GTI White Paper

Global TD-LTE Initiative

Optimized Spectrum Use with LSA/ASA

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Executive Summary

Mobile data has grown dramatically over the recent years. It is projected to continue with ever more people moving to ever more data hungry devices and applications. Cisco recently confirmed this trend in their Visual Networking [1] with 61% compound annual traffic growth rate between 2013 and 2018, excluding Wi-Fi offload of mobile devices. Consequently, the traffic to be carried on the IMT networks alone is projected to almost double every year. This leads to a huge challenge in terms of higher network efficiency, more Base Stations and substantially more spectrum to be made available for IMT.

To meet the requirements on more spectrum, GTI sees exclusive spectrum access remaining the basis for IMT. But spectrum sharing techniques can be used to optimize spectrum utilization and, more importantly, to provide opportunities for operators to access additional spectrum, which is typically allocated to other radio services and thus not available via traditional exclusive licensing. Licensed Shared Access (LSA), also known as Authorized Shared Access (ASA), is a new regulatory concept that allows license holders (incumbents) to share spectrum with other service providers, under well-defined conditions and provide predictable quality of service. The purpose of LSA is not to replace the traditional exclusive access. LSA would enable the sharing of spectrum with non MNOs incumbents. For the bands which is still possible to license for IMT via re-farming or just being included in the ITU IMT spectrum proposals, e.g. UHF 700 MHz, lower C-band, etc., the exclusive approach should be firmly stuck to.

GTI recommends regulators to consider LSA in harmonised bands which are difficult to redistribute or repurpose to mobile/IMT within a reasonable time frame and that can help mobile network operators turn the spectrum challenge into big opportunities. And in addition, GTI proposes to consider LSA on two potential global harmonized TDD bands of 2.3GHz in Europe and 3.5GHz in U.S.

Terminology

Abbreviation	Explanation
3GPP	3rd Generation Partnership Project
ASA	Authorised Shared Access
BS	Base Station
CEPT	European Conference of Postal and Telecommunications Administrations
ECC	Electronic Communications Committee of the CEPT
ERM	Technical Committee ERM (Electromagnetic Compatibility) and Radio of ETSI
ETSI	European Telecommunication Standards Institute
FCC	Federal Communications Commission
FM	Working Group Frequency Management of ECC
GTI	Global TD-LTE Initiative
HetNet	Heterogeneous Networks
IMT	International Mobile Telecommunications
ITU	International Telecommunication Union
ITU-R	International Telecommunication Union – Radio Communications Sector
LSA	Licensed Shared Access
LTE	Long Term Evolution
MNO	Mobile Network Operator
MWC	Mobile World Congress
NRA	National Regulatory Authority

OAM	Operation, Administration and Maintenance
QoS	Quality of Service
SRDoc	System Reference Document of ETSI
RAN	Radio Access Network
RRM	Radio Resource Management
RRS	Technical Committee Reconfigurable Radio Systems of ETSI
RSPG	Radio Spectrum Policy Group
TD-LTE	Time Division Long Term Evolution
TDD	Time Division Duplex
UHF	Ultra High Frequency
WRC	World Radiocommunication Conference

1. Introduction

The IMT (International Mobile Telecommunications) networks face a tremendous increase in data traffic volumes over the next 20 years. To satisfy this demand, large amounts of spectrum will be a key prerequisite for any radio access network evolution. The mobile network operators will need new spectrum allocations on the one hand and, on the other hand, how to provide new spectrum allocations for IMT development is an important consideration for regulators. Looking at the situation of the regulator's spectrum allocation globally, the spectrum suitable for cellular mobile communication is very crowded and it's difficult to find some unused spectrum below 6GHz for IMT. On the contrary, some specific spectrum allocated for some non-IMT service is not utilized well, e.g. only utilized in limited local area or limited time and frequency domain. If such kind of characteristics of the spectrum utilization in time, frequency and geographical domain could be taken into account, it would provide an opportunity for the operators to share the spectrum for different service. This kind of spectrum sharing is called as Licensed Shared Access (LSA) or Authorized Shared Access (ASA).

This white paper will provide analysis on the versatile spectrum use for more spectrum, and focus on LSA as a complementary method to exclusive usage and unlicensed usage, bring deep insights into the LSA applicable scenario/conditions, impacts to industry, economical benefits and the prerequisites, etc. In the last section, GTI also provides observations and recommendations on LSA to regulators and operators to turn the spectrum challenge into opportunities.

2. Spectrum Versatile Use

The higher demand on the data-enriched mobile services accelerates the development of the IMT. However, the planned availability of licensed spectrum might not be sufficient to satisfy the increased demand for mobile bandwidth. So how to manage and use the spectrum is a key issue to be considered by the government, regulators, operators and manufacturers. In this section, the spectrum demand for IMT development is briefly introduced, and then versatile spectrum usage is reviewed to give a full picture of the spectrum usage from the low frequency bands to higher frequency bands. Besides clearing the planned exclusive spectrum for IMT as the top priority method, additional spectrum could be made available with the spectrum sharing approaches such as LSA.

2.1. Spectrum Demand for IMT Development

Spectrum is a scarce non-renewable resource that is the basis of a mobile communication network. However the demand for spectrum due to IMT development is increasing in exponential growth.

The mobile data over the recent years is in a dramatic growth. It is projected to continue with ever more people moving to ever more data hungry devices and applications. Cisco recently confirmed this trend in their Visual Networking [1] with 61% compound annual traffic growth rate between 2013 and 2018, excluding Wi-Fi offload of mobile devices. Consequently, the traffic to be carried on the IMT networks alone is projected to almost double every year. This leads to a huge challenge in terms of higher network efficiency, more Base Stations and substantially more spectrum to be made available for IMT.

How to manage spectrum responsibly, how to meet the spectrum demand efficiently and rationally and how to improve spectrum utilization are extremely pivotal for government, regulator, operators and manufacturers.

2.2. More Spectrum with Versatile Spectrum Use

The spectrum, deployment strategies and the allocation status or availability are complicated but a suitable approach to utilize the specific spectrum should consider all the aspects.

Spectrum between 400 MHz and 6 GHz is best suited for mobile applications as lower bands would require antennas too large to be integrated into mobile devices, and higher bands would limit cell sizes. This entire range of “good” spectrum, however, is already allocated to a number of different services and technologies, such as broadcast, aeronautical, satellite, defense, public safety and other commercial and non-commercial services; many of which do not utilize the spectrum intensively. There are several ways to get more spectrums for mobile networks. ‘Clearing the spectrum’ is one straightforward way to free up more exclusive spectrum for MBB use. This has been best practice over the years, and will continue to be the preferred option for cellular mobile networks. In most cases, however, clearing spectrum requires significant investment and/or lengthy development time. Thus spectrum sharing approach may be, cost-wise and time-wise, a very efficient means to gain at least partial access to additional spectrum resources for IMT use.

Frequency bands below 1 GHz are in key position for network coverage. The amount of this coverage spectrum is very limited and typically as of today there are only

10~30 MHz carriers available per operator. Additional coverage spectrum can be made available by clearing spectrum from terrestrial TV broadcast, like it has been done in Europe for 800 MHz band and is under way for global harmonization of the 700 MHz band. In longer term, this should continue also into bands below 700 MHz.

High frequency bands can provide additional spectrum (e.g. 1800/1900, 2100, 2600 MHz bands and C-bands) for each Base Station, while the Heterogeneous Networks (HetNets) and network densification (adding more macro and micro Base Stations) could expand the network capacity further. Adding more bands provides a means of capacity expansion. In longer term, e.g. lower C-band (3400-3600 MHz) and higher C-band (3600-3800 MHz) would be ideal for small cell deployments, offering even larger amounts of spectrum and thus enabling very dense small cell layer with very high capacity on top of existing HetNet. Spectrum sharing techniques can be used to optimize spectrum utilization and, more importantly, to provide opportunities for operators to access additional spectrum, which is typically allocated to other radio services and thus not available via traditional exclusive licensing. In this way different spectrum sharing options are complementing network capacity.

The figure below provides an exemplary roadmap showing how spectrum use by IMT could evolve in Europe towards the year 2020. Here, beside the evolution of classic exclusive use (yellow color) new sharing options involving LSA at 2300 MHz and co-primary sharing in the upper C-band (light grey color) can contribute significantly after 2015. Furthermore, the roadmap indicates (dark color) potential long term co-primary usage options in the Lower UHF bands (470–694 MHz) which are currently allocated to broadcast services on a primary basis. As illustrated, a total of 1500 MHz could be made available for IMT during the next 10 years and spectrum sharing techniques will provide an important contribution. Furthermore, it is expected that in the upcoming World Radio communications Conference 2015 (WRC-15) even some additional bands not listed here will be identified for IMT.

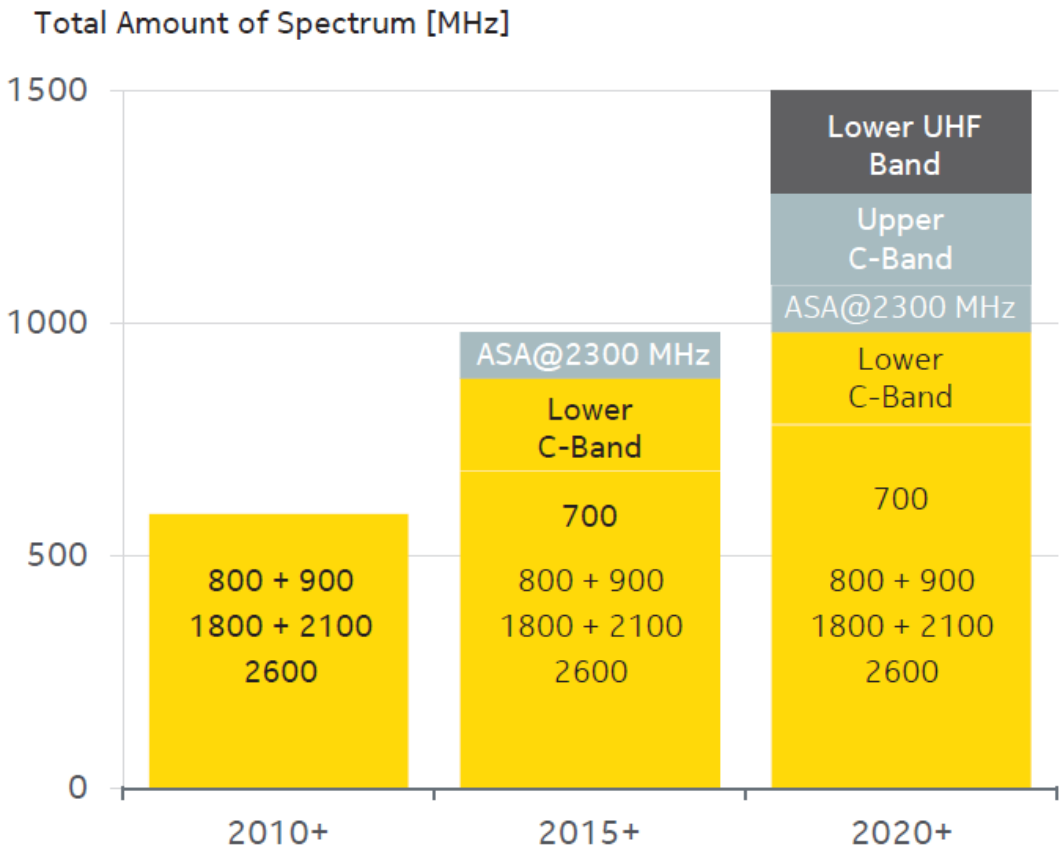

Figure 1: Example Spectrum Roadmap for IMT highlighting the key bands in Europe

Ultimately, the availability of spectrum and the efficiency of its usage contribute fundamentally to the achievable capacity and performance of radio networks. Furthermore, affordability is crucial, so the harmonization of radio frequency bands will remain important to ensure economies of scale, to facilitate roaming and to minimize interference across borders. Spectrum harmonization should be a key policy objective in line with ITU-R recommendations.

3. LSA as a Complementary Method

In last section, the spectrum sharing is discussed as being used to optimize spectrum utilization to provide opportunities for operators to access additional spectrum. Since mobile networks are based on predictable quality of service; therefore it is required that sufficient control mechanisms be implemented when applying spectrum sharing. Licensed Shared Access (LSA) is a new regulatory concept that allows license holders (incumbents) to share spectrum with a limited number of service providers, under well-defined conditions and provide predictable QoS. However, the exclusive spectrum access is still remaining the basis and top priority for IMT, and unlicensed spectrum as a possibility to increase data rates, LSA is as a

complementary method for spectrum regulation in the quest for additional spectrum for IMT which may not succeed based on exclusive spectrum allocations alone.

3.1. Exclusive License Remains Top Priority

Aiming to make more spectrum available for mobile services, the most widely used way is through a market-driven mechanism, namely spectrum auctions, which create huge socio-economic benefits and ensure best experience for users.

Since their introduction in 1994, spectrum auctions have been remarkably successful in assigning and pricing spectrum. More than 500 auctions have been conducted around the world to assign tens of thousands of wireless licenses. Assigning spectrum licenses to private for-profit companies throughout most of the world, including developed and developing countries, has led to rapid development of wireless telecommunications. The primary advantage of a spectrum auction is its tendency to assign the spectrum to those best able to use it. This is accomplished by competition among license applicants.

From a global perspective, exclusive licensing of spectrum is universally achieved by auctions in contrast to non-exclusive use. Exclusive licensing of spectrum is the model that has underpinned the success story of mobile telephony around the world. The advantage of this approach is that it guarantees that the operator's communication technology will not suffer interference at the hands of other operators/technologies and it also provides a long time window for the operator to deploy their network increasing the likelihood of their becoming profitable. Further, this approach accelerates the development of wireless telecommunications that have become a vital factor in economic development. For the time being, most spectrum is under exclusive terms such as 800MHz, 900MHz, 1800MHz, 2100MHz, 2600MHz, 700MHz, lower C-band and other spectrum in sub-6GHz.

3.2. Unlicensed Spectrum as an Possibility to Increase Data Rates

Besides licensed spectrum described above, there is another spectrum usage - unlicensed spectrum in the 2.4GHz and 5GHz bands, particularly WiFi communication.

In spectrum that is designated as "unlicensed" or "license-exempt," users can operate without a license but must use certified radio equipment and must comply with the technical requirements, including power limits. Users of the license-exempt bands do not have exclusive use of the spectrum and are subject to interference.

In a word, the best way to maximize the value of spectrum in the bands is to make it available for licensed use whatever the challenges, while unlicensed spectrum uses occupied by other services e.g. Wi-Fi start to play a more important role than before in addressing the explosive data demands. However the unlicensed spectrum could only provide best-effort service, and the QoS is not predictable and reliable.

3.3. LSA to Open More IMT Spectrum providing QoS

Current spectrum allocation mechanisms are based on either exclusive allocation to an operator or unlicensed/license-exempt operation. The former is commonly used because of its well-known ability to provide predictable QoS in all load situations. The latter, unlicensed scheme, are also well known but on the expense of providing no QoS guarantees since there are no limits on the number of users/operators in a given geographical area.

Despite the great success of exclusive licensed spectrum and the increasing possibility of unlicensed spectrum for mobile services, “spectrum crunch” still exists, impelling the industry to find innovative solutions to access those underutilized spectrums held by other services.

Many bands already host important services that must have access to spectrum but do not necessarily use it fully:

a) Some only use spectrum in certain regions, e.g. big cities, airports, etc. For example, spectrum allocated to defense organizations might only be required in a few geographic locations, with the potential for it to be made available to IMT in other parts of a given country.

b) Some spectrum have been only used by licensees at certain times of the year, e.g. driven by events, seasonal, etc, and could at other times be made available to other parties.

c) Some bands have been assigned to IMT service in some countries but are difficult to be released by incumbents in foreseeable time and all other potential approaches and negotiations have been best tried before.

New emerging cognitive technologies make it possible to share these spectrums by using radio environmental awareness techniques and interference management, which allow multiple systems to occupy the same spectrum. In order that such capabilities can be realized, new regulatory approaches will be needed that allow more flexible, shared spectrum usage.

Typically there are two types of spectrum sharing schemes widely considered. One example is the so-called TV whitespaces where upcoming technologies like cognitive

radio seem to allow their exploitation. Key to whitespace use is the idea of license-exempt and free access for everyone and every service under a secondary right of use. License-exempt spectrum use and whitespace technology in particular do seem to be compelling solutions to the spectrum crunch problem. Nevertheless, there is a significant drawback: no predictable minimum amount of spectrum available in any location and limitations on allowed transmit powers. Also some other service may require access to the same chunk of spectrum at the same time under the same secondary right of use, such as program making and special events (e.g. wireless microphones). In the case of TV whitespaces, stringent TX power limitations and spectrum masks required to protect TV reception may not allow for large cell ranges in rural areas where wire-free connectivity would be needed most. Conditions to access spectrum are not predictable, so an operator cannot plan for a certain level of coverage, capacity and quality of service - all key elements to justify the business case of an investment into network infrastructure and operations. This may limit the applicability of whitespace technology to initiatives such as municipal Wi-Fi, typically targeted at providing free internet access restricted to best effort conditions.

In another example for regulatory approach, the targeting 2.3GHz band has been assigned to IMT service but is not available in some of European countries since the spectrum is already used by incumbent users, and it is difficult to be emptied by incumbents in foreseeable time and thus this can cause bottlenecks in providing sufficient capacity. To share spectrum with the incumbent users could be one way forward in such exceptional cases, if e.g. the incumbent user is not using its spectrum all the time and/or using it in limited area(s). LSA as the more robust and attractive sharing opportunity fits the case and provides predictable QoS as a complement of exclusive spectrum.

4. LSA Introduction

Spectrum sharing opens opportunities for mobile operators to quickly unlock additional, currently underutilized spectrum, with the LSA approach showing great promise. In particular, LSA is a viable way to share spectrum with existing non-mobile incumbent users that exhibit low or localized utilization in their bands, and where it is undesirable to change the conditions of use within a reasonable time period.

4.1. LSA in General

LSA as being defined and framed by RSPG is a regulatory approach to allow spectrum sharing under well-defined conditions. LSA provides a solution for bands that cannot easily be vacated by their incumbent users, but where actual spectrum usage is underutilized and infrequent. The concept was originally proposed by an industry consortium under the name “Authorised Shared Access”.

Through this new access model a primary license holder (incumbent) would grant spectrum access rights to one or more other users which may then use the band under specific service conditions. Conditions defining how the spectrum may be used would be subject to individual sharing agreements, and to permission from the NRA (National Regulatory Authorities). The NRA would be expected to issue licenses to one, or a very limited number of mobile operators that would allow them to use specific bands as LSA licensees. Thereby orthogonal usage by time, frequency or location should always be coordinated between the operators and the incumbent in order that a certain level of performance predictability can be realized. This setting will provide predictable levels of service quality – thus strengthening motivation for investment in infrastructure compared to the scenario where usage is made available under a license-exempt scheme such as a TV White Spaces concept.

LSA is a valuable spectrum optimization concept, as it aims to balance the needs of legacy spectrum users with those of operators, and it enables timely availability and licensed use of harmonized spectrum with predictable QoS. A major benefit envisioned with LSA is that the number of LSA licensees is limited, and certain spectrum band in the specific region at certain time duration is only authorized to one LSA licensee. The LSA licensee can use the spectrum exclusively with the sharing conditions fulfilled. There are not complicated coexistence problems to be solved among LSA licensees on the LSA framework. Thus, in time, the concept may further evolve to embrace even more dynamic sharing principles.

LSA is a regulatory approach that is technical neutral. It does not restrict any access technologies, and provides enough flexibility adapting to different marketing needs. LSA can unlock additional spectrum, esp. the bands which already identified to IMT however in some regions or countries the band is not obtainable for IMT use in reasonable time due to incumbent use. Since these bands are already global harmonized band with good support from industrial ecosystem and sharing the similar commonalities on coexistence globally, the benefits of opening these bands via LSA is obvious on boosting the economic scale and reducing the cost on providing services.

4.2. LSA Principles

LSA is a new approach to utilize the mobile spectrum that:

- is currently assigned to and used by an incumbent non-mobile user
- exhibits low or localized utilization
- is difficult to redistribute or repurpose to mobile/IMT within a reasonable time frame.

Typical examples are government and military spectrum subject to sparse use, either in terms of geographic coverage or temporal characteristics. Figure 2 shows an example situation in France for the 2.3-2.4GHz band (3GPP band 40) with very localized incumbent military telemetry use.

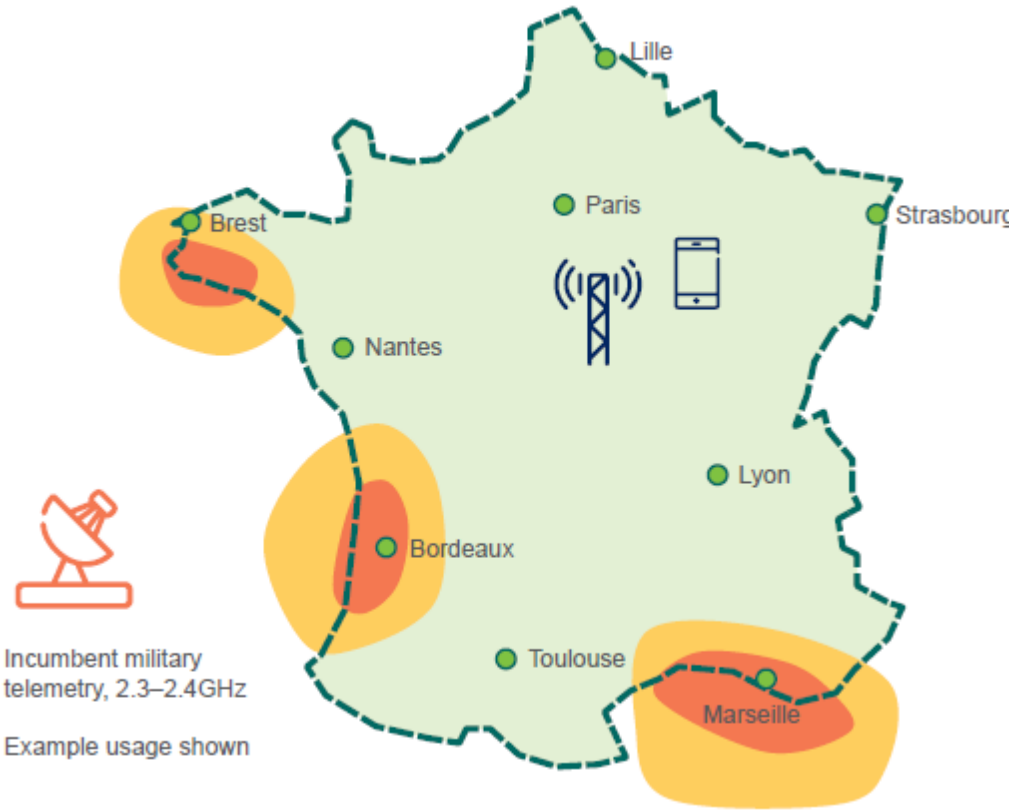

Figure 2: Example situation in France for 2.3-2.4GHz band with localized incumbent military telemetry service

LSA assigns licenses that are similar in structure to dedicated, licensed spectrum with similar benefits to LSA licensees. A LSA spectrum usage right is binary: the spectrum is used by either the incumbent user or by the LSA licensee in any given place at any given time. The low or localized utilization by the incumbent makes it easier to

characterize the rights of the incumbent, and provides scale and certainty to the LSA licensee.

4.3. LSA system architecture

A novel aspect of LSA licenses is that, in order to use the license, the licensee needs a sharing agreement with the incumbent user, based on a sharing framework negotiated multilaterally between the parties and the regulator (see Figure 3). The sharing agreement outlines the terms of shared use in an LSA Repository, including the geographical areas included, technical conditions for protection, and how to vacate the spectrum if needed. Since LSA licensees are known and limited in number, the incumbent user can be certain of adequate protection. Harmonized LSA regulations will facilitate sharing agreements with the incumbent user through well-defined processes and a standardized structure for the technical sharing conditions. As described in [6], the following functional blocks may be required when implementing LSA on a national basis:

A LSA repository is required to deliver the information on spectrum availability and associated conditions when this information is subject to changes over time. The LSA repository may be managed by the Administration, the NRA or the incumbent, or be delegated to a trusted third party.

The LSA controller manages the access to the spectrum made available to the LSA licensee based on sharing rules and information on the incumbent's use provided by the LSA repository. It retrieves information about spectrum from the LSA repository through a secure and reliable communication path.

The LSA controller can interface with one or multiple LSA repositories as well as with one or multiple LSA licensee's networks. The LSA controller may be managed by the Administration, the NRA, the incumbent, the LSA licensee(s) or be delegated to a trusted third party.

There could be one or more repositories and/or controllers per country, depending e.g. on the LSA band and the incumbents' nature. The following figure depicts an example of implementation of LSA with repository and controller.

The LSA repository contains in particular the relevant information on LSA spectrum that must be protected together with the level of protection provided by the incumbent(s).

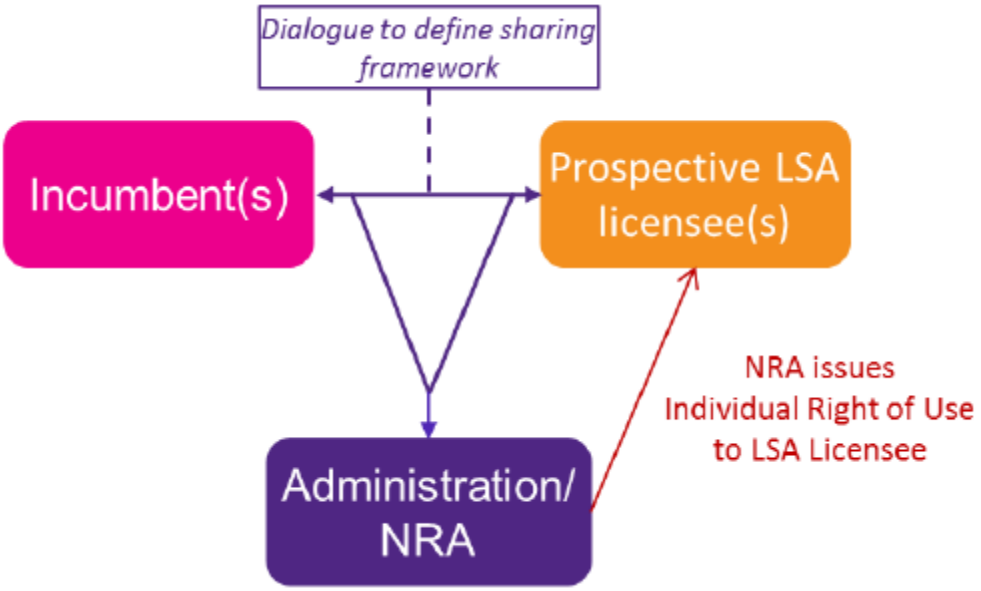

Figure 3: Regulatory process required before the introduction of MFCN in a band under LSA [6]

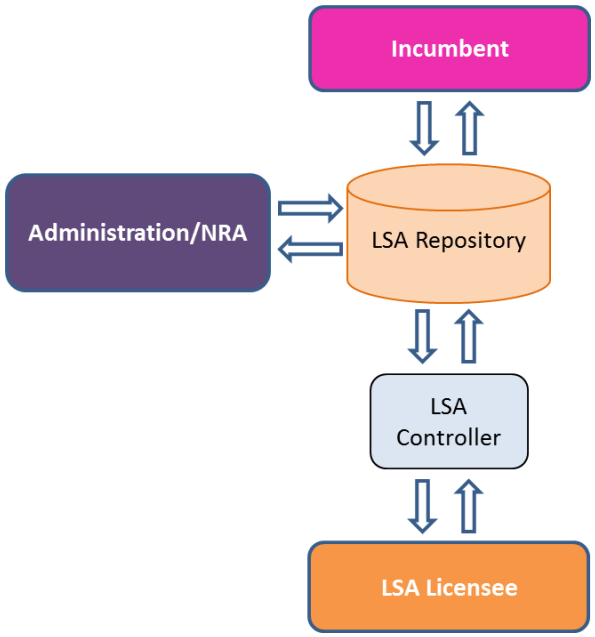

Figure 4: An example of LSA functional blocks and interactions [6]

The following figure depicts an example of implementation of the network with LSA controller and MNO network.

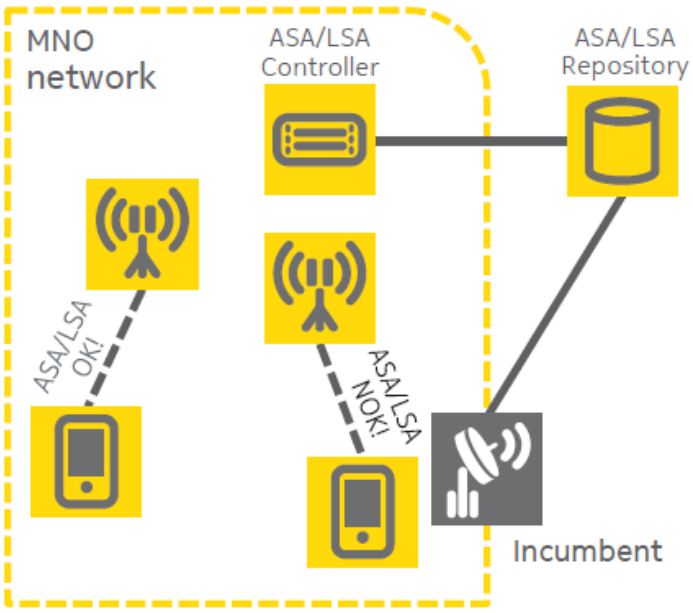

Figure 5: LSA Controller and MNO network

In this example, the LSA controller is fully in the domain of the MNO's network. The design principle for this is that the LSA Controller is fully inside the domain of the MNO's network. The reasons for this and that not an external controller configures the network parameters include:

- Such configuration process requires deep insights into the MNO's radio access network.
- Such configuration requires access to information that is business sensitive for the MNO.
- There are many parameters to be configured taking into account the entire network layout and interactions of Base Stations, which is best managed by the MNO also in order to avoid a real danger of "mis-configuration".
- The MNO must have control to optimize the traffic in its network.
- There are various internal elements to a network that an externally managed Controller cannot and should not oversee.

However, the licensee should be responsible for compliance with technical requirements obtained from the incumbent such as meeting certain interference thresholds. This can best be accomplished via the Controller under the full control of the network operator. There could also be multiple LSA Controllers for each LSA licensee and the Controller can interface with one or multiple LSA Repositories.

4.4. Use Case of a LSA-applied Mobile Network

Mobile broadband networks based on 3GPP specifications for Release 10 (carrier aggregation for LTE) and beyond have extensive multi-carrier functionalities. The

multi-carrier functionalities enable multiple standardized spectrum bands and band combinations to be used together for improved capacity and performance. And LSA band is also possible be utilized similar as a 3GPP band. In most cases, an IMT operator would not rely on LSA band alone but see this as a capacity overlay to services in exclusive spectrum.

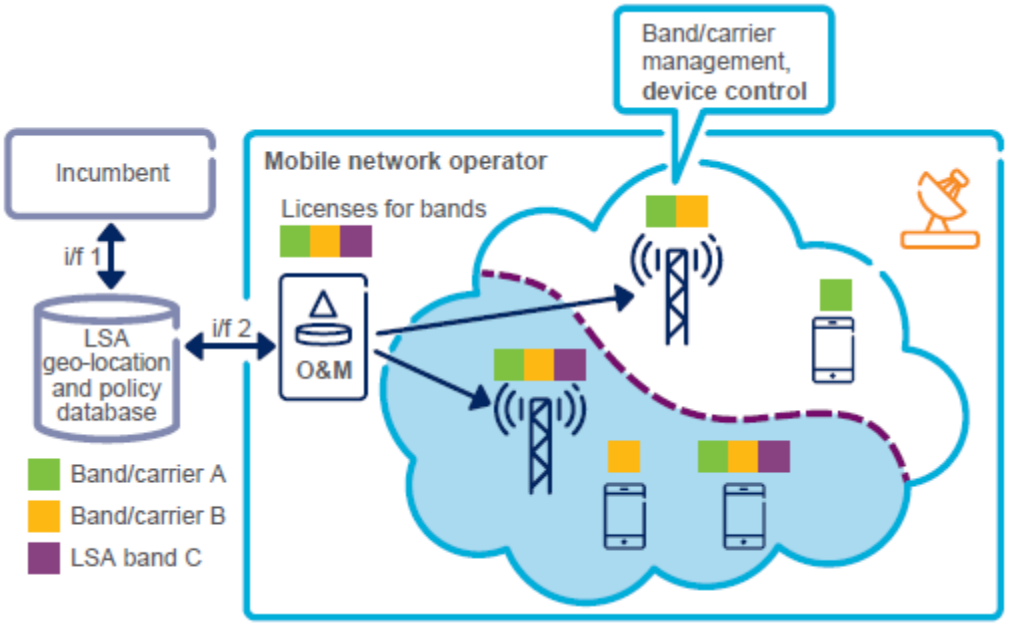

Figure 6: Example of Mobile Operator with multiple frequency bands including LSA band

Figure 6 features a use case example of mobile network operator with licenses for three bands: two standard bands A and B and one LSA band C, which in this case has a geographic constraint on usage. The LSA controller could be distributed in various internal elements of the mobile network, e.g. the Q&M, the BS RRM etc., which an externally managed Controller cannot oversee. The database interfaces reside within the operations and maintenance (O&M) system of the mobile network, which configures the radio network nodes accordingly. The radio network nodes use standardized procedures to manage all the configured bands on a device level. Channels for critical control signaling Radio Resource Management (RRM), mobility procedures and so on) are allocated to standard, non-LSA bands, which ensures that the system can instantly hand over the traffic from a shared LSA carrier to a standard carrier when it becomes necessary.

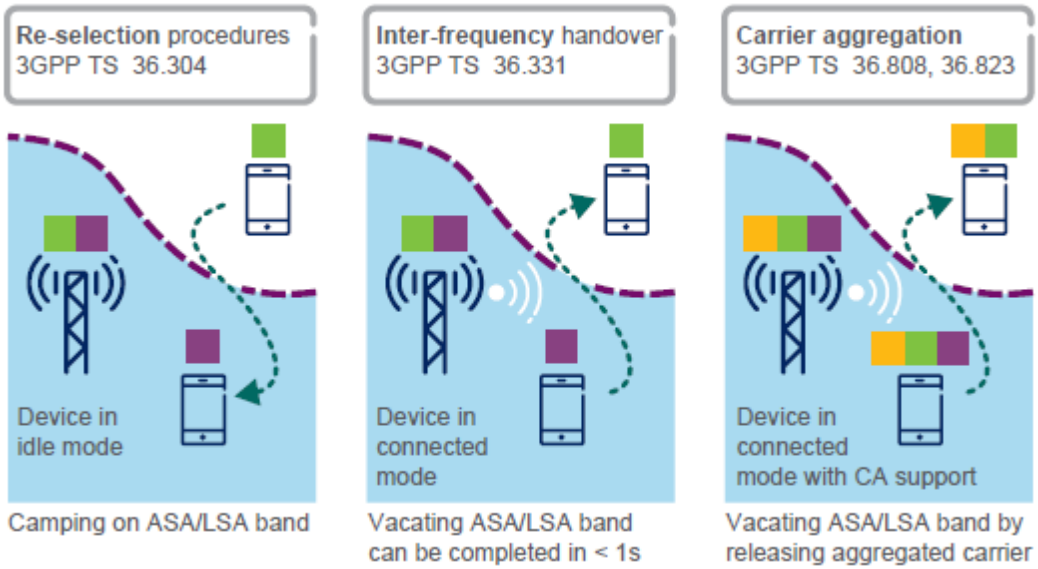

Figure 7: Procedures to manage LSA bands

Figure 7 shows examples of some standardized mechanisms and procedures for efficient band/carrier management on a device level. In cell reselection procedures [3], the UE procedures in idle mode will select and camp on the cell on the LSA band according to the same re-selection procedures in 3GPP TS 36.304. To handle inter-band management for idle-mode devices, the network will instruct a device to camp on a new band. Switching bands for connected mode devices is managed with inter-frequency handover procedures [4] Finally, devices with carrier-aggregation capabilities (LTE R10 and beyond) can use carrier reconfiguration procedures [4][5] to include and remove an LSA band as needed.

4.5. Mobile Devices

From a device perspective, the LSA band is just like any other band; regular multiband devices can be used without any additional changes (provided that radio frequency hardware for the given band is in place). Further, the fixed radio network is controlling the band usage of the mobile devices, which ensures that mobile devices do not use the LSA band when it is not permitted according to the terms of the LSA sharing conditions. This ensures the incumbent reliable protection.

5. LSA Implementation

5.1. Standardization and Regulatory Discussions

The discussions on LSA are actively underway in various regions.

LSA is being developed through the European Commission's Radio Spectrum Policy Group (RSPG), which issued a report on LSA in November 2013 with recommendations to member countries. Ongoing work relating to the 2.3-2.4GHz band in Europe will benefit from LSA regulations (ECC FM 52). Standardization activities on LSA technical conditions and geo-location databases are ongoing at ETSI (the European Telecommunications Standards Institute), where they are being carried out by the Technical Committee on Reconfigurable Radio Systems (RRS).

- CEPT ECC FM52 and FM53 European decision on 2.3-2.4 GHz + general LSA framework for spectrum sharing[6]
- Radio Spectrum Policy Group (RSPG) opinion (Nov 2013), Commission mandate to standardize LSA
- ETSI RRS and ERM, a SRDoc for LSA has been published; technical specifications about system requirements and system architecture are under development in ETSI RRS
- In ECC Decision (14)02[7] approved on June 27, 2014, Licensed Shared Access (LSA) is the recognised approach by CEPT for administrations wishing to introduce Mobile/Fixed Communication Networks (MFCN) while maintaining the current incumbent use. Regulatory provisions based on LSA can ensure this long term incumbent use of the band. This ECC Decision aims at harmonising implementation measures for Mobile/Fixed Communications Networks (MFCN), including broadband wireless systems (BWS) in the frequency band 2300-2400 MHz. It includes the least restrictive technical conditions (LRTC), taking into account the existing standardisation framework and activities at the worldwide level, and an appropriate frequency arrangement.

In the USA the national regulator (FCC) has requested proposals on spectrum sharing for the commercial use of 3.5GHz band in the USA. Several companies have proposed Shared access based on the LSA concept.

5.2. LSA Demonstration and Field Trial

Multiple demos on LSA concepts have been shown by mobile networks suppliers and chipset manufacturers e.g. Ericsson, NSN and Qualcomm at the Mobile World Congress 2014 (MWC-14) in Barcelona. A joint NSN Qualcomm hardware demo for LSA comprises a real NSN Flexi Base Station operating a dedicated carrier (FDD @ 2.6 GHz) and a shared carrier (TDD @ 2.3 GHz) (incl. core emulation + application servers) and several Qualcomm terminals.

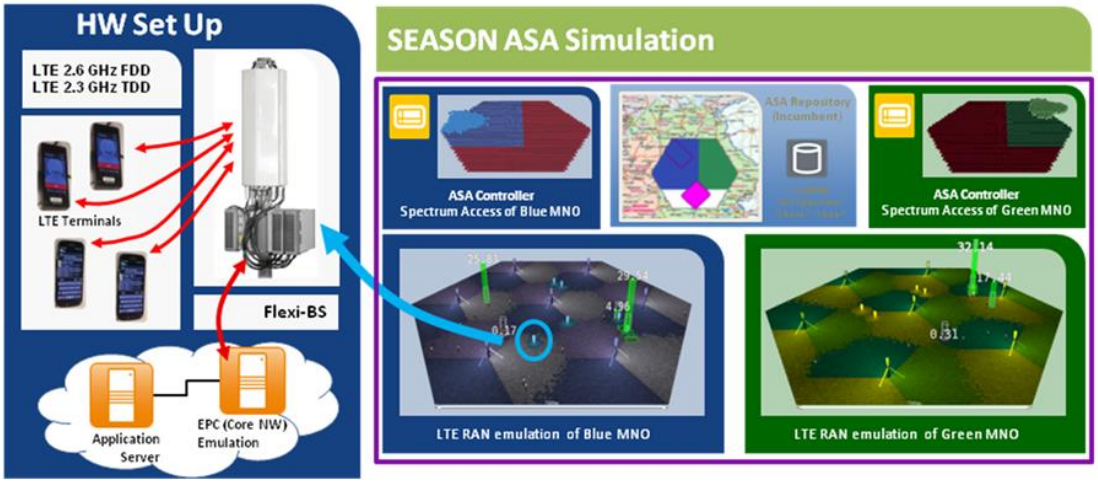

Figure 7: Joint NSN-Qualcomm MWC-14 Hardware Demo for LSA

The World first live LSA trial took place on September 2013 in Finland by NSN with commercial Base Station products. The trial was carried out with NSN Single RAN Flexi Multi-Radio Base Stations, commercial Core Network and NetAct network management system. The trial included full ecosystem, national spectrum regulator, incumbent and operator as well as the key control elements, LSA Controller and LSA Repository. The initial trial in the same environment was shown already at May, and before that NSN has been successfully demonstrating LSA concept with simulation demos e.g. at Mobile World Conference February 2013.

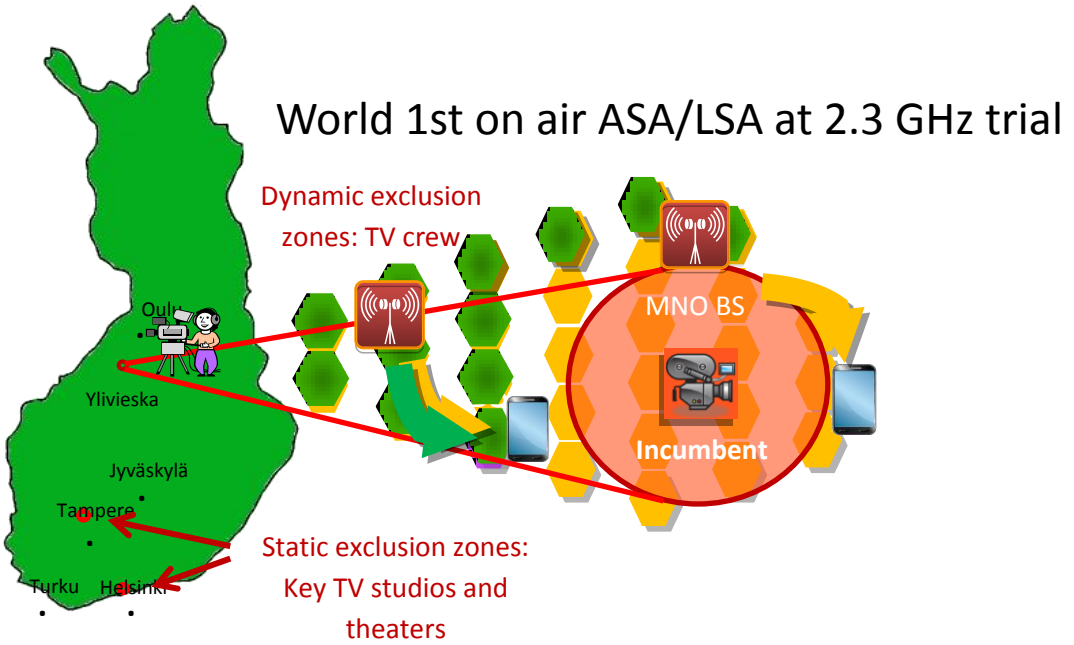

Figure 8: World 1st on air LSA in Finland

5.3. Harmonic Bands are Vital via LSA Implementation

The additional value of opening a spectrum clearly depends on the conditions agreed with the incumbent spectrum user and the particular band.

IMT operators require harmonised spectrum which is paramount for economies of scale, avoiding interference issues and best possible roaming capabilities. The harmonised bands for IMT service are vital via LSA implementation that the industrial ecosystem could be booming with the newly opened spectrum in some region however the same spectrum and products are already exploited in other places globally.

The use of LSA is expected to create the means for greater global harmonization of spectrum bands. LSA is expected to be applied to bands that are dedicated to IMT use in large parts of the world, but where the same bands are allocated to other purposes in some parts. Consequently, the first bands to look at would be existing IMT bands with 3GPP band definition and evolving ecosystem.

In consideration of concrete LSA frequencies the 2300-2400MHz band is especially attractive because it is already an IMT band recommended by the ITU-R and is in use in some countries, e.g. in Asia, and is also specified as band 40 in 3GPP. It is widely supported in terminals including first attractive multi-mode multi band smart phones. In Europe this band is a good candidate for LSA as it is used in many countries limited in geography and/or time for e.g. governmental applications, including defense or wireless cameras. Through LSA it could be utilized for IMT at least locally or on a scheduled basis in countries where it is currently blocked entirely thus contributing to global spectrum harmonization.

Another example of this is provided by the 3.5GHz allocation in the US, which can be harmonized with 3GPP bands 42 and 43. e.g. for 3550-3650 MHz band that is currently used by incumbent Federal Government radar systems and commercial fixed satellite systems. In 2012, the FCC made a first 3-Tier proposal for the prioritization of the users.

Targeting to the harmonic band via LSA implementation will make the shared spectrum use more attractive for mobile network operators to take advantage of scale economies.

5.4. LSA with huge economical benefit

The mobile networks need to be prepared for a huge 1000x mobile traffic increase by 2020. This means that the IMT networks in particular need a significant amount of additional spectrum.

LSA can help to open IMT bands for shared use by IMT otherwise blocked by legacy services which may only sparsely occupy that band. LSA is designed to balance the needs of the legacy spectrum users with those of the IMT operators, which will introduce huge economical benefit due to make the spectrum available. The application of LSA provides a low-cost, short-cycle investment option for operators. New benefits could be produced from frequency bands that have not been used before where LSA is applied. This could boost further innovative applications/services for operators, and contribute to the increase of the nation's economics.

Recently Plum consulting conducted a study [2], jointly tasked by Ericsson, NSN and Qualcomm, on the economic benefits of implementing LSA in 2.3 GHz band in Europe. The band 2300-2400 MHz which is a harmonized IMT band recommended by the ITU in certain regions and defined as band 40 in 3GPP with an evolving ecosystem. Plum quantifies the immediate economic benefit of opening the 2.3 GHz band in Europe by €12bn over the period to 2030. Additionally, this would foster growth in adjacent sectors and drive innovation along the entire communications value chain with new services. The study shows that there will be potential demand for spectrum at 2.3 GHz to support future IMT traffic i.e. that demand will exceed current and planned future spectrum supply in many locations. Without LSA only a minority of countries in Europe would be able to offer access to the 2.3 GHz band. In particular, an ECC harmonization measure could not be implemented without LSA. The resulting market would not be sufficiently big for major operators to deploy the band and for vendors to manufacture European handsets supporting the band.

In addition to the single case for 2.3GHz in European countries, LSA is also possible and should be considered in other candidate bands. Furthermore it should also be observed that the benefits are sizeable partly due to the harmonization measures and the scale economies.

6. GTI Observation and Recommendation

With the current trend of near-doubling every year, IMT traffic may grow by a factor of 1000 over the next decade. GTI has identified spectrum usage as one of the key steps in upgrading today's networks to handle this growth. Although we are targeting to open more exclusive IMT spectrum, it seems the potential available spectrum amount of exclusive use is still not sufficient to fulfill the spectrum requirements. We must also strive for optimized use of spectrum by all radio services involved. Even it is the case that exclusive spectrum will remain the

preferred option for IMT, this must be complemented by new options for sharing spectrum, including LSA. Both strategies together can be expected to fulfill the additional radio spectrum needs of future mobile networks in coping with the rapidly increasing capacity demand.

GTI views LSA as a valuable additional tool for spectrum regulation in the quest for additional spectrum for IMT which may not succeed based on exclusive spectrum allocations alone. However the exclusive spectrum access is still remaining the basis for IMT. For the bands which are still possible to license for IMT via re-farming or just being included in the ITU IMT spectrum proposals, e.g. UHF 700 MHz, lower C-band, etc., the exclusive approach should be firmly adhered to. LSA only targets to the bands where the legacy user will exist for long time thus the band could not be released on exclusive spectrum allocations alone in reasonable time. And LSA is a complementary approach which will not replace the traditional approaches of exclusive licensing or license-exemption.

The particular interest is given to bands that have already been identified for International Mobile Telecommunications (IMT) with 3GPP band definitions and commercial equipment ready and deployed in other regions such as the band 2300-2400 MHz or upcoming such as the bands 3400-3800 MHz. These large bands are absolutely required in the timeframe towards 2020 to cost-efficiently cope with the huge traffic growth. Wherever possible, these bands shall be assigned exclusively to IMT. And specifically from the view of GTI, the global TD-LTE initiative, these two bands are potential global harmonized TDD bands and will provide great scaling economic benefit for TDD ecosystem if opened by LSA.

Furthermore, as a new regulatory framework, the LSA could also be applied to other frequency bands if necessary. Only where important legacy use prevents such exclusive allocation, LSA can be considered as one means to open at least part of those bands for IMT, ideally for large amounts of time and in the locations where they are most needed for capacity.

In summary, GTI views

- Exclusive Spectrum Access has top priority for IMT and additional spectrum (e.g. UHF 700 MHz, lower C-band) should be allocated and put into use without delay.

- LSA can unlock additional spectrum which is not obtainable in reasonable time due to incumbent use for LTE use. Harmonised spectrum access via LSA implementation should be achieved. A good example is the 2.3 GHz band in

Europe, given that this band already supports IMT deployments in other regions, thus contributing to global spectrum harmonization and providing economies of scale. In China, it is also possible to consider LSA as a potential technology for 2.3GHz to extend the current indoor usage to outdoor, sharing with military Radar. Another interesting band for LSA and small cells is 3.5 GHz band in US.

- Specifically from the view of GTI, the global TD-LTE initiative, these two bands 2.3GHz and 3.5GHz are potential global harmonized TDD bands and will provide great scaling economic benefit for TDD ecosystem if opened by LSA in Europe (for 2.3GHz) and U.S. (for 3.5GHz). The TD-LTE networks and terminals are already available for some regions or countries, and could be reused in the new opened markets. The coexistence for these bands has some commonalities; the roaming could be more easily supported with lower cost products.

GTI recommends regulators to consider LSA in harmonised bands which are difficult to redistribute or repurpose to mobile/IMT within a reasonable time frame and that can help mobile network operators turn the spectrum challenge into big opportunities. And in addition, GTI encourages consideration of LSA in the two potential global harmonized TDD bands of 2.3GHz in Europe and 3.5GHz in U.S.

7. Reference:

[1] [Cisco report] http://www.cisco.com/en/US/netsol/ns827/networking_solutions_sub_solution.html#~forecast

[2] [Plum report] The economic benefits of LSA in 2.3 GHz in Europe, A report for Ericsson, NSN and Qualcomm, Dec.2013

[3] [3GPP TS36.304, Evolved Universal Terrestrial Radio Access(E-UTRA)]

[4] [3GPP TS 36.808,Evolved Universal Terrestrial Radio Access(E-UTRA); Carrier Aggregation; Base Station(BS) radio transmission and reception]

[5] [3GPP TS 36.823, Evolved Universal Terrestrial Radio Access(E-UTRA); Carrier aggregation enhancements; User Equipment(UE) and Base Station(BS) radio transmission and reception]

[6] ECC Report 205, Licensed Shared Access, 12-02-2014

[7] ECC Decision (14)02, Harmonised technical and regulatory conditions for the use of the band 2300-2400 MHz for Mobile/Fixed Communications Networks (MFCN), 27 June 2014