An Analysis of Licensed Shared Access Use in Brazil - Advantages and Challenges

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***Abstract*—The increase in mobile network traffic is leading to a spectrum scarcity challenge. Spectrum sharing techniques, such as Licensed Shared Access (LSA), are an effective solution to enhance spectrum utilization and, as a result, support the growing volume of mobile network traffic. This paper provides an overview of the LSA technique and its regulation around the world. An analysis of the technique's implementation in Brazil is also presented, outlining the benefits for the National Telecommunications Agency (Anatel), current spectrum incumbents, and future LSA licensees. Furthermore, the 900 MHz, 2.3 GHz, 3.7 GHz, and 26 GHz bands have been proposed as promising candidates for the implementation of the LSA technique in Brazil.**

Keywords – Spectrum Sharing, Licensed Shared Access, LSA

I. Introduction

Mobile network traffic is experiencing significant growth, leading to an escalating demand for spectrum [1]. Bands exclusively licensed for long-term commitments hinder efficient spectrum utilization since some of these bands remain underused in many areas where they have been licensed. A solution for harnessing this idle spectrum is Licensed Shared Access (LSA).

LSA is a regulatory approach that allows spectrum sharing through an "individual licensing regime." This approach manages the introduction of new users, termed LSA licensees, into a spectrum band already allocated to a spectrum incumbent [2]. Consequently, LSA licensees share the spectrum with existing operators, coordinating their operations so that all spectrum users (incumbents and LSA licensees) can benefit from a specified QoS [3].

LSA is facilitated through a Sharing framework developed by the National Regulatory Authority (NRA) and necessitates participation from all relevant stakeholders, including the NRA, incumbents, and LSA licensees. The Sharing framework comprises a set of rules or compatibility conditions that define the technical and operational terms for spectrum sharing under LSA [2].

Anatel, Brazil's NRA, has expressed interest in this technique to optimize spectrum utilization. Therefore, the primary objective of this paper is to assess its feasibility for implementation in Brazil, pinpointing potential candidate bands for use and evaluating the benefits and challenges for all parties involved. Moreover, this paper introduces the LSA technique and deliberates its regulation in various parts of the world.

The structure of this paper is organized as follows: Section II describes the LSA approach and its version, eLSA (evolved Licensed Shared Access); Section III offers an overview of how the technique is approached globally, while Section IV examines a potential implementation of LSA in Brazil, considering the benefits, challenges, and possible candidate bands; Section V concludes this paper and outlines future works.

II. LSA/eLSA Archiecture

The LSA technique is a valuable solution for optimizing spectrum usage. Information about the existing networks is stored in a repository to ensure harmonious coexistence among the various licensees in the band,. This repository is accessed by LSA licensees who need to obtain prior regulatory approval to automatically access the spectrum under specific conditions, thus allowing for efficient and coordinated use of the available spectrum [2].

In a Licensed Shared Access (LSA) implementation, we have the following functional blocks, as shown in Figure 1:

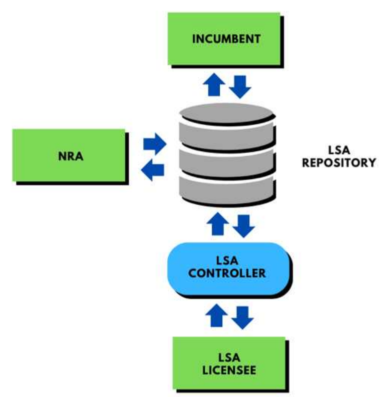

Figure 1 - LSA Functional Blocks

- LSA Repository: The LSA repository aims to provide information about spectrum availability and its associated conditions. This data can be subject to changes over time. The repository may be managed by the NRA, the incumbent, or duly authorized third parties [4].
- LSA Controller: The LSA controller is responsible for managing access to the spectrum made available to LSA licensees based on sharing rules and information about the incumbent operator's usage, which is sourced from the LSA repository. The LSA controller also ensures secure and reliable access to spectrum data from the LSA repository. It can interact with one or several LSA

repositories and with one or multiple licensed LSA networks [4].

LSA is particularly useful for expanding the bandwidth utilized by mobile network operators, allowing them to obtain licenses to operate on additional bands beyond those already licensed, thereby increasing the total bandwidth available through the Carrier Aggregation (CA) feature [5]. Figure 2 shows an example of LSA being used for this purpose. In it, an operator aggregates two carriers: the one represented in green, which corresponds to the already licensed spectrum, and the one depicted in blue, which corresponds to the LSA spectrum.

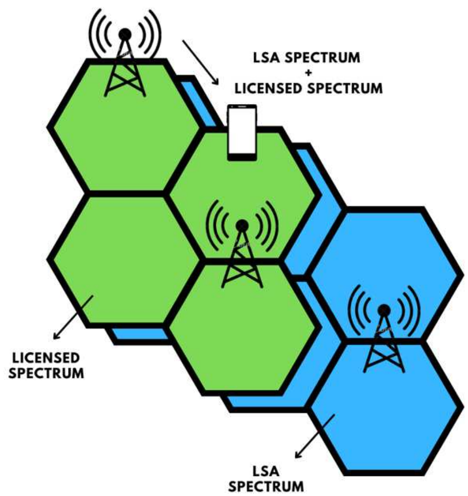

Figure 2 - LSA Carrier Aggregation

The ETSI (European Telecommunications Standards Institute) worked on an evolved version of the LSA framework called eLSA (evolved Licensed Shared Access) [6].

The aim is to facilitate spectrum access for high-quality local wireless networks operated by verticals, such as industrial automation, audiovisual production, public protection, and e-health sectors [6].

While the initial version of LSA mainly targeted mobile communication operators, the eLSA approach aims to consider and cater to the needs of other market systems, opening opportunities for a larger number of stakeholders seeking to use the shared spectrum to safeguard their businesses and implement high-quality services [6].

The findings of the "ETSI Technical Report (TR) 103 588" identified several use cases within the realm of "high-quality local wireless networks" and proposed three viable spectrum access schemes to facilitate eLSA operations: Local licensing, Renting/Sub-renting and Spectrum as a Service [7].

ETSI established eLSA as a frequency-independent technological approach. It is proposed in International Mobile Telecommunications (IMT) and non-IMT bands. The IMT bands are motivated by the availability of devices already operating in these bands. However, eLSA should be applicable regardless of the frequency band [8].

III. Overview of the LSA Approach Worldwide

Countries worldwide are working on research and pilot tests with the LSA technique.

The first LSA pilot project was established in Italy in 2015. The 2.3-2.4GHz band was chosen for spectrum sharing using the LSA approach. In Italy, the main incumbent in this band is the Fixed Service. However, the band is also used by the PMSE (Programme Making and Special Events) services and, to a small extent, by governmental use [9].

The Sharing Framework was established to define the spectrum usage rules. Criteria such as the maximum allowed interference-to-noise (I/N) ratio were adopted to protect the incumbent services in the 2.3-2.4 GHz frequency band. This pilot allowed testing the feasibility of LTE (Long Term Evolution) systems operating as LSA licensees, ensuring the correct application of sharing rules and the protection of existing services [9].

The pilot results demonstrated the feasibility of shared use of the 2.3-2.4 GHz band to meet the growing demand for broadband wireless connectivity [9].

In 2020, Portugal conducted a pilot test to explore the feasibility and effectiveness of the LSA technique in different spectrum-sharing scenarios. The pilot was conducted in the 2.3-2.4 GHz frequency band, aiming to provide additional spectrum access for MFCN (Mobile/Fixed Communications Networks) broadband mobile services [4].

The main challenge in Portugal was ensuring coexistence between incumbent PMSE application systems and LTE mobile networks. For this, redundant protection mechanisms were adopted and automatic interaction was established between the PMSE system and the LSA database. The test concluded that coexistence between LTE networks and PMSE systems is possible, provided protection and exclusion zones are respected [4].

Finland also conducted a field test in the 2.3-2.4 GHz band in 2014, concluding that spectrum sharing using the LSA concept between incumbents (PMSE system) and LSA licensees, which were an LTE network, was feasible [10].

Later, in 2020, Finland carried out new field tests with an innovative focus, exploring the coexistence between satellite systems and cellular networks in the pioneering 5G bands, which include the 3.4-3.8 GHz and 24.25-27.5 GHz frequencies. Four use cases were proposed in which satellite systems acted as incumbents, terrestrial networks were licensed under the LSA technique, and vice versa. The research sought to assess issues such as interference between systems, evacuation time in conflict situations, and the ability to change frequency when necessary [11].

Both tests successfully demonstrated the feasibility of the spectrum-sharing concept introduced by the LSA model. Moreover, the pilots helped identify necessary improvements and optimizations, ensuring harmonious coexistence between different systems and efficient spectrum use [11].

The conclusions of the pilot tests conducted with the LSA approach show the possibility of harmonious coexistence of satellite services with terrestrial systems in the same frequency bands. However, it is important to emphasize that further work is still needed to assess interference limits that the regulatory framework should allow, ensuring the protection of incumbents and the quality of services.

Another significant conclusion is that the spectrum sharing concept, like LSA, can be extended to mmWave frequency bands, which might open new opportunities for spectrum access and drive the development of advanced wireless network technologies.

IV. Analysis of LSA Implementation in Brazil

In order to support a future introduction of the LSA technique in Brazil, this section is dedicated to analyzing its potential implementation in the country. In this context, we will discuss the benefits for the NRA (called National Telecommunications Agency – Anatel in Brazil), incumbents, and future licensees under the LSA regime. Furthermore, we will address the challenges inherent to this implementation and the most promising bands for its adoption in the Brazilian territory.

A. *Benefits for NRA (Anatel), incumbents, and future LSA licensees*

a) Benefits for incumbents:

- By sharing their underutilized spectrum with third parties, incumbents can receive monetary compensation from the LSA-licensed service, leading to increased revenue and profit;
- Sharing via the LSA technique is a secure approach, as the rules and conditions for sharing will be agreed upon and overseen by the NRA. Plus, there is the possibility to reclaim the band (as long as defined in the sharing agreement);
- Ensuring broader spectrum usage prevents the loss of broadcasting rights in the band due to underutilization.

b) Benefits for LSA licensees:

- The primary benefit for LSA licensees is access to new spectrum, leading to increased data traffic capacity;
- In the case of the LSA licensee being an MNO, they can gain access to new low-cost LSA bands for new 4G/5G networks without strict coverage obligations;
- Savings on network expenses can be achieved by acquiring new LSA spectrum and deploying base stations in existing locations instead of densifying a current network deployment in an exclusive spectrum band, which would require more significant investments;
- The MNO can use an LSA band in network congestion situations, offloading users to the LSA band with guaranteed QoS.

c) Benefits for NRA:

- Ensure spectrum access for different services and improve spectrum usage efficiency;
- The social benefit of ensuring the best use of a natural resource;
- Provide more spectrum to new market players through LSA licensing;
- Fulfill its social role by ensuring spectrum availability for various purposes. Finding a fair balance between different demands and services.

B. *Challenges of Implementing LSA in Brazil*

In implementing LSA in Brazil, several key challenges must be considered to ensure the harmonious coexistence between LSA licensees and spectrum incumbents.

One such challenge is the need for a reliable sharing agreement between the primary user (incumbent) and the LSA licensee, which is put into place under the supervision of Anatel. Anatel should establish the conditions under which the incumbent commits not to cause excessive interference to the LSA licensees and the conditions under which LSA licenses might be asked to cease using the band due to unforeseen requirements of the incumbent to use it again [7].

Anatel must ensure that the behavior of the incumbent is predictable, meaning that unforeseen needs to reclaim band usage are genuinely rare.

Protection and exclusion zones are of utmost importance in LSA management, as they guarantee the protection of incumbent holders by specifying the maximum interference levels allowed on the receivers based on the protection criteria determined by Anatel [12].

Exclusion zones require LSA licensees to prohibit using LSA bands within a specific geographic area and time period.

On the other hand, protection zones require interference levels caused by LSA licensees to remain below a maximum limit defined in the sharing agreement [12].

Managing cross-border issues is also crucial to prevent undesired interferences in LSA systems. In this regard, there are two management options: to set up a separate LSA repository and management entities on each side of the border or to create a common LSA repository containing spectrum usage information for stakeholders on both sides of the border [12].

Cross-border setup is essential to ensure that the spectrum is used efficiently and without causing issues between neighboring countries [12].

C. *Candidate Bands for LSA Implementation in Brazil*

In Brazil, the National Telecommunications Agency (Anatel) assigns and manages spectrum licenses for the incumbents. Thus, incumbents hold these licenses and have exclusive rights over the licensed spectrum.

As this study outlines, the LSA technique is ideal for use in underutilized spectrum bands. This allows the spectrum to be used by licensed LSA systems, thus ensuring greater efficiency in the use of this spectrum.

Figure 3 displays the distribution of base stations in Brazil according to their operating frequencies. Based on this distribution's analysis, bands centered at 700MHz, 850MHz, 1.8GHz, 2.1GHz, and 2.5GHz were eliminated as candidates, as their high usage hinders the feasibility of sharing using the LSA approach. Moreover, the 3.5GHz frequency was excluded due to its rapid growth linked to the 5G expansion in Brazil.

Therefore, this study suggests the examination of the following frequency bands as potential candidates for the LSA technique implementation in Brazil: 900 MHz (898.5 - 960 MHz), 2.3 GHz (2.3-2.4 GHz), 3.7 GHz (3.7 - 3.8 GHz), and 26 GHz.

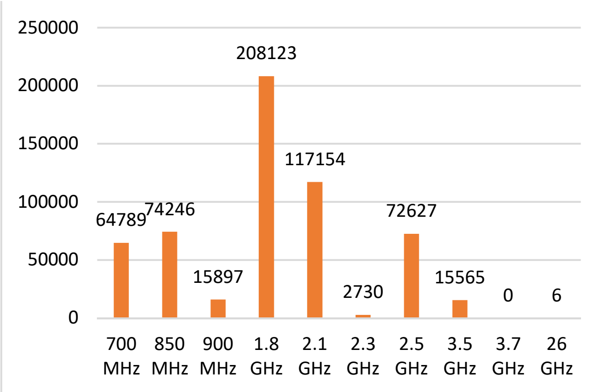

Figure 3 – Number of Base Stations by operating band

In this study, we utilized data from six leading operators in Brazil, referred to as Operators **A**, **B**, **C**, **D**, **E**, and **F**, to preserve the confidentiality of their identities.

Brazil is composed of 27 states, spread across five geographic regions: North, Northeast, Central-West, Southeast, and South. In this study, we will adopt a specific nomenclature for each region. Thus, the North region will be represented by 'NO', the Northeast by 'NE', the Central-West by 'CW', the Southeast by 'SE', and the South by 'SO'.

a) 900 MHz

The 900 MHz band is currently composed of 4 blocks of 5 MHz, distributed from 898.5 MHz to 960 MHz [13]. This frequency band is characterized by providing a good coverage range. Figure 4 shows the number of base stations by operators operating in the 900 MHz band. There are 13,056 base stations, a low number compared to other frequencies, such as 700MHz, where 56,961 stations operate [14]. Additionally, Figure 5 displays the distribution of base stations in the 900 MHz band by operator across the five regions of Brazil, highlighting the underutilization of this spectrum band in all of them[14].

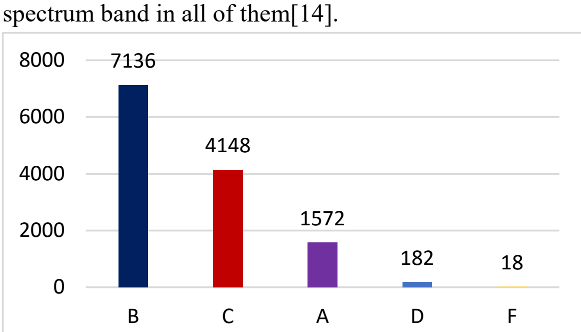

Figure 4 – Number of Base Stations by operator in the 900MHz operating band

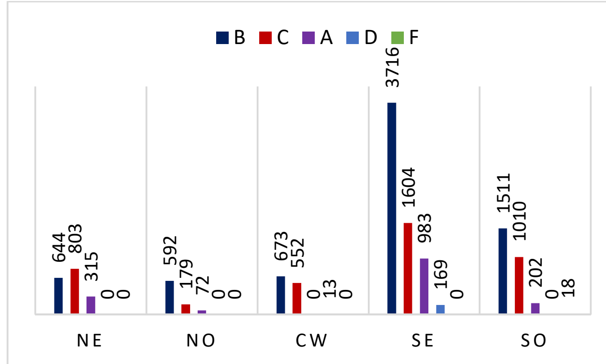

Figure 5 – Distribution of base stations by operator in the 900MHz Band across the five regions of Brazil

This band can be exploited through horizontal and vertical sharing.

In horizontal sharing, operators operate under the LSA licensing regime, entering into sharing agreements with other carriers. Thus, in areas where one operator is not using the frequency, another operator can utilize it. This arrangement can generate revenue or be based on a cooperation agreement model between operators.

In vertical sharing, operators issue licenses to other market verticals. Considering the evolution of mobile communications, several IoT and Industry 4.0 applications can benefit from this spectrum derived from LSA licensing.

b) 2.3 GHz

The 2.3 GHz band consists of 50 and 40 MHz blocks, spanning from 2.3 to 2.4 GHz [13]. Each state has operations from 1 to 3 operators.

Figure 6 shows the number of base stations by operators operating in the 2.3 GHz band. There are 2258 stations, serving 480 municipalities [14]. This scenario makes this band a high-potential candidate for sharing under the LSA approach. Additionally, Figure 7 illustrates the distribution of base stations by operator in the five regions of Brazil, considering this specific spectrum band. From it, the spectrum's idleness is evident due to the limited activity of the operators.

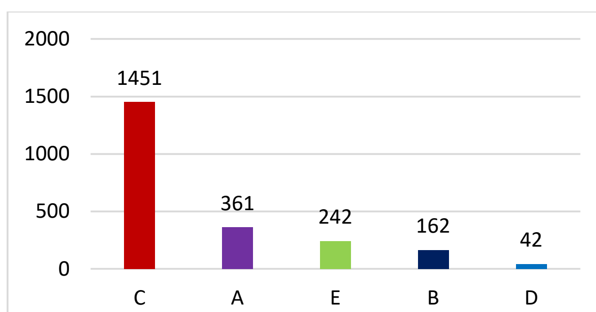

Figure 6 - Number of Base Stations by operator in the 2300 MHz operating band.

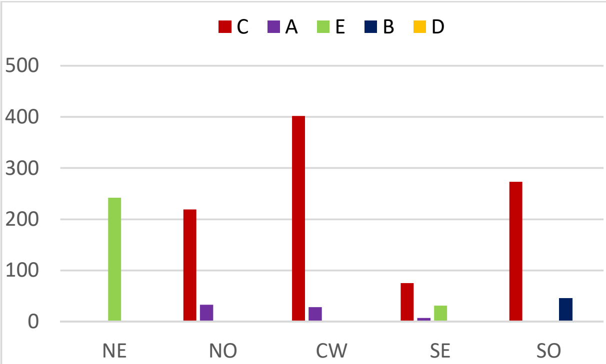

Figura 7 - Distribution of base stations by operator in the 2.3 GHz Band across the five regions of Brazil

Just as in the 900MHz band, the 2300MHz band can also be exploited through horizontal and vertical sharing.

c) 3.7 GHz

The frequency range of 3.7-3.8GHz is part of the C Band. The C band encompasses the range from 3.3 GHz to 4.2 GHz and has gained global attention because it is pointed out as one of the main bands for 5G mobile system operations.

In Brazil the 3.3-3.7 GHz range currently has mobile system operators as incumbents. However, the 3.7 to 4.2 GHz range has the Fixed Satellite Service (FSS) as the incumbent.

Anatel, in the Spectrum Use Plan 2021 to 2028, determined that the 3.7-3.8 GHz band will be shared between the Fixed Satellite Service and private 5G networks [15]. Anatel also identified LSA as a promising technique for managing sharing in this band [15].

Currently, the sharing in this band is done statically. In June 2022, Anatel approved the technical requirements for the use of the 3.7-3.8 band for low-power terrestrial mobile stations. The published act defines that in an area where satellite systems do not utilize the band, licenses can be issued for signal transmission by 5G antennas with a maximum power of 30dBm/10MHz in an Indoor system and 26 dBm/10MHz in an Outdoor system. Moreover, the band was divided into ten blocks, which are presented in Table I [16]:

TABLE I. BLOCKS OF FREQUENCY SUB-BANDS

Block	Sub-band (MHz)	Block	Sub-band (MHz)
41	3.700 a 3.710	46	3.750 a 3.760
42	3.710 a 3.720	47	3.760 a 3.770
43	3.720 a 3.730	48	3.770 a 3.780
44	3.730 a 3.740	49	3.780 a 3.790
45	3.740 a 3.750	50	3.790 a 3.800

This solution presents limitations that directly influence the efficiency of spectrum utilization:

- Licenses grant rights over the spectrum to new operators even when they are not operating;
- Maximum power is set statically;
- Furthermore, the blocks are also licensed statically.

Using the LSA approach, the spectrum can be controlled dynamically due to the management adopted by the LSA controller, where there would be spectrum coordination for several licensed users using the network. The main benefits would be:

- More than one network could be licensed simultaneously, and the LSA controller would manage the spectrum for the active licensed users;
- The LSA-licensed users can operate at higher power levels, according to the permission of the LSA controller. Always protecting incumbent systems through all the protection zones and exclusion zones, which are stored in the LSA repository;
- The defined blocks could be shared dynamically by active users.

In summary, while the current sharing, defined by the Act, brings static geographical sharing, LSA provides dynamic geographical, temporal, and spectral sharing.

d) mmWave

5G considers new millimeter wave bands for operation. These bands were agreed upon at WRC-19 and included several bands above 24.25GHz [17].

In Brazil, Anatel auctioned the 26 GHz band to operators A, B, C, and D.

Operators **A**, **C**, and **B** acquired national licenses with bandwidths of 600 MHz, 400 MHz, and 200 MHz, respectively. Operator **D** acquired a regional license with a bandwidth of 1000 MHz for certain cities in four states.

High frequencies like those of these bands are characterized by providing connections with high data rates due to high bandwidths but with limited coverage, as millimeter waves suffer high attenuation in free space and by obstacles.

Therefore, the operators holding operating licenses in these bands in Brazil do not plan to use the frequencies to meet coverage goals but in specific points that require high rates.

Sharing through LSA can be a business model for operators to share this spectrum, which will be idle, with other operators and market verticals that also need spectrum for their operations. Thus ensuring the technique's benefits, good use of the spectrum, generating revenue for incumbents, and new opportunities for future licensees.

V. CONCLUSION

In this study, we analyzed the implementation of the LSA spectrum-sharing approach in Brazil for more efficient spectrum use.

The main benefits of a potential implementation of the technique for Brazil's NRA, Anatel, incumbent operators, and future LSA licensees were highlighted.

The implementation of LSA offers opportunities for both horizontal and vertical sharing. In the context of horizontal sharing, Brazil could reap significant benefits, given that we have leading operators in various regions of the country, which can be emphasized through the following points:

- The National Operator **A** is pioneering in its operations in the Northeast, where it has a large number of base stations across all states [15]. It could use additional spectrum from the LSA approach, allowing the use of idle spectrum from operators with a smaller presence in this region.

- National Operator **B**, leading in its operations in the South and Central-West, would have the opportunity to acquire additional spectrum through the LSA licensing of operators with a less significant presence in that area.
- The largest regional operators mentioned in this article, **D** and **E**, hold spectrum with the right to operate in specific geographic regions [14]. However, due to the smaller number of Base Radio Stations compared to national operators, there is underutilization of the spectrum across vast geographic areas [15]. LSA licensing would allow these operators to provide their spectrum as incumbents while achieving financial returns.

Regarding vertical sharing, this approach could encourage the entry of new operators into the market, boost the automation of existing companies, and contribute to rural connectivity projects, one of Brazil's main areas of research and action.

In this study, we analyzed the 900 MHz, 2.3 GHz, 3.7 GHz, and mmWave bands as potential candidates for the LSA approach in Brazil. We concluded that, in all these bands, the approach would be viable, bringing benefits for spectrum utilization.

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