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Reconfigurable Radio Systems (RRS);
Feasibility study on existing spectrum sharing frameworks for temporary and flexible spectrum access

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ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - APE 7112B
Association à but non lucratif enregistrée à la
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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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Executive summary

The present document provides information on use cases of vertical sectors with specific characteristics of spectrum usage and access, such as audio PMSE, e-health, wireless industrial automation, PPDR, intelligent transport system, car test track, and drone control and payload, and introduces various spectrum sharing frameworks, including standardized architectures, such as LSA, eLSA, and CBRS, standardized technology specific protocols, e.g. Listen Before Talk, Detect And Avoid, and Dynamic Channel Selection, and spectrum allocation procedures, such as audio PMSE frameworks and National Local Licensing.

After an extraction of the most challenging use case parameters and a comparison of all sharing frameworks against it, the present document summarizes the following features which need to be supported by a sharing framework for temporary and flexible spectrum access:

- ensuring incumbent protection and inter-system coordination between secondary users;
- allowing for usage independent of specific frequency bands and RF technology; and

- introducing a high degree of flexibility and scalability to adapt to the specifics of the frequency bands, incumbents, and secondary users.

Proposed next steps are to:

1) develop envisaged adjustments for AFC, eLSA and CBRS (adding, removing, and/or modifying features); and

2) consider the creation of a SRdoc for spectrum sharing for local private networks.

Introduction

Exclusive spectrum access is the predominant paradigm for spectrum access and guarantees high spectral efficiency and easy network planification for services requiring constant access to radio spectrum. However, many services only need access to the medium in specific zones and time slots, leaving spectrum underutilized.

As demand for local private wireless networks increases and regulators have begun to identify frequency bands for vertical use, appropriate spectrum sharing frameworks need to be adjusted to the specific needs of private networks to share the spectrum efficiently and to significantly simplify handling for the end user.

Depending on the nature and the characteristics of the local private wireless network, automatic, temporary, and flexible spectrum access can be a key component for generally efficient spectrum sharing as well as user-friendly operability. The term "local private wireless network" refers not only to wireless broadband connectivity controlled and managed by a private organization, but also to a network with special characteristics and a high level of Quality of Service (QoS) that a public network typically cannot provide. Similar to a public network, a private network needs access to spectrum but in contrast to public networks it shares the spectrum with e.g. incumbents or other secondary users. It can either use spectrum that is assigned to a spectrum owner or use unlicensed spectrum. The use of unlicensed spectrum conflicts with the need for a high level of QoS. Therefore, the present document focuses on access to licensed spectrum for local private networks. To optimize efficiency of spectrum sharing and support flexibility and high dynamic spectrum demand, the spectrum access procedure should be automated and reflect the different use case characteristics and levels of QoS.

1 Scope

The present study addresses technical approaches for automated spectrum access to support dynamic, temporary, and flexible spectrum sharing. Existing spectrum sharing frameworks (e.g. CBRS, LSA, etc.) are evaluated with regard to their suitability for temporary and flexible spectrum access. To evaluate such suitability, the study identifies and assesses properties and parameters (e.g. for scalable localized dedicated networks) that need to be considered. It includes a gap analysis to identify possible for spectrum access for on-demand use cases. This scope includes nomadic deployments.

The applications and use cases described claim a certain, typically high Quality of Service (QoS) but are often limited in range and differ in the duration of operation which can vary from short-term (e.g. some days to some weeks) to long-term (e.g. some weeks to some years). Some use cases allow for prior network planning, others demand very short-term deployment without a prior planning phase.

To support the use cases described, the study evaluates:

- suitability of sharing frameworks for temporary and flexible spectrum access to support ad hoc and on-demand use cases;
- procedures and functionalities for automated spectrum negotiation, assignment, and application specific QoS guarantee;
- suitability for the support of scalable localized dedicated networks;
- suitability for the support of fixed, nomadic, or mobile deployments; and
- characteristics, system architectures and high-level procedures for spectrum access for use cases described.

If needed, this study proposes evolution and improvement of the existing technical approaches or develops new technical solutions for spectrum sharing.

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.

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[i.9] ECC Report 254 (November 2016): "Operational guidelines for spectrum sharing to support the implementation of the current ECC framework in the 3600-3800 MHz range".

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[i.16] Report on spectrum requirements for Audio PMSE, by Daniel Künzi, Schweizer Radio und Fernsehen, 24.03.2022.

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[i.18] ETSI EN 300 328: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Wideband transmission systems; Data transmission equipment operating in the 2,4 GHz ISM band and using wide band modulation techniques; Harmonized EN covering essential requirements under article 3.2 of the R&TTE Directive".

[i.19] ETSI EN 301 175-3: "Digital Enhanced Cordless Telecommunications (DECT); Common Interface (CI); Part 3: Medium Access Control (MAC) layer".

[i.20] ETSI TS 103 652-1 (V1.1.1): "Reconfigurable Radio Systems (RRS); evolved Licensed Shared Access (eLSA); Part 1: System requirements".

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3 Definition of terms, symbols and abbreviations

3.1 Terms

Void.

3.2 Symbols

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

dBm	deciBel-milliwatts
GHz	GigaHertz
MHz	MegaHertz
mW	MilliWatt

3.3 Abbreviations

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

3GPP	Third Generation Partnership Project
4G	4th generation technology standard for broadband cellular networks
5G	5th Generation technology standard for broadband cellular networks
AFC	Automated Frequency Coordination
AP	Access Point
BNetzA	Bundesnetzagentur
BVLOS	Beyond Visual Line Of Sight
CBRS	Citizens Broadband Radio Service
CBSD	Citizens Broadband Radio Service Device
CDMA	Code Division Multiple Access
CEPT	European Conference of Postal and Telecommunications
CIM	Computer-Integrated Manufacturing
CRC	Cyclic Redundancy Check
C-V2X	Cellular Vehicle-to-Everything
DAA	Detect And Avoid
DCS	Dynamic Channel Selection
DECT	Digital Enhanced Cordless Telecommunications
DFS	Dynamic Frequency Selection
DL	Downlink
DoD	Department of Defence
DP	Domain Proxy
DPA	Dynamic Protection Area
DSS	Dynamic Spectrum Sharing
ECC	Electronic Communications Committee
EIRP	Effective Isotropic Radiated Power
eLC	evolved Licensed Shared Access Controller
eLR	evolved Licensed Shared Access Repository
eLSA	enhanced Licensed Shared Access
EN-DC	E-UTRA-NR Dual Connectivity
ERC	European Radiocommunication Committee
ESC	Environment Sensing Capability ITM Irregular Terrain Model
E-UTRA	Evolved Universal Mobile Telecommunications System Terrestrial Radio Access
FCC	Federal Communications Commission
FDMA	Frequency Division Multiple Access
FHSS	Frequency Hopping Spread Spectrum
FR1	Frequency Range 1
FR2	Frequency Range 2
FSS	Fixed Satellite Service
FT	Fixed Terminal
GAA	General Authorized Access
GPS	Global Positioning System
GWPZ	Grandfathered Wireless Protection Zone
HD	High Definition
ID	Identifier
IEM	In Ear Monitor
IMSI	International Mobile Subscriber Identifier
IMT	International Mobile Telecommunications
IoT	Internet of Things
IPRM	public Integrated, Private Mobile/Fixed communications network
ISM	Industrial Scientific Medical
ITS	Intelligent Transport System
ITS-G5	European standard for vehicular communications based on IEEE 802.11p standards
KPI	Key Parameter Indicator
LBT	Listen Before Talk
LC	Licensed Shared Access Controller
LOS	Line Of Sight
LPI	Low Power Indoor

LR	Licensed Share Access Repository
LSA	Licensed Shared Access
LSRAI	L Spectrum Resource Availability Information
LTE	Long Term Evolution
MAC	Medium Access Control
MBSFN	Multimedia Broadcast Single Frequency Network
MCS	Modulation Coding Scheme
MFCN	Mobile/Fixed Communications Network
MNO	Mobile Network Operators
NGMN	Next Generation Mobile Networks
NLL	National Local Licensing
NM	Network Management
NPN	Non-Public Network
NR	New Radio
NRA	National Regulatory Administration
NSA	Non-Standalone
NTIA	National Telecommunications and Information Administration
OFCOM	Office Of Communications
PAL	Priority Access Licenses
PLMN	Public Land Mobile Network
P-MFCN	Public Mobile/Fixed Communications Network
PMSE	Programme Making & Special Events
PNI-NPN	Public Network Integrated Non-Public Network
PNO	Private Network Operator
PPDR	Public Protection & Disaster Relief
PT	Portable Terminal
QoS	Quality of Service
R&O	Report and Order
RAT	Radio Access Technology
RF	Radio Frequency
RLAN	Radio Local Access Network
SA	Standalone
SAS	Spectrum Access System
SHNI	Shared Home Network Identifier
SIB2	System information block type 2
SNPN	Standalone Non-Public Network
SP	Standard Power
SPRM	Standalone, Private Mobile/Fixed Communications Network
SRD	Short Range Device
TC	Technical Committee
TDD	Time Division Multiplex
TDMA	Time Division Multiple Access
TV	Television
TVWS	Television White Space
TVWSD	Television White Space Device
UAS	Unmanned Aerial Services
UAV	Unmanned Aerial Vehicles
UE	User Equipment
UHF	Ultra High Frequency
UL	Uplink
URLLC	Ultra Reliable Low Latency Communication
USA	United States of America
V2X	Vehicle-to-Everything
VHF	Very High Frequency
VLOS	Visual Line Of Sight
VLP	Very Low Power
VSP	Vertical Sector Player

4 Use cases and their characteristics

4.1 Introduction

This clause analyses the needs and characteristics of selected vertical sectors, e.g. Culture and Creative Industry (audio PMSE), Public Protection & Disaster Relief (PPDR), e-Health, Industrial Automation, etc.

Each use case is analysed based on the parameters listed in Table 1.

Table 1: Description of use case parameters

Parameter	Description	Range of values
Deployment	The way the infrastructure is installed/used	Fixed: infrastructure is fixed installed nomadic: infrastructure can be moved but is fixed during operation Mobile: infrastructure can be moved during operation
QoS levels	The specific KPIs of the use case	Various values
Radio Access Technology (RAT)	The kind of RAT which exists for the specific use case	Standardized, proprietary
Network architecture	The way the network is built to support the use case	P-MFCN: public MFCN SPRM: standalone, private MFCN IPRM: public integrated, private MFCN
Network coverage	The area where the service is available	Local, national, transnational, worldwide
Usage period	The overall time the use case occupies the spectrum	Various values
RF channel holding time	The time during which the RF channel is used continuously without free time slots for system adjustments such as frequency change, MCS change, etc.	Various values
Spectrum access mode	The way in which spectrum access is provided	Planned, ad-hoc
Spectrum access	The way/process how the spectrum is accessed	License-exempt, Licensed: shared and coordinated, Licensed: shared and non-coordinated, Licensed: not shared
Spectrum bands	The frequency bands the service/use case is available	Various values
Spectrum demand	The total amount of spectrum needed for the use case	Various values

According to CEPT, the term "MFCN" (Mobile/Fixed Communications Network) includes International Mobile Telecommunications (IMT) and other communication networks in the mobile and fixed services [i.47]. A Public MFCN (P-MFCN) refers to a communication network for the specific purpose of providing data transmission services for the public, e.g. a PLMN, whereas a private MFCN describes local networks where restrictions and access rules are established in order to relegate access to a select few. Private MFCNs can be separated into:

- SPRM: standalone, private MFCN without any connection to a public MFCN.
- IPRM: private MFCN which is integrated into and managed by a P-MFCN.

Is the SPRM based, for example, on 5G, it is called SNPN.

Depending on the use case, the values in the following tables represent the state of the art and/or future realizations.

4.2 Audio Programme Making & Special Events (audio PMSE)

Programme Making and Special Events (PMSE) is a term summarizing front-end 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.

PMSE equipment is divided into:

- video PMSE: wireless cameras;
- audio PMSE: wireless microphones, In-Ear Monitor systems (IEM), wireless conference systems, talkback; and
- remote control: wireless light and effect remote controls.

The individual user of audio PMSE equipment configures a system according to the actual needs of the production i.e. number of performers, musical instruments, sound effects and location with careful consideration of the link budget. Available spectrum at a location has a major impact on the possible number of wireless microphone and IEMs. A lack of spectrum restricts the size and quality of the overall audio production. Further considerations are:

- the tuning ranges of the available equipment;
- co-located events at the location;
- other wireless equipment in use e.g. security, etc.; and
- the total number of audio channels, which fits into a given amount of spectrum. Many manufacturers now offer modes which double or triple the channel count, but this currently comes at a price of reduced coverage, robustness or audio performance.

Usually, the use of audio PMSE frequencies in and around a location site is known. With these considerations and the observed use of radio spectrum the 'worst case' scenario of all equipment being in use can be assessed and calculated. This allows to establish a controlled interference scenario even in hotspot areas with dense audio PMSE use.

Audio PMSE equipment operates on a free tuning range concept. A tuning range is the frequency range in which equipment is able to operate. Within this tuning range, the use will be limited to the range of frequencies identified for audio PMSE nationally or geographically and the audio PMSE equipment will be operated in accordance with the related national regulatory conditions.

Audio PMSE equipment's primary frequency band is 470 MHz - 694 MHz which is globally available.

Professional use of audio PMSE needs detailed frequency planning in advance to make spectrum sharing possible and to guarantee interference-free operation with the broadcast service which is the primary user in the 470 MHz - 694 MHz band in most countries of the world. Spectrum that is useable for professional audio PMSE needs to be:

- observable, e.g. by spectrum scanning procedures or other information; and
- predictable, e.g. stable in its operational times and frequency for the PMSE event time and location.

Table 2 summarizes characteristics of different use cases of audio PMSE.

Table 2: Characteristics of different use cases of audio PMSE

Parameter	Live Audio Production/Special Events		Electronic News Gathering
Deployment	Nomadic	Fixed	Nomadic; mobile
QoS levels	Very high reliability (no audible disturbance allowed) Ultra-low latency	Very high reliability (no audible disturbance allowed) Ultra-low latency	High to very high reliability; Low latency
RAT	Proprietary	Proprietary	Proprietary
Network architecture	SPRM	SPRM; IPRM	SPRM; IPRM; P-MFCN
Network coverage	Local	Local	Local; transnational
Usage period	Few days to several weeks	Few to several months	Few hours to few days
RF channel holding time	6h to 12h	6h to 12h	2h to 6h
Spectrum access mode	Planned	Planned	Planned; ad-hoc
Spectrum access	License-exempt; licensed: shared and coordinated; licensed: shared and non-coordinated	License-exempt; licensed: shared and coordinated; licensed: shared and non-coordinated	License-exempt; licensed: shared and coordinated; licensed: shared and non-coordinated
Spectrum bands	See clause 5.3	See clause 5.3	See clause 5.3
Spectrum demand	[i.15]: approximately 96 MHz in sub 1 GHz for daily use [i.16]: average spectrum needs from 42 MHz (small events) to 115 MHz (large events); major events need 174 MHz		

Today, TV UHF spectrum from 470 MHz to about 900 MHz is best suited for audio PMSE operation for the following reasons:

- low ambient RF noise level;
- high antenna efficiency for antennas used with small portable devices, e.g. wireless microphones and small body receivers;
- efficient propagation in both indoor and outdoor spaces over short distances; and
- ability to pass through moderate amounts of clutter, e.g. stage equipment and scenery, without excessive losses.

4.3 E-Health

The term e-health summarizes the use of information and communication technology in support of health and health related fields. It encompasses a wide range of uses, from mobile health (m-health), which describes the use of mobile wireless technology for health, to telehealth/telemedicine, which describes the use of telecommunications and virtual technology to deliver health care outside of traditional health care facilities, and increasingly underpins, supports, and enhances all critical medical applications and health care activities.

According to 3GPP TR 22.826 [i.3], critical medical applications can be categorized as follow:

- static - local: medical team and patient are collocated; devices are not moving while the care is delivered;
- moving - local: medical team and patient are collocated; devices are moving while the care is delivered;
- static - remote: medical team and patient are not collocated; devices are not moving while the care is delivered; and
- moving - remote: medical team and patient are not collocated; devices are moving while the care is delivered.