objective to manage the national spectrum resource, and act to deter or eliminate any harmful interference.

46. The Authority shall ensure that its "real-time" computerised spectrum monitoring and management system is effectively managing the use of the radio frequency spectrum resources in Trinidad and Tobago.

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