ETSI TR 103 588 V1.1.1 (2018-02)

**Reconfigurable Radio Systems (RRS);
Feasibility study on temporary spectrum access
for local high-quality wireless networks**

Reference
DTR/RRS-0148

Keywords
radio, system, use case

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Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Reconfigurable Radio Systems (RRS).

Modal verbs terminology

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1 Scope

The present document addresses different technical possibilities for local high-quality wireless networks (nomadic or fixed) to access spectrum on a shared basis during a certain time period ranging from short-term (e.g. some days to some weeks) to long-term (e.g. some months to some years).

Also the present document describes high-level use cases, review the feasibility of existing spectrum sharing frameworks, and, if required, propose evolved, extended or new technical solutions for spectrum sharing and network architectures addressing different network topologies and device types.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] PMSE-xG White Paper.

NOTE: Available at http://www.pmse-xG.research-project.de.

[i.2] ECC Report 205: "Licensed Shared Access (LSA)", February 2014, CEPT WG FM PT53.

[i.3] ETSI TS 103 235: "Reconfigurable Radio Systems (RRS); System architecture and high level procedures for operation of Licensed Shared Access (LSA) in the 2 300 MHz - 2 400 MHz band".

[i.4] Funktechnologien für Industrie 4.0: "VDE Positionspapier, ITG AG Funktechnologie Industrie 4.0", June 2017.

[i.5] Functional Safety and IEC 61508. .

NOTE: Available at http://www.iec.ch/functionalsafety/.

[i.6] ECC Report 102: "Public Protection and Disaster Relief Spectrum Requirements", Helsinki, January 2007.

[i.7] 5GPPP White Paper: "5G and e-Health", September 2015.

[i.8] WWRF White Paper: "A New Generation of e-Health Systems Powered by 5G", November 2016.

[i.9] ECC Report 132: "Light Licensing, Licence-Exempt and Commons", June 2009.

[i.10] 3GPP TR 32.855 (V1.0.0) (02-2016): "3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Telecommunication management; Study on OAM support for Licensed Shared Access (LSA); (Release 14)".

[i.11] Ericsson, RED Technologies, and Qualcomm Inc. conduct the first Licensed Shared Access (LSA) pilot in France.

NOTE: Available at http://www.redtechnologies.fr/.

[i.12] D. Guiducci et al.: "Sharing under licensed shared access in a live LTE network in the 2.3-2.4 GHz band end-to-end architecture and compliance results", 2017 IEEE International Symposium on Dynamic Spectrum Access Networks (DySPAN), Piscataway, NJ, 2017, pp. 1-10.

[i.13] FCC 15-47: "Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550- 3650 MHz Band", April 2015.

[i.14] FCC 16-55: "Order and Reconsideration and Second Report and Order, Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550- 3650 MHz Band", May 2016.

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

temporary: spectrum allocations lasting, existing or effective for a period of time only; which can range from short-term (e.g. days or weeks) to long-term (e.g. months to years)

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AGV	Automated Guided Vehicle
AR	Augmented Reality
BEM	Blocking Edge Mask
CBRS	Citizen Broadcast Radio Service
CBSD	CBRS Device
CEPT	European Conference of Postal and Telecommunications Administrations
DP	Domain Proxy
ECC	Electronic Communication Committee
ESC	Environmental Sensing Capability
FCC	Federal Communications Commission
GAA	General Authorization Access
HEN	Harmonized European Norm
IA	Incumbent Access
IEC	International Electrotechnical Commission
IEM	In-Ear-Monitor
IMT	International Mobile Telecommunications
KPI	Key Performance Indicator
LC	LSA Controller
LR	LSA Repository
LSA	Licensed Shared Access
LSR	LSA Spectrum Resource
LSRAI	LSA Spectrum Resource Availability Information
MFCN	Mobile/Fixed Communication Networks
mMTC	massive Machine Type Communication
MNO	Mobile Network Operator
MVNO	Mobile Virtual Network Operator
NPRM	Notice of Proposed Rule Making

NRA	National Regulatory Authority
OAM	Operation, Administration, and Maintenance
PA	Public Address
PAL	Priority Access License
PER	Packet Error Rate
PMSE	Programme Making and Special Events
PPA	PAL Protection Area
PPDR	Public Protection Disaster Relief
QoS	Quality of Service
RAT	Radio Access Technology
RF	Radio Frequency
SAS	Spectrum Access System
SLA	Service Level Agreement
SRC	Spectrum Resource Controller
SRR	Spectrum Resource Repository
UC	Use Case
UCC	Use Case Class
WIA	Wireless Industrial Automation

4 Local High-Quality Wireless Networks

4.0 Introduction

The next generation of broadband mobile communication networks aims to integrate applications of vertical sectors in its holistic ecosystem of enabling technologies, spectrum management frameworks and networking paradigms. To make this happen, key requirements of vertical sectors should be communicated, properly discussed, and finally reflected within the relevant design and standardization processes.

Clause 4 of the present document analyses the communication requirements of selected vertical sectors, e.g. Industrial Automation, Utilities, Culture and Creative Industry, PPDR, e-Health, etc. The analysis will identify a set of use cases typically demanding predictable Quality of Service (QoS) levels at all operation times, within short-term to long-term deployments in local environments. As well, the set of identified use cases favour private network infrastructure and own management functionality for implementing specific security standards or simply due to privacy reasons.

Based on this analysis, the concept of *local high-quality wireless networks* is proposed as a collective term to enclose that kind of use cases.

4.1 High Level Use Cases and Requirements

4.1.1 Programme Making and Special Events (PMSE)

4.1.1.1 General

Programme Making and Special Events (PMSE) is a term denoting wireless applications used to support broadcasting, news gathering, audio and video production for film, theatre and music, as well as special events such as sport events, culture events, conferences, and trade fairs.

The PMSE industry delivers key enabling equipment for the culture and creative industries, both having a significant socio-economic impact in the EU.

Typical PMSE equipment includes for example wireless microphones, in-ear monitors, video cameras, conference systems, light and remote controls.

Wireless audio PMSE equipment (e.g. wireless microphone, in-ear monitors, conference systems) employ digital or analogue wireless technologies, which are specific, typically link-based developments of the PMSE manufactures to support reliable, very low latency audio streaming transmissions required by the targeted professional audio applications.

4.1.1.2 Use Cases and Requirements

4.1.1.2.0 General

This clause introduces three representative high-level use cases (UCs) of the PMSE industry and their requirements:

- Use case 1 (UC-1): Live Performance
- Use case 2 (UC-2): Presentation
- Use case 3 (UC-3): Tour Guide

For each UC, a short description is provided, as well, its major requirements as defined and used in the German research Project PMSE-xG [i.1] are discussed.

These three UCs highlight two key aspects of wireless audio productions: low latency and high reliability. As such, they can be grouped into a use case class (UCC) addressing *low latency and high reliability audio streaming* applications. As a general requirement for this UCC, all wireless mobile devices need to be synchronized inside one local high-quality wireless network.

4.1.1.2.1 UC-1: Live Performance

The use case 'Live Performance' involves several wireless microphones (handheld or body-worn) used to capture the singers voice or the sound of instruments, several stereo in-ear monitors (IEM), at least one mixing console and a PA system.

A typical scenario is for instance a concert, where an artist on stage is using a wireless microphone while he is hearing himself via the wireless IEM system. The audio signal coming from the wireless microphone is streamed to one or more mixing consoles, where different incoming audio streams (e.g. from different music instruments, choir) are being mixed. After mixing, several audio streams can be generated, e.g. PA mix, individual IEM mixes for the artists or recording mixes. From those, IEM mixes are wirelessly transmitted to the artist and musicians while most of the other mixed signals are streamed via wired connections.

Depending on the type of event, the number of active wireless audio links or the data rates of the respective wireless audio streams may vary. However, the requirements regarding latency and reliability remain principally the same for all kind of live events/productions. Reliability is an essential feature because during live productions one cannot afford repeating audio transmissions until it is error-free. Low latency is an essential feature because in this use case source and sink of the audio transmission can be co-located, think of an artist equipped with wireless microphone and IEM. Because the artist receipts audio of the environment also via its cranial bone, very low end-to-end delay (i.e. from the wireless microphone to the mixing desk back to the IEM) is tolerated.

Table 1 summarizes the KPIs of the use case Live Performance.

Table 1: KPI Requirements for the UC-1: Live Performance, as described in [i.1]

KPI	Requirement
End-to-end delay	< 4 ms
User data rate	The user data rate per audio link can vary depending on the application but will stay constant during operation: 150 kbit/s - 4,61 Mbit/s
Control data rate	≤ 50 kb/s Data rate per control link
PER	The PER of the system is required to be below 10^{-4} for a packet size of 1 ms. Depending on the error concealment the following exemplary error distribution may be tolerable: • maximum continuous error duration = 30 ms • consecutive minimum continuous error-free duration = 100 ms
Number of audio links	50 - 300 simultaneous
Event area	≤ 10 000 m^2, indoor and outdoor
Mobile user speed	≤ 14 m/s

4.1.1.2.2 UC-2: Presentation

In the use case Presentation, a presenter on stage is using a wireless microphone for example to present a slide set to the audience. The wireless microphone is used for streaming the presenter's voice to the loudspeakers installed in a conference room. When using more than one wireless microphone a mixing console is added, which mixes the incoming audio streams to one or more output audio streams. One of these outgoing audio streams may be distributed to the loudspeaker inside the conference room, another via Ethernet to several clients of the audio distribution network. In this use case, no IEM is required, which relaxes the requirement on end-to-end latency.

Low latency and high reliability of the wireless link are essential for the use case, so that the assisting playback via the loudspeakers is not irritating the audience or the moderator by distortions or not matching auditive-visual impression.

Table 2 summarizes the KPIs of the use case Presentation.

Table 2: KPI Requirements for the UC-2: Presentation, as described in [i.1]

KPI	Requirement
End-to-end delay	< 10 ms
User data rate	150 kbit/s - 1,15 Mbit/s
Control data rate	≤ 50 kb/s Data rate per control link
PER	The PER of the system is required to be below 10^{-4} for a packet size of 1 ms
Number of audio links	5 - 10 simultaneous
Event area	≤ 10 000 m^2, indoor and outdoor
Mobile user speed	≤ 5 m/s
Security	Encryption of the user data

4.1.1.2.3 UC-3: Tour Guide

In the use case Tour guide, a guide is guiding a group of visitors being in close proximity. One can think for instance of a conducted tour in a factory site, museum, sports venue or a guided city tour. The guide speaks to a wireless microphone and the audio is distributed to the receiving head-sets of the visitors, so the distribution of the spoken information from the guide to the audience while walking from spot to spot is in focus. Nevertheless, one can imagine interactions between guide and audience in the form of questions and answers turning the tour guide system in a mobile conferencing solution.

Low latency and high reliability of the wireless link are essential for the use case, so that the assisting playback via the headphones is not irritating the audience or the guide by distortions or not matching auditive-visual impression. Here, at least one multicast audio link (from the guide to the visitors) should be supported, and up to ten unicast audio links (from the visitors to the guide) are necessary.

Table 3 summarizes the KPIs of the use case Tour guide.

Table 3: KPI Requirements for the UC-3: Tour-Guide, as described in [i.1]

KPI	Requirement
End-to-end delay	< 10 ms
User data rate	150 kbit/s - 350 kbit/s
Control data rate	≤ 50 kb/s Data rate per control link
PER	The PER of the system is required to be below 10^{-4} for a packet size of 1 ms
Number of audio links	5 - 10 uni cast, 1 - 2 multicast but 50 - 100 devices
Event area	≤ 10 000 m^2, indoor and outdoor
Mobile user speed	≤ 5 m/s
Security	Encryption of the user data

4.1.2 Wireless Industrial Automation (WIA)

4.1.2.0 Introduction

Industrial communication has fundamentally different requirements to conventional commercial communication. Essentially, industrial communication is used to control and monitor real-world actions and conditions concerning specific physical equipment, while the primary function of commercial communication is data transfer and processing.

Industrial communication has a broad range of use cases and deployment scenarios with a unique set of requirements on the communication latency, reliability, availability, and throughput. The isolated application and heterogeneity of wireless communication systems in existing industrial deployments can be mainly attributed to the following three reasons:

i) challenging propagation and channel conditions with strong fading and multipath effects;

ii) no determinism for channel access; and

iii) extreme requirements in terms of very low latency and high degree of reliability.

4.1.2.1 Industrial Communication Requirements

4.1.2.1.0 General

Many of the industrial application use cases have extremely high requirements on the communication system. Figure 1 shows a comparison between mobile broadband and industrial communication. As illustrated, industrial communication has particularly high requirements in terms of high reliability and low latency. Please note that requirements on high reliability and low latency in industrial applications typically come hand in hand, i.e. extreme values for both metrics are needed at the same time. Other distinguishing factors include device density, relatively small packets with very short inter arrival times, and high data rates that further increase the requirements in industrial communication. Moreover, dependent on the use case there is a need to support very high communication distances such as in process automation deployment scenarios. In use cases of logistics and warehouses, communication distances are typically small and a high degree of flexibility is expected. An example includes the scenario to rapidly deploy and run different processes or to support the mobility and connectivity of mobile devices such as augmented guided vehicles (AGVs), which are interacting with different processes and warehouses.

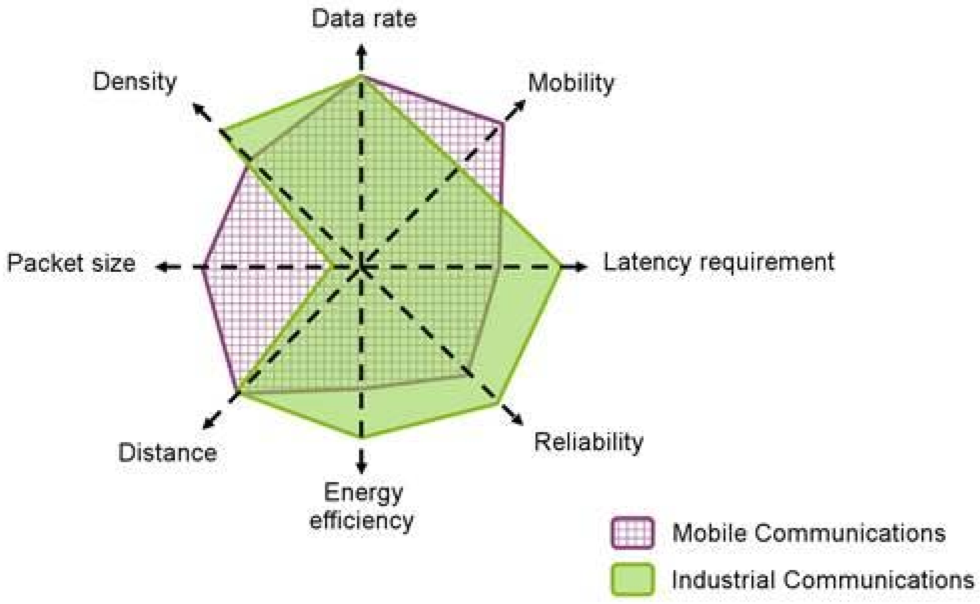
Figure 1 shows a consolidated view for high-level industrial use cases. Not all requirements are to be supported at the same time. In addition, for the different use cases the presented metrics vary significantly. In the following, different industry high-level use cases and their related requirements are presented.

4.1.2.1.1 Discrete Manufacturing

In discrete manufacturing, a countable number of objects is produced. This involves assembling, testing or packaging products in many discrete steps (e.g. in automotive, general consumer electronic, goods production, etc.). Discrete manufacturing has the most stringent communication requirements on latency and reliability, and these can be in the range of (1 ms - 12 ms) for latency and 10^{-9} packet error rate (PER) for reliability [i.4]. Examples of discrete manufacturing include printing machines, pressing machines and packaging/palletizing machines. In discrete manufacturing, machine tools, robots, sensors and programmable logic controllers typically exchange small sized data packets with very short intervals. Small data sizes generated periodically at very small instants of time from a high density of devices eventually constitute significant overall data rate requirements in a production facility. Redundancy, cyber security and functional safety are also very important for factory automation.

4.1.2.1.2 Monitoring and Maintenance

The monitoring of sensor data and collection of maintenance information from machines typically do not have very tight requirements on the communication latency and reliability. The reliability requirements for monitoring and maintenance application use cases is in the order of 10^{-4} packet error rate (PER), which means that only one out of 10 000 packet should be lost within the relatively relaxed time budget (typically more than 20 ms) [i.4].



NOTE: Source: VDE/ITG Positionspapier Funktechnologien für Industrie 4.0.

Figure 1: A consolidated view for high-level industrial use-cases [i.4]

4.1.2.1.3 Motion Control

Motion control involves controlling the speed, acceleration, angle or a combination of those in discrete manufacturing processes. Examples of motion control involves actuators such as the controllers for electric motors in assembly lines or hydraulic cylinder controllers in presses. Motion control targets very high reliability (10^{-9} PER) and extremely low latency (250 µs to 1 ms).

4.1.2.1.4 Process Automation

Process automation typically involves chemical processes engineering, where heating, mixing, separation or synthesis of substances takes places. It is needed, for instance, in oil and gas production and purification, generation of electricity or in foundries where alloys are produced. Process automation is typically associated with continuous operation, with specific requirements for deterministic delivery of messages, reliability, redundancy, cyber security and functional safety. In process automation, steps are sequential, continuous and irreversible compared to the discrete manufacturing.

Process applications need deterministic delivery of messages and therefore target low latencies in the range between 50 ms and a few seconds and reliability in terms of 10^{-5} PER. Process automation applications may cover communication ranges of up to a few kilometres.

4.1.2.1.5 Condition Monitoring

In general, in condition monitoring the machines and processes are continuously measured and certain states are monitored. Concretely, physical parameters such as temperatures, humidity, vibration, acceleration and position are continuously measured by sensors and analyzed by a controller. If the measured values exceed a certain threshold, a concrete action is initiated by the controller. Condition monitoring has similar requirements as process automation, see Table 4 for detailed values.

4.1.2.1.6 Augmented Reality

Augmented reality (AR) is a computer-assisted extension of reality. In theory, it can be applied to all senses, but in practice it is typically used as a visual stimulus where in addition to the reality pictures are projected (augmented) onto head-mounted AR devices such as glasses. For example, AR can be used in the industrial context to train shop floor workers locally or remotely, or even to perform maintenance work. In the first case, specific instructions can be projected onto the glasses, which can assist the worker in controlling the machine. Instructions can be given either locally or remotely. Regarding maintenance, error messages and specific instructions can be augmented to rapidly fix the error. Since videos or images already need relatively large packet sizes and high data rates (in the megabit range), they need also to be augmented and synchronized with the reality. This can be achieved with a latency of 10 ms and a reliability in the order of 10^{-5} PER.

4.1.2.1.7 Logistics and Warehouses

Logistics and warehouses can be differentiated between mobile vehicles such as automated guided vehicles (AGVs) and static systems such as cranes and hoists. Examples for AGVs are mobile robots, small transportation vehicles, mobile working platforms which transport heavy products or materials among production plants, storage halls, and warehouses. Since the AGVs can move across the entire factory hall or even between different factory halls, mobility needs to be supported in the order 10 meter per second. In addition, a latency between 15 ms and 20 ms paired with a reliability in the order of 10^{-6} PER needs to be ensured. The static case of cranes and hoists, are an essential part of production, storage, and commissioning. Cable replacement is particularly interesting in this case, the rotational movements and the resulting wear makes their application very problematic. The requirements of the crane case regarding latency and reliability match the requirements of the AGVs case.

4.1.2.1.8 Functional Safety

In many of the above mentioned high-level use-cases, it is usually necessary to ensure a certain safety integrity level, e.g. as defined by the international standardization body IEC 61508 [i.5]. Safety is not only needed to protect people from injuries but also to protect machines, their environment, and production processes. For this purpose, sensors such as laser scanners or protective skins are used to protect a certain area or a machine. The communication requirements for functional safety are marginally lower then discrete manufacturing, i.e. a latency of 10 ms with a reliability of 10^{-9} PER should be guaranteed. Table 4 gives an overview of different use-cases and their requirements for industrial communication [i.4].

Table 4: Overview of different use-cases and their requirements for industrial communication

	Monitoring & Diagnostics		**Discrete Manufacturing**		**Logistics and Warehouse**					
Key Performance Indicator	**General**	**Condition Monitoring**	**General**	**Motion Control**	**General**	**AGV**	**Cranes**	**Process Automation**	**Augmented Reality**	**Functional Safety**
Latency/Cycle Time	> 20 ms	100 ms	1 ms - 12 ms	250 µs - 1 ms	> 50 ms	15 ms - 20 ms	15 ms - 20 ms	50 ms - Xs	10 ms	10 ms
Reliability	$1 - 10^{-4}$	$1 - 10^{-5}$	$1 - 10^{-9}$	$1 - 10^{-9}$	$> 1 - 10^{-2}$	$> 1 - 10^{-6}$	$> 1 - 10^{-6}$	$1 - 10^{-5}$	$1 - 10^{-5}$	$1 - 10^{-9}$
Data Rate	kbit/s - Mbit/s	kbit/s	kbit/s - Mbit/s	kbit/s - Mbit/s	kbit/s - Mbit/s	kbit/s - Mbit/s	kbit/s - Mbit/s	kbit/s	Mbit/s - Gbit/s	kbit/s
Packet Size	> 200 Byte	1 - 50 Byte	20 - 50 Bytes	20 - 50 Bytes	< 300 Bytes	< 300 Bytes	< 300 Bytes	< 80 Byte	> 200 Byte	< 8 Byte
Communication Range	< 100 m	100 m - 1 km	< 100 m	< 50 m	< 200 m	~ 2m	< 100 m	100 m - 1 km	< 100 m	< 10 m
Device Mobility	0 m/s	< 10 m/s	< 10 m/s	< 10 m/s	< 40 m/s	< 10 m/s	< 5 m/s	Generally static, otherwise < 10 m/s	< 3 m/s	< 10 m/s
Device Density	0,33 - 3 m^{-2}	10 - 20 m^{-2}	0,33 - 3 m^{-2}	< 5 m^{-2}	~ 0,1 m^{-2}	~ 0,1 m^{-2}	~ 0,1 m^{-2}	10 000 / Factory	> 0,33 - 0,02 m^{-2}	> 0,33 - 0,02 m^{-2}
Energy Efficiency	n/a	10 years	n/a	n/a	n/a	< 8 h	n/a	10 years	1 day	n/a

4.1.3 Public Protection Disaster Relief (PPDR)

According to ECC Report 102 [i.6], mission critical communication systems including PPDR (Public Protection Disaster Relief) are used for situations where human life, rescue operations and law enforcement are at stake and public safety organizations cannot afford the risk of having unsecured communications, transmission failures or even interruptions of service. Mission critical communication services have very high availability requirements.

Mission critical communication systems show an increasing demand for higher bandwidth emergency communication infrastructure to cope with new services demanding high throughput and low-delay requirements for the daily tasks and particularly during immediate post-emergency period, including real-time video streaming and video surveillance, exchange of high resolution pictures, etc. As well, foreseen/unforeseen events with large aggregation of professional and consumer users such as e.g. big sport events, road shows or concerts may require high bandwidth communications. In addition, PPDR users require a secure communication, usually realized by an end-to-end encryption mechanism.

The 24/7/365 broadband mission critical communication system is expected to be available "everywhere" and can be complemented by local hot-spot type to be used on an event or special situation basis, where higher capacity is required.

In response to a disaster or an emergency, access to additional spectrum on a temporary and local basis may be required, while the additional spectrum is provided by other mobile broadband services during the required period, in order to support public safety.

Temporary PPDR network deployment high-level use cases are e.g.:

- Emergency and crisis operations
- Tactical operations (e.g. peacekeeping)
- Unplanned large events (e.g. demonstrations)
- Natural disasters
- Terror attacks

4.1.4 e-Health

Within the health sector, the World Health Organization (WHO) defines *e-health* as the transfer of health resources and care by electronic means. In this clause, the focus is on the delivery of health information by telecommunication means.

A relevant use case for the present document is the pre-hospital emergency scenario [i.7]. This use case aims at providing a remote laboratory for emergency relief actions, extending the hospital coverage and regular analysis to the remote locations or during transport (e.g. in an ambulance) from the remote location to the hospital. Hereby, it is important to provide a secure customized connectivity to specialized devices in the hospital. The emergency medical staff can send medical data (including sounds, images and video), captured using wearable medical devices, to the hospital. The hospital staff can send medical treatment-assistance to the emergency medical staff in the remote location or during the transport.

Another relevant use case for the present in a hospital scenario is the *assets and interventions management in Hospitals* [i.8]. That is, the tagging and real-time tracking of equipment and consumables (e.g. pharmaceuticals) in the Hospital. Hereby it is important to, in a real-time manner, manage a massive number of objects for accountability, patient safety and quality control. Further, the QoS-level is expected to be guaranteed. This use case belongs to the massive machine type communication (mMTC) use case family, where QoS is mainly measured in terms of device density.

4.1.5 Characteristics

The analysis results in the identification of common characteristics across the use cases:

- Local geographical area;
- Short-term to long-term deployments;
- Need for predictable QoS levels; and
- Preference for private network infrastructure.

These four characteristics are leveraged to define the concept of *local high-quality wireless networks*.

4.2 Terminology

In the context of professional usage scenarios, the concept of local high-quality wireless network is used to refer to wireless communication networks capable of supporting different (vertical) use cases with following commons:

- their operation is confined in a local geographical area;
- have short-term to long-term deployments;
- need predictable levels of QoS, particularly in terms of deterministic communication behaviour, reliability and latency; etc.
- network infrastructure and management with a suitable combination of private and public networks for implementing specific security standards or due to privacy reasons.

Local high-quality wireless networks can be used as a collective term for a family of use cases targeting professional services and applications requiring predictable levels of QoS, privacy and security while showing either locally or temporally constrained operation.

Based on their similarities, verticals sectors deploying *local high-quality wireless networks* would benefit from similar spectrum access frameworks and standardization measures. Indeed, the availability of suitable spectrum bands for the deployment of *local high-quality wireless networks* will determine their success. The need for predictable levels of QoS would mostly preclude the operation of *local high-quality wireless networks* in a license-exempt spectrum, due to coexistence problems, and target exclusively licensed spectrum. However, due to the current scarcity of suitable exclusive (licensed) spectrum resources, which can be directly accessible by verticals, *local high-quality wireless networks* might focus on spectrum sharing as the enabling spectrum access technology.

Next clause reviews different existing spectrum access frameworks according to their suitability for the deployment of local high-quality wireless networks.

5 Spectrum Access Strategies

5.1 Spectrum Access Strategies

5.1.0 Introduction

This clause describes possible spectrum access strategies in a wide-sense to serve the process of ensuring that the architecture, depicted in clause 6, supports the possible spectrum access possibilities. CEPT report 132 [i.9] discusses use of terminology. However, it should be noted that the licensing and access to spectrum is a national decision and some strategies might not be allowed in all countries. Clauses 5.1.1, 5.1.2 and 5.1.3 provides a high-level overview of some of the regulatory options for use of frequencies, while clause 5.1.4 describes sharing options in the context of *local high QoS wireless networks*.

5.1.1 Exclusive Use of Spectrum

The allocation of dedicated spectrum to operators or users is typically done in use cases requiring QoS. The allocations are typically national coverage or regional coverage. An operator has exclusive rights to a spectrum block in a certain geographical area. The RF protection limits to adjacent frequency blocks is typically defined by a Block Edge Mask (BEM). The bands identified for IMT are examples where this allocation method is used. In ECC Report 132 [i.9] this type of licensing is denoted individual license.

5.1.2 Light Licensing Use of Spectrum

Light licensing is not clearly defined. In the present document, the terminology used in the ECC Report 132 [i.9], Table 1, will be adopted, where there are two different categories of Light licensing. The two variants are:

a) Light licensing can mean that there is no need to do any planning and there are no restrictions in number of users but there is a need to notify or register with the regulatory authority. QoS cannot be guaranteed as there are no limits of the number of users. It is therefore considered as a General authorization scheme.

b) Light licensing can also mean that frequency planning/coordination is needed and limitations of the number of users in same area can be imposed. The use may be authorized by the national regulatory. Thus, this type of light licensing scheme can be categorized as an individual authorization but with a simplified procedure for issuing the license compared to individual licensing. QoS could therefore be possible to be supported.

5.1.3 License Exempt Use of Spectrum Use of Spectrum

Following the terminology in ECC Report 132 [i.9], Table 1, the term license exempt is defined as no need to do any frequency planning/coordination and no requirement to notify the regulator when using such spectrum. Thus, there are no limitations in the number of users in the same area using same frequency, and no need to acquire a dedicated license to be permitted to use a portion of a licensed band. Unlicensed bands are examples of licensed exempt use. QoS service cannot be guaranteed as there are no limits of the number of users sharing the band. As an example of licensed exempt, it is possible in some countries to use a portion of a licensed frequency band in a license exempt way. This is e.g. done in a sub-block of the IMT 1 800 MHz, 3GPP Band 3, in Sweden using a 2 × 5 MHz block. A unique set of rules are defined for IMT1 800 MHz independently of the usage (individual licenses, light licensing or license exempt) and thus the same ETSI EN applies (i.e. IMT related harmonised standard).

5.1.4 Spectrum Sharing for Providing Local Area Services with QoS

The focus in this framework is on licensed bands and possible ways to introduce local area services. It will also facilitate wide availability of equipment since the frequency bands are also used for Mobile Network Operators (MNOs) in case of e.g. IMT-bands.

The possible sharing methods for providing local area services focusing on QoS are:

- Mobile network operators can offer dedicated local area services in their licensed frequencies.
- Mobile network operators can sublease part of their spectrum locally to local area service providers.
- Spectrum licensed to local area service providers:
  - Sharing the band in many local areas nationally.
  - Example of local area definitions are e.g. real estate boundaries and/or polygons.
- Part of the licensed band is using light licensing with control and limits on use, see clause 5.1.2, bullet b):
  - QoS can be difficult to guarantee, unless the networks are not overlapping each other or can be controlled providing a certain QoS guarantee.
  - It is authorized, granted use to have the possibility of control of used equipment, network planning, providing certain level of QoS, and possibly also for billing, charging for use of spectrum, etc.
  - Sharing the band in many local areas nationally.
  - Example of local area definitions are e.g. real estate boundaries and/or polygons.

The spectrum access options for QoS enabled local networks are captured in Figure 2 for a mobile service band like IMT. It may also be possible to use the controlled light licensing method, as described in 4th bullet above, given that the needed level of QoS can be provided. All options may not exist in the same band and may need to be shared with incumbents depending on choice of band and country (as a national decision).

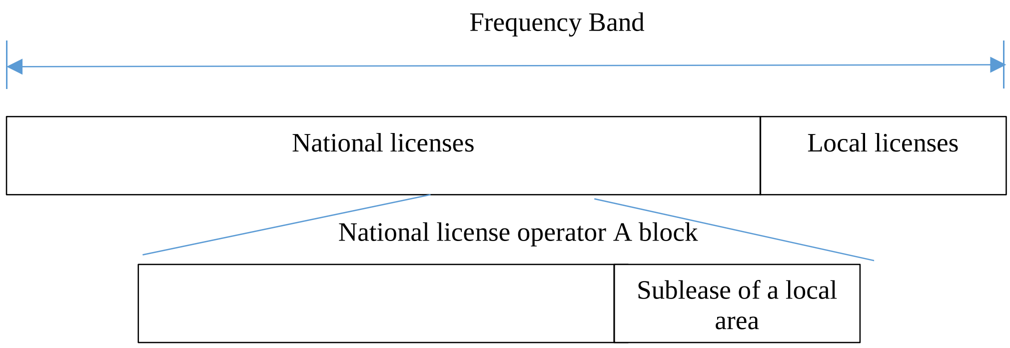


Figure 2: Example of the different QoS enabled spectrum allocation possibilities for a frequency band allocated to mobile services such as IMT

5.2 Existing Spectrum Sharing Schemes

5.2.1 Licensed Shared Access (LSA)

The LSA concept, as defined by CEPT in [i.2], is a complementary spectrum management tool that fits to an "individual licensing regime". LSA foresees the introduction of new users (licensees) in a frequency band while maintaining incumbent services in that band. At first, an appropriate 'sharing framework' is to be defined by the National Regulatory Authority (NRA) including all relevant stakeholders. Here, a set of sharing rules constitutes the regulatory and legal basis that ensures QoS levels for all authorized users.

Based on the current regulation and standardization frameworks [i.2], [i.3], LSA focuses on nation-wide, long-term sharing arrangements between incumbents and LSA licensees. According to CEPT [i.2], a deployment of an LSA system requires the introduction of two new architecture building blocks: the LSA Repository and LSA Controller (see Figure 3, a)). The LSA Repository holds information such as spectrum resources for sharing, protection requirements of incumbents, LSA usage rights and sharing conditions in general. The LSA Controller is a management entity relaying this information to licensee networks it is connected to.

The first practical use case of LSA is to access the spectrum for mobile broadband services (MFCN) in the 2,3 GHz - 2,4 GHz band.

ETSI proposed in [i.3] the LSA system architecture depicted in Figure 3 b). Based on the work in ETSI, 3GPP opened a new study item [i.10] considering the impact of LSA on their specifications. Several trials have successfully proved the applicability of respective technologies [i.11], [i.12].

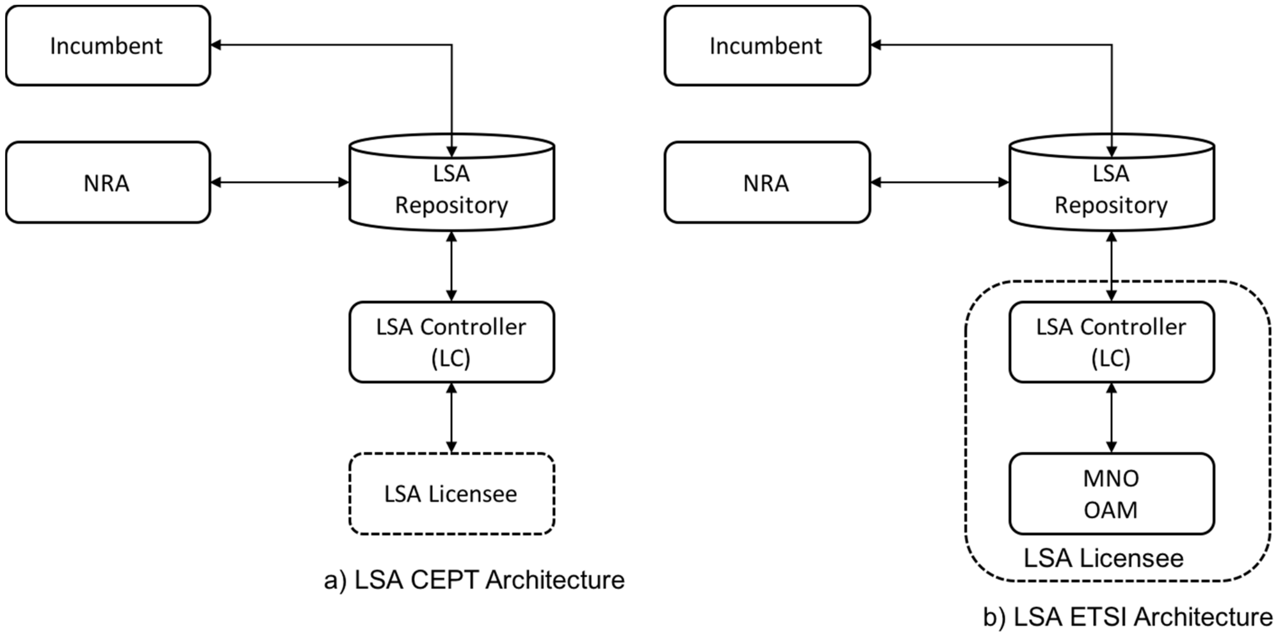


Figure 3: a) Baseline LSA architecture as described by CEPT in [i.2]; b) Baseline LSA architecture as defined by ETSI for mobile broadband applications in the 2,3 GHz - 2,4 GHz band [i.3]

For scenarios with multiple LSA licensees, some differences exist between CEPT and ETSI architectures. The ETSI architecture foresees the presence of one LSA Controller per LSA licensee. In contrast, in the CEPT architecture, one LSA Controller may manage the access of multiple LSA licensees to the band.

5.2.2 Citizen Broadband Radio Service (CBRS) with Spectrum Access System (SAS)

In the US, a new spectrum sharing approach called Citizens Broadband Radio Service (CBRS) to enable deployment of relatively low powered network technologies in the band 3 550 MHz - 3 700 MHz has been introduced by the Federal Communications Commission (FCC) [i.13]. CBRS introduces a 3-tier spectrum sharing method, which differentiates three hierarchies of spectrum users:

- Tier 1: Incumbent Access (IA), users will be protected from harmful interference coming from Tier 2 and Tier 3 users.
- Tier 2: Priority Access (PA), users acquire PA licenses (PALs), valid for a single geographical service area, through a competitive bid process. PA users are protected from harmful interference coming from Tier 3 users.
- Tier 3: General Authorized Access (GAA), users can access any portion of the band not assigned to a higher tier. They may also operate opportunistically on unused PA channels. GAA users have no interference protection.

The band 3 550 MHz - 3 650 MHz would be dedicated to the PAL and if not used by PAL GAA users may be able to use it. The band 3 650 MHz - 3 700 MHz would be exclusively used only as GAA.

The CBRS architecture is shown in Architecture Figure and contains following main functional entities and interfaces:

- Spectrum Access System (SAS) is a geo-location based database system that will manage the spectrum resources in the 3 550 MHz to 3 700 MHz band in 10 MHz blocks called channels based on knowledge of the base station sites, relevant configurations, and operational parameters.
- CBRS Device (CBSD) defines a Base Station which temporarily transmits at the CBRS spectrum based on a grant and transmission authorization provided by the SAS.
- Domain Proxy (DP) is an optional entity and acts on behalf of multiple CBSDs for a coordinated CBSD-SAS communication.

- Environmental Sensing Capability (ESC) monitors for incumbent radar activity in coastal areas and near inland military bases and acts as detection for spectrum resource usage of an Incumbent.
- CBSD-SAS interface is a standardized interface that allows CBSD registration and temporarily spectrum access for CBSD based on SAS management.
- SAS-SAS interface is a standardized interface which allows to offer competitive SAS services by different SAS operators even for the same spectrum resources (area and frequency band). Via the SAS-SAS interface a SAS informs other SAS systems on respective spectrum grants to guarantee the correct handling of PAL and GAA users according to the FCC rules, for instance to support the protection of PAL users from GAA users.

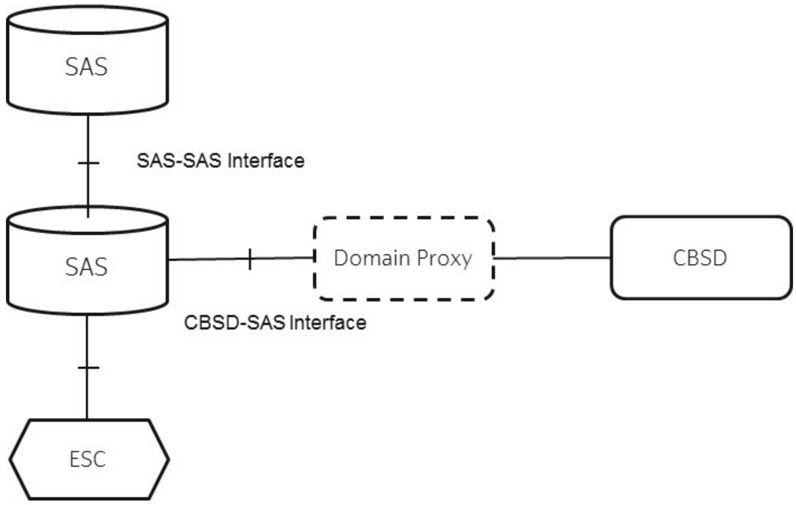


Figure 4: CBRS Architecture

The first phase CBRS supports GAA users only. The support of interference protected Priority Access License PAL is planned for the second phase. The reason is that the rules for PAL terms and auction is currently in NPRM process with the expectation to reach final ruling by early 2018. In the current ruling a PAL is built upon the US census tract grid and defines a 10 MHz channel for a license area of one census tract. A priority access licensee is allowed on the one hand to aggregate up to four 10 MHz channels in a license area, on the other hand to form a service area which contains multiple adjacent license areas. The number of PALs per census tract is limited to seven.

Based on this, the PAL holder may establish a so-called PAL Protection Area (PPA) that defines an area within a service area for protecting the exclusive use of channels based upon the acquisition of the PAL rights. There may be more than one PPA in a service area. Within this scope, another operator can lease any portion of a priority access licensee's licensed geographic area for any bandwidth or period of time under a light-touch leasing process with a simplified FCC oversight [i.14].

Even if CBRS is a frequency arrangement and a spectrum sharing method that is only available for the US 3,5 GHz band, CBRS includes some functions for the deployment of local high-quality wireless networks. For example, the temporary spectrum access handling via the SAS, the sub-licensing via PPA claims, and the handling of a high number of spectrum resource licensees.

6 Temporary Spectrum Access in the Context of Local High-Quality Wireless Networks

6.0 General

In clause 5.1.4, four possible spectrum sharing schemes for providing local area services focusing on QoS were identified. From those four schemes, the following three are considered of main interest:

- Mobile network operators can offer dedicated local area services in their licensed frequencies
- Mobile network operators can sublease part of their spectrum locally to local area service providers
- Spectrum can be licensed to local area service providers

All three spectrum sharing schemes supports access to frequency bands with or without Incumbents. Depending on the frequency band, respective protection measures, e.g. as defined for LSA in [i.2], [i.3], may be needed to guarantee QoS for *local high quality wireless networks* and incumbent networks. LR and LC functionality are included in the spectrum resource repository and spectrum resource controllers, as described below.

Some *local high-quality wireless networks* scenarios may require the parallel use of different spectrum sharing schemes, and therefore, may need to combine the use of different functional architectures. For instance, the operator of a large industrial plant may request the use of licensed spectrum following scheme 3. in local automation cells for motion control applications, while it may run monitoring and maintenance applications as local services within an MNO network (following schemes 2. or 1.).

In the following, clause 6.1 provides examples of functional architectures that may enable the use of these three spectrum sharing schemes for *local high quality wireless networks*. In clause 6.2 these functional architectures are further detailed in a LSA framework.

6.1 Functional Use Cases

6.1.1 Local Service Areas Hosted by MNO Networks

This spectrum sharing scheme aims at the provisioning of *local high-quality wireless networks* as part of the MNO ecosystem. A possible functional architecture is depicted in Figure 5.

The MNO provides a *local high-quality wireless network* as an independent service network area comprising Network Entities, which belongs to the MNO domain. The MNO's Operation, Administration, and Maintenance (OAM) system configures respective radio resources in the service network area according to the needs of the local wireless communication services.

A *local entity* representing a service network area is responsible to provide information on the local wireless communication services needs and provides them to the OAM of the MNO. The OAM can take care of inter service-area coexistence and avoid harmful interference. Spectrum reuse between service network areas is possible, if location areas do not overlap or the MNO's OAM takes care of interference.

The interface between the MNO and the local entities is of critical importance for the acceptance and success of this scheme from the perspective of vertical industries. For example, this interface should provide means to reliably monitor and manage the proper realization of service level agreements (SLAs) from both the perspective of the service provider (MNO) and the vertical industry users.

The implementation of this scheme would allow *local high-quality wireless networks* to share network infrastructure from the hosting MNO but also to be deployed, at least to some extent, with attached private network infrastructure (e.g. network densification with private femtocells). Due to the expected complexity, the details on deployment of private network infrastructure and its integration and coexistence with the MNO infrastructure is for further study. All service network areas would have to implement an RAT that is accepted by the MNO.

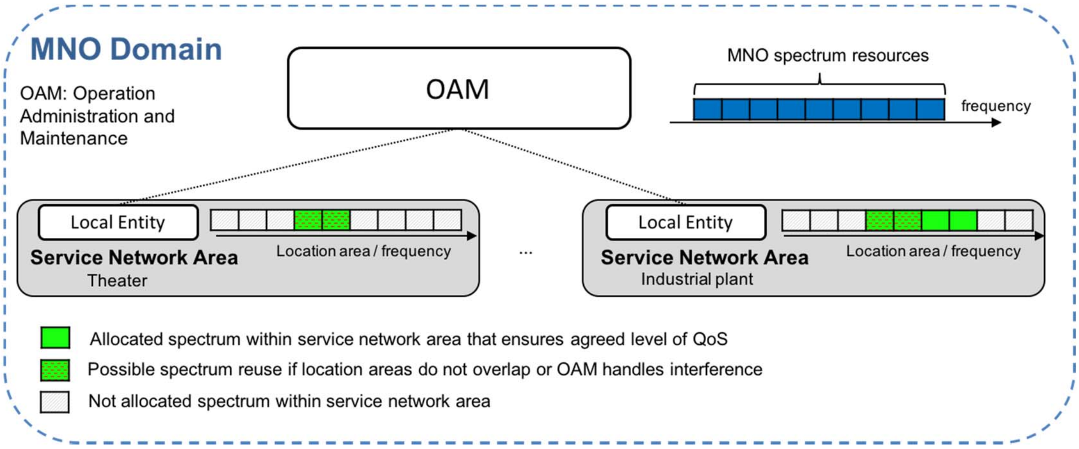


Figure 5: Functional use case for the integration of local high-quality wireless networks into an MNO ecosystem as service network areas

6.1.2 Private Network Areas with Local Subleasing

This spectrum sharing scheme foresees the set-up and operation of *local high-quality wireless networks* as stand-alone private network areas, subleasing spectrum access rights directly from an MNO. A possible functional architecture is presented in Figure 6.

If the regulatory environment allows for spectrum subleasing in the target frequency band, new market players (subleasers) can acquire spectrum access rights to some bands by subleasing them from the MNO.

Within the MNO domain, the OAM entity may receive several spectrum subleasing requests, with geographic and time information, from different subleasers. The OAM entity assigns suitable radio spectrum resources to the subleasers according to a subleasing contract. The radio conditions governing the use of spectrum, and to be fulfilled for each subleased area, so called allowance zones (see clause 6.1.3), are typically based on radio constraints such as a maximum allowed signal strength level on the border of the area.

The role of the subleaser could be occupied directly by the operator of a private network area or by a third-party entity delivering spectrum management service to several private network areas within a subleaser's area (if this is allowed by the MNO).

Network operation and control in each private network area could be done stand-alone, according to the subleasing contract. The subleaser should ensure that the radio conditions given by the MNO are fulfilled. Except by enough separation in distance or frequency, it might be challenging to perform global interference management between neighbouring private network areas as well as to the MNO. Optimization of this process is for further study. For example, private network areas may be able to negotiate network management agreements with the subleaser to ensure inter-network area interference management.

The implementation of the proposed functional architecture would allow *local high-quality wireless networks* to use any Radio Access Technology (RAT) complying with the relevant regulation and the subleasing contract.

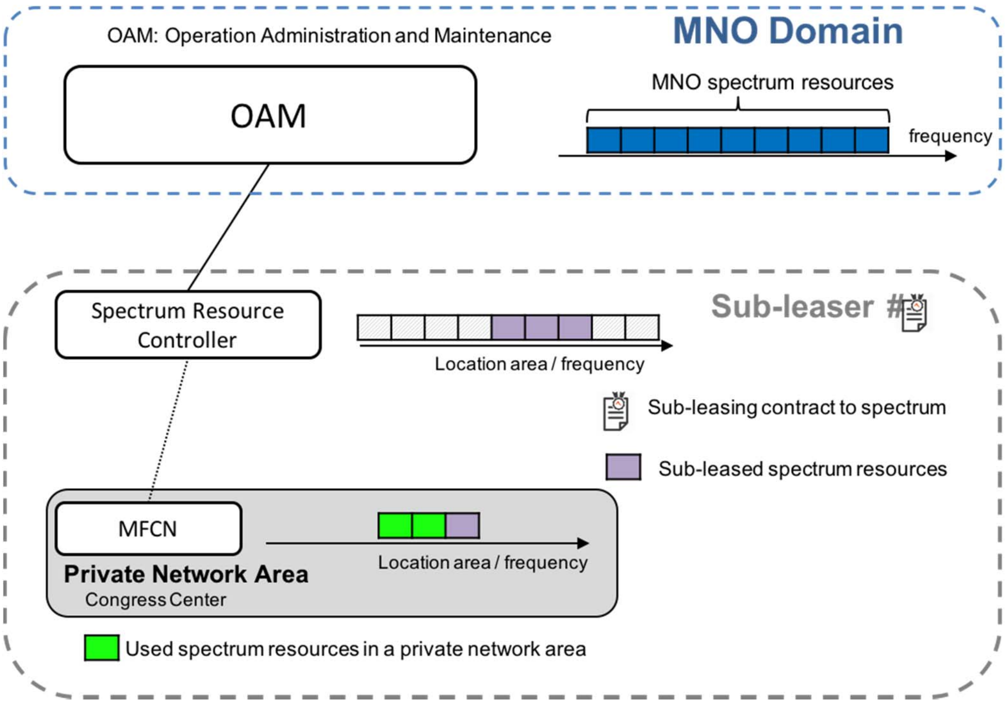


Figure 6: Functional use case for the deployment of local high-quality wireless networks as stand-alone private network areas with spectrum subleasing

6.1.3 Private Network Areas with Local Licensing

This spectrum sharing scheme foresees the set-up and operation of *local high-quality wireless networks* as stand-alone private network areas, without the necessary direct involvement of an MNO. A possible functional architecture is presented in Figure 7. The role of a local licensee could be occupied by different market actors, e.g. MNO, virtual MNO (MVNO), but also by new vertical service providers, the latter owning spectrum access infrastructure and providing spectrum management services.

In Figure 7, two options are presented:

a) The Spectrum Resource Controller (SRC) belongs to the local licensee domain, as in the case of local licensee #n.

b) One SRC entity can manage the access of multiple local licensees; this is the case of SRC#1.

In both cases, an SRC entity provides respective information related to the licensee's allocated radio spectrum resources to the private network areas (green blocks in Figure 7). Within each private network area, the allocated frequency resources are used in the most appropriate way by the MFCN. Network operation and control for each private network area can be done stand-alone, reducing dependence on 3rd parties with regards to the spectrum assignment. In case b), local licensees may be able to negotiate network management agreements with the serving SRC to ensure inter-network area interference management.

The local licensing conditions should allow for locally-confined spectrum access for short-term to long-term deployment periods (i.e. from days to years). Therefore, the interface between the Spectrum Resource Repository (SRR) and the SRC entities, may need to explicitly negotiate spectrum access rights in a geographic area (e.g. private network area) for a limited period of time. For instance, by the introduction of the concept of *allowance zone*. The allowance zone describes an area where the licensee has the right to transmit at a defined frequency range until the allowance time expires. Each allowance zone will have a set of associated radio conditions provided with the spectrum resource. Those radio conditions will e.g. ensure that neighbour areas are protected and can operate without disturbance. The local licensee will need to ensure that the radio conditions are fulfilled.

The interface between the SRC and the MFCN in each private network area may not necessarily be permanent, leaving open the possibility for a detached operation of *local high-quality wireless networks*.

The implementation of the proposed architecture instantiation would allow *local high-quality wireless networks* to use any Radio Access Technology (RAT) complying with the relevant harmonised standard in the target frequency band.

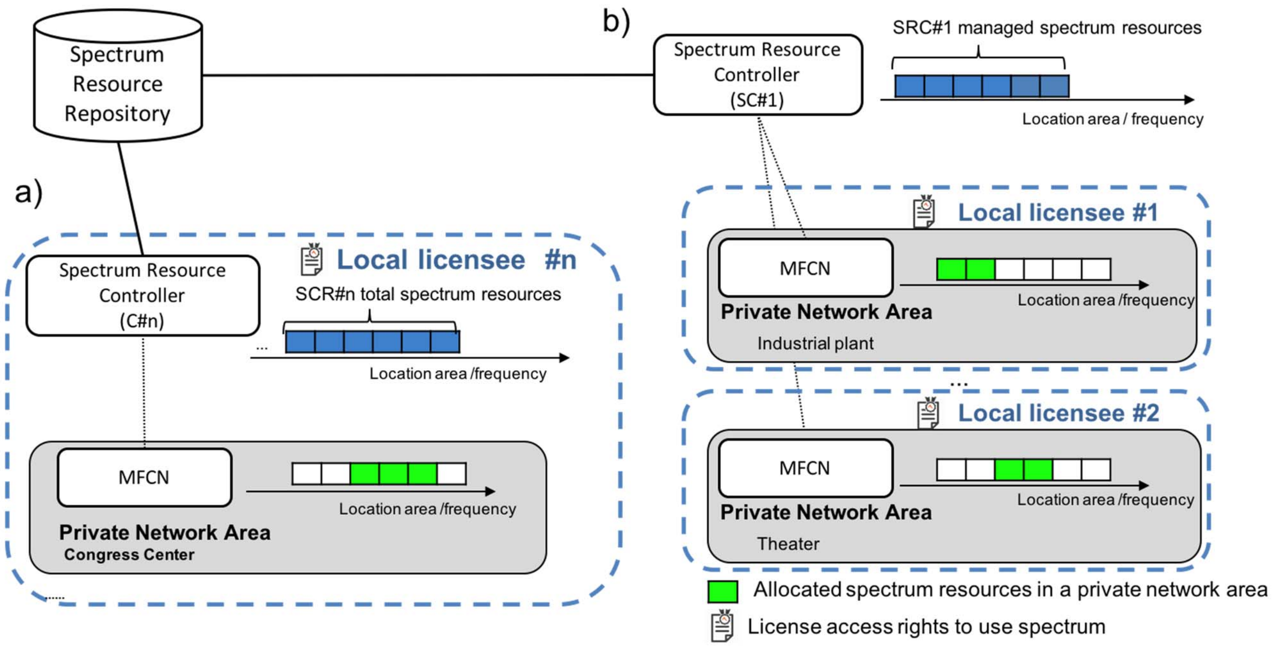


Figure 7: Functional use case for the deployment of local high-quality wireless networks as stand-alone private network areas

6.1.4 Comparison of Functional Use Cases

Table 5 compares the proposed spectrum sharing schemes. All three schemes aim to facilitate licensed spectrum sharing between vertical industries, with specified geographical and temporal limits, and incumbents both in IMT and non-IMT bands. The adoption of these proposals would create the potential to foster new dynamic business models for future wireless communications.

Table 5: Comparison of the three proposed functional use cases

	Local High-Quality Wireless Networks		
	Service Network Area	Private Network Area	
	Service	Subleasing	Local Licensing
Spectrum	Managed by MNO	Subleased from MNO to the vertical service provider	Allocated by Spectrum Resource Repository to the vertical service provider
Network infrastructure	MNO infrastructure (e.g. Network Slicing) Private attached to public MNO (Network Densification)	Private	Private
Radio Access Technology	Used by MNO	Any, following harmonised standards (e.g. HEN)	Any, following harmonised standards (e.g. HEN)
Network management	National, MNO-supported	Local, stand-alone	Local, stand-alone

6.2 LSA enhancements to Support Spectrum Sharing for Providing Local Area Services Focusing on QoS

6.2.0 General

A relevant sharing approach for providing local area services focusing on QoS is the European LSA [i.2] approach. The bottom line of LSA is that it aims to ensure a certain level of guarantee regarding radio spectrum access and protection against harmful interference for both the incumbent and LSA licensees, thus allowing them to provide a predictable QoS.

For locally confined and temporally flexible spectrum sharing system, the current LSA method needs to be evolved on LSA System level. Also, the regulatory framework needs to be considered.

CEPT/NRA level:

- Opening and using the LSA method to include vertical sectors players
- Using appropriate frequency bands and establishing a Sharing Framework for the vertical sector players
- May allow additional sharing methods like subleasing of spectrum resources
- Simplification of the LSA License process to handle a high number of vertical sector players

LSA System level:

- Establishment of allowance zones, each describing a locally confined deployment area where the licensee has the right to transmit at a defined frequency range until the allowance time expires (see clause 6.1.3)
- Locally confined deployment areas may be indoor and/or outdoor
- Deployment durations may range from several hours to several years, i.e. supporting flexible spectrum allocation procedures for LSA spectrum resources
- Channel arrangements should be deterministic and predictable (e.g. fixed channel plans) to satisfy the stringent QoS requirements of *local high-quality wireless networks*

6.2.1 Exemplary LSA Architecture Extensions

Assuming the enhancements indicated above are feasible, this clause aims to leverage the LSA concept as a suitable spectrum management tool for *local high-quality wireless networks*. The functional use cases described in clause 6.1 in combination with support of the spectrum access strategies defined in clause 5.1.4 builds the basis to evolve the LSA architecture defined in [i.3].

The following will provide information on an evolved LSA architecture and respective interface extensions for Incumbents, LSA Licensees, and the LSA entities itself. Another aspect addresses the operating concept for the evolved LSA entities to realize the hosting of *local high-quality wireless networks* (service network areas) by mobile network operators (MNOs) as well as the deployment of *local high-quality wireless networks* as standalone private networks.

Main advantage of the LSA method is that the shared spectrum provides a predictable level of QoS at a defined location for all spectrum resource users. The current LSA architecture in [i.3] was designed to share spectrum resources between Incumbents and LSA Licensees acting as MNOs. The support of additional MFCN operator types, which asks for both shorter or longer time of spectrum resource deployments without violating the QoS level and the associated higher number of LSA Licensees make it necessary to enhance the current LSA architecture to provide respective functions. The following Table 6 provides an overview of the identified potential functional enhancements and the affected LSA entities.

Table 6: Examples of potential functional enhancements

Function	Evolved LSA Repository	Evolved LSA Controller	Evolved Interfaces
Spectrum resource assignment (see note) to a MFCN including border conditions to protect neighbours.	Processing of a spectrum resource needs and decision of assignment to a MFCN.	Initiation of spectrum resource needs and enforcement of assignment decision to a MFCN.	LSA1 extension to exchange information related to spectrum resource needs and assignment to a MFCN.
Automated handling of high number of LSA Licensees / MFCNs.	Extended handling of security authentication and authorization for LSA Licensees (extension of registration information process).	Handling of LSA Licensee, LSA Controller, and MFCN authentication and authorization relevant information, especially when external LSA Controller serves multiple MFCNs.	LSA1 extension to exchange information related to LSA Licensees, LSA Controller, and MFCN.
Interference handling to guarantee predictable QoS.	Extension to exchange Incumbent and neighbourhood protection information.	LSA Controller may require more interaction with the OAM system and neighboured LCs.	LSA1 may require extension to optimize LSRAI exchange or to allow interference optimization indication from LC/MFCN to LR.
Support of "allowance zone" concept to protect network details of MFCN.	Extension to provide a spectrum resource for an "allowance zone" with respective Incumbent and neighbourhood protection.	Mapping of "allowance zone" to wireless network with possible help of the OAM system.	LSA1 extension to exchange information related to the "allowance zone".
Spectrum resource usage by Incumbents.	In case that some verticals are to be considered as Incumbents, the Repository may require processing respective Incumbent information in an automated way.	The functional requirement is comparable to the PMSE handling in the 2,3 GHz - 2,4 GHz band. It is for further study if an eLC like functionality for the Incumbent may be beneficial to provide spectrum resource.	LSA3 interface may require standardization.
Local subleasing of MNO spectrum resources (LSA and exclusive licensed).	Two options may be possible: (1) Repository based solution - MNO operates a Repository to handle the own spectrum resources and the LSA spectrum resources (LSR); for LSR, this may also include the interaction with LRor (2) LC based solution - MNO provides LSA spectrum resources via eLC with possible help of the OAM system Note that in some countries it may be required to inform or register the sublease with LR (of the regulator).	Option (1) - the subleaser (e.g. a vertical MFCN operator) operates an eLC and interacts with a Repository of an MNO Option (2) - the subleaser (e.g. a vertical MFCN operator) operates a LC based solution (eLC) (Spectrum Resource Controller) to communicate with a eLC operated by the MNO; alternatively, the eLC of the MNO interacts with the OAM system.	Option (1) - LR-LR interface may require standardization Option (2) - LSA1 interface may require additional standardization to handle exclusive licensed (i.e. subleased) spectrum resources and/or eLC-eLC communication.
Usage of MNO spectrum resources (LSA and exclusive licensed) for service network areas.	Not applicable - Same as for LSA spectrum assignment to MNO.	Internal separation and interference handling of allowance zones of multiple served MFCNs with help of the OAM system.	Not applicable - Same as for LSA spectrum assignment to MNO.
NOTE: The validity of the assigned spectrum resources may range from short-term assignments to long-term assignments depending on use case.			

Assuming that the evolved LSA entities and evolved LSA interfaces also provides backward compatibility to the current LSA system, the proposed new LSA architecture uses evolved components to allow for locally-confined and temporarily-flexible spectrum resource access. The evolved LSA Repository eLR, evolved LSA Controller eLC, and the $eLSA_1$ and $eLSA_3$ interface, i.e. the interface between the eLR and eLC and between Incumbent and eLR forms the basis to explicitly negotiate spectrum access in a specific geographic area for a defined period. The evolvement contains for instance, the concept of an "allowance zone", which may have to be added to the information elements and protocols of the $eLSA_1$ interface. The "allowance zone" describes an area where the LSA Licensee has the right to transmit at a defined frequency range until the allowance time expires.

Figure 8 shows the evolved LSA Architecture to provide temporarily-flexible spectrum access for *local high-quality wireless networks*. Two options are considered . In the first, an LSA licensee holds an evolved LSA Controller (eLC); see the upper case eLC is part of the LSA licensee domain. In the second, the eLC acts on behalf of one or more LSA licensees operating respective MFCNs.

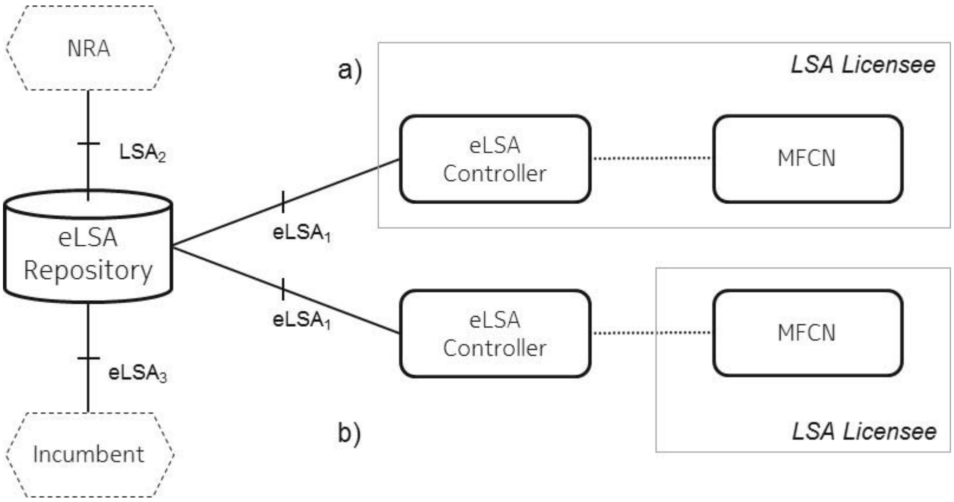


Figure 8: Evolved LSA Architecture

The aspect that eLSA Repository functions and/or eLSA Controller functions may require to be installed in different domains and that eLR and eLC entities may be additionally installed in multiple domains, e.g. to handle MNO subleasing of spectrum resources is not shown in Figure 8 but also covered by the evolved LSA concept.

The original LSA Concept described in [i.2] defines 4 roles operating the LSA entities. With introduction of vertical operators and the possibility that a MNO may be allowed to sublease spectrum resources to a vertical operator, it may be necessary to modify the role concept for LSA to allow a more flexible mapping of the roles (Regulator, Incumbent, LSA Licensee, and 3rd party) to the respective operation options of an evolved LSA Controller and evolved LSA Repository. For example, a MNO may act as a 3rd party to provide a Repository service of its spectrum resources to a MFCN of a vertical operator.

7 Conclusion

In the present document, high level use cases of selected vertical sectors, e.g. industrial automation, PMSE industry, PPDR and e-Health are presented. For these uses cases, service requirements and typical deployed network topologies have been described. From the comparison and analysis of these high-level use cases, the concept of local high-quality wireless networks has been introduced. This concept should be use as a collective term to enclose a kind of use cases targeting local area services requiring predictable level of QoS.

The present document identifies three possible spectrum sharing schemes for providing spectrum access to local high-quality wireless networks. All three proposed schemes aim to facilitate licensed spectrum sharing between operators of local area services, with specified geographical and temporal limits, and incumbents both in IMT and non-IMT bands. For each of these three possibilities, the report provides examples of functional architectures.

LSA [i.2], [i.3] primarily, but also some functionality of CBRS [i.13], have been recognized in the present document as relevant licensed spectrum sharing approaches for providing local area services focusing on QoS. For LSA to support the required locally confined and temporally flexible deployments, the current existing LSA method would need to be evolved on both LSA system and CEPT/NRA levels. The present document provides a list of functional enhancements at LSA system level.

The next step following the identification of feasible spectrum sharing schemes will include developing a technical specification, covering the specific system requirements for providing spectrum access for local high-quality wireless networks.

Annex A: Change History

Date	Version	Information about changes
28.08.2017	7	Adding clause 5.1
14.09.2017	8	Adding clause 6.1
26.10.3017	10	Adding clause 6.2
14.11.2017	11	Revision of clause 2.2. Informative References In clause 3.1 Definitions, inclusion of the term "temporary" Revision of clause 3.3 Abbreviations Revision of clauses 4.1.1 and 4.1.2 resulting in minor changes in the values of some parameters. Adding some text (use cases) to clause 4.1.3 and 4.1.4 Repairing formatting issue with clause 5.1.4
21.11.2017	12	Revision of clause 4.1.1 PMSE
21.11.2017	13	Adding clause 7
21.11.2017	14	Including TR number (103 588)
12.01.2018	18	Minor editorial revision

History

Document history		
V1.1.1	February 2018	Publication