LSA field trials using LTE network and SON LSA controller

Status and plans for 2015

WInnComm-Europe 2015, October 6, 2015

Spectrum Sharing Workshop

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Nokia Networks

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Outline

- Use case
- System concept
- System architecture and functional elements
- Trial environment
- Field trial results
- Technical enablers
- LSA architecture evolution

Nokia Networks Technology Vision 2020

Delivering gigabytes of personalized data per user per day profitably and securely

Support up to 1000 times more capacity

Reduce latency to milliseconds

Teach networks to be self-aware

Flatten total energy consumption

Reinvent Telcos for the cloud

Personalize network experience

Everything contributes to reducing cost/bit

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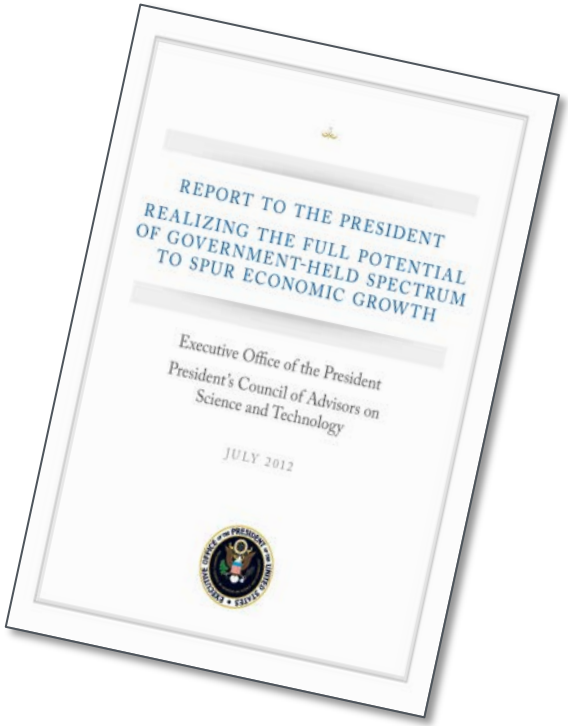
+ WRC 2015 afterlife

New era in spectrum regulation and standardization

US President's Council of Advisors on Science and Technology Report Proposed Major Changes to Spectrum Policy, Using Federal Spectrum

1. *Define a spectrum license to be a right not to be interfered with, but with no right to exclude -- all spectrum therefore usable by somebody*
2. *Provide a band where all types of users have the same capability, but still allow for purchasing protection (3 tiers)*
3. *Allow for spatial and temporal sharing of a band among a wide class of users (initially, federal radars and civil broadband)*
4. *Automate de-confliction through micro transactions based on interference criteria*
5. *Shorter term licenses to enable successor uses to enter the band naturally*



+ Sharing economy

Harmonization and global standards drive economies of scale

Spectrum usage models

Mainstream approach
auctions
of cleared spectrum

Exclusive use
ensures
Quality of Service

Complementary
license model
Licensed Shared Access

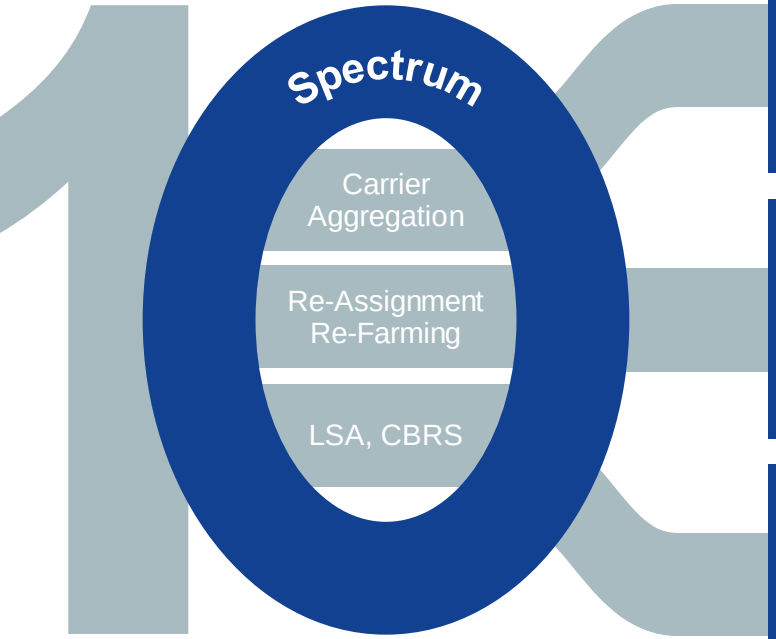
Exclusive shared use
exclusive use on a *shared* and *binary*
basis in time, location, and/or frequency
with incumbent (government, defense etc.)
predictable Quality of Service

Shared approach
unlicensed
(Wi-Fi, LTE-U, …)

Shared use
unpredictable
Quality of Service

10x spectrum for 1000x capacity

Main levers to optimize spectrum use for Mobile Broadband in bands below 6 GHz



Dynamic combination of fragmented spectrum

- **Wideband RF technologies**

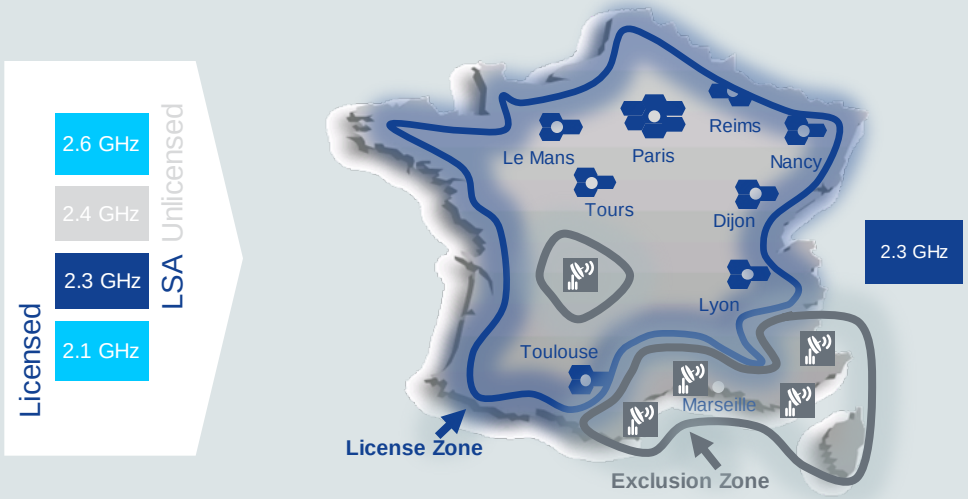
Additional harmonized spectrum for LTE by re-farming & re-assignment

Unlock more spectrum by shared access with predictable QoS

LSA opens TD LTE 2300 band for operators in Europe

Example - Static LSA case with military incumbent in France

Enables timely availability and licensed use of harmonized spectrum with predictable QoS



Accelerates spectrum harmonization

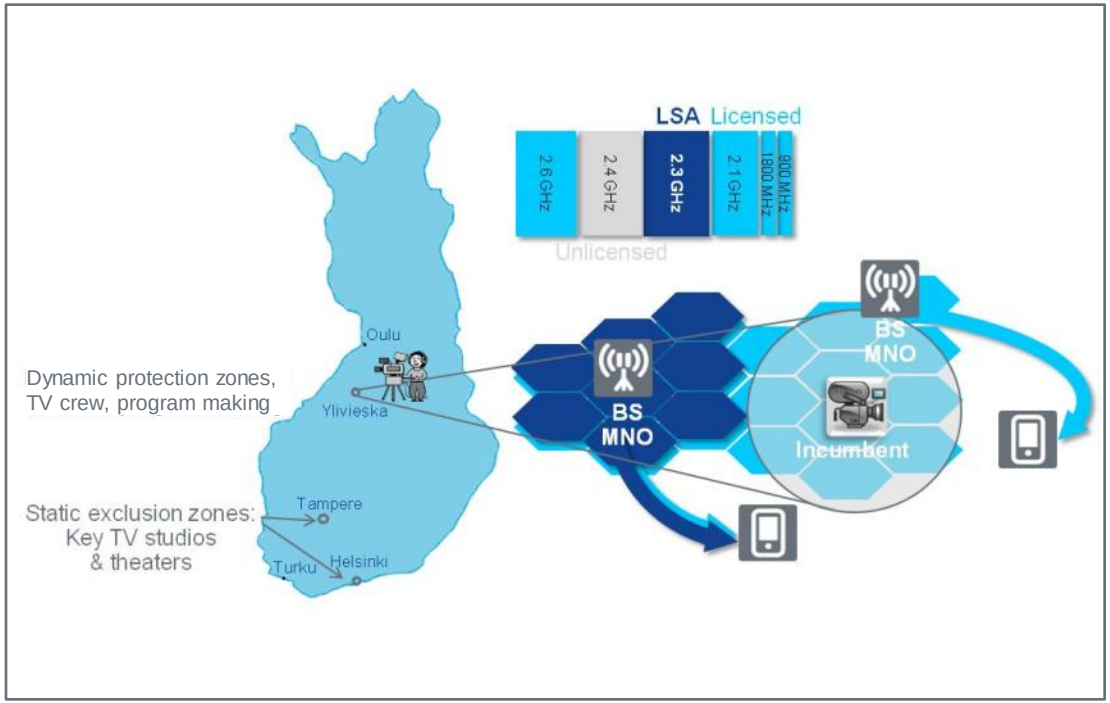
Leverages available LTE technologies to ensure early use and economy of scale

Opportunity for lower cost and high quality licensed spectrum

Spectrum harmonization

LSA opens TD LTE 2300 band for operators in Europe

Example - Semi static LSA case with PMSE incumbent in Finland



LSA opens bands otherwise locked for long time for harmonized MBB use like the 2.3 GHz 3GPP band 40 in Europe supported in commercial devices today

LSA

QoS spectrum

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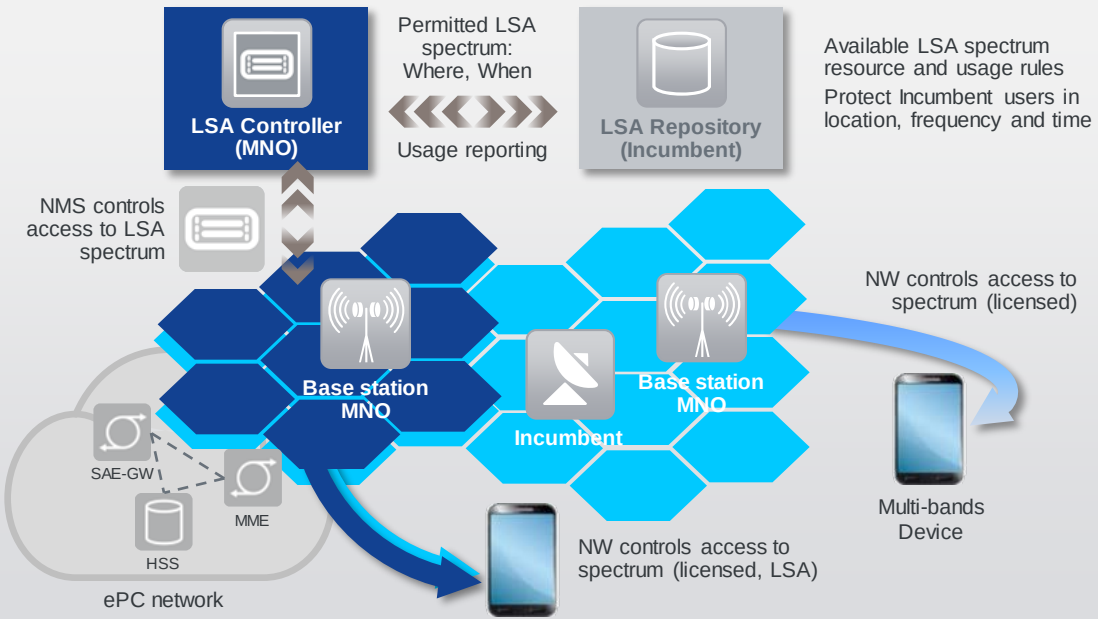
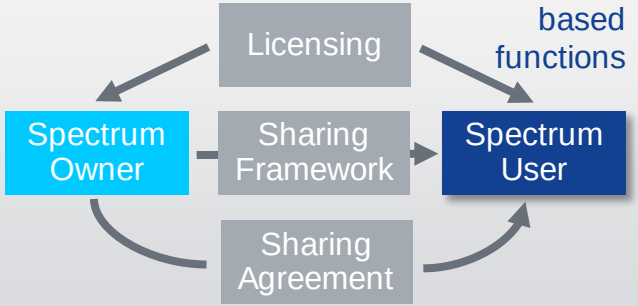
Licensed Shared Access functional model

Technical, administrative and role based functions

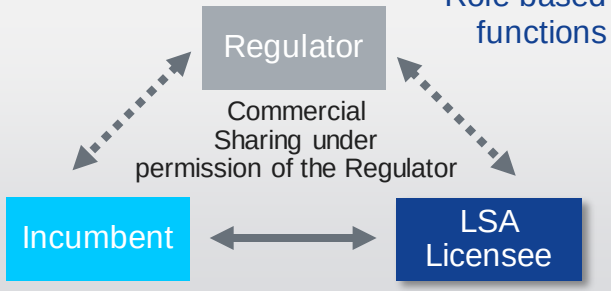
Technical functions



Administration based functions

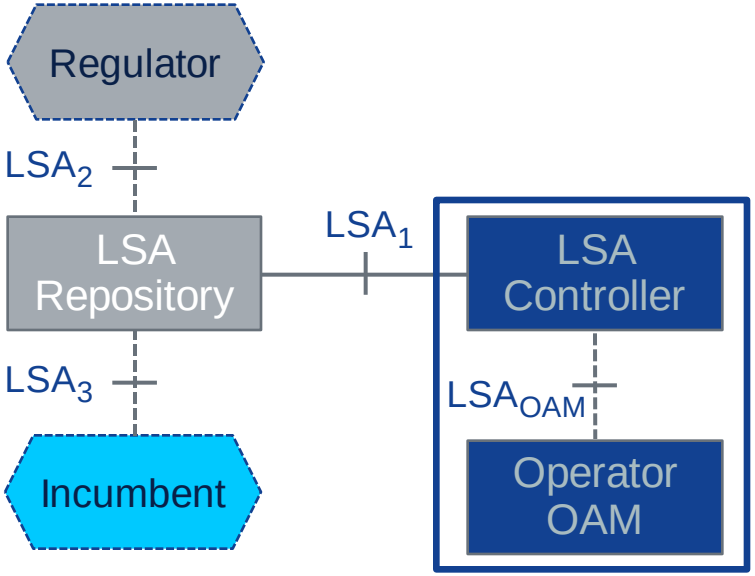


Role based functions

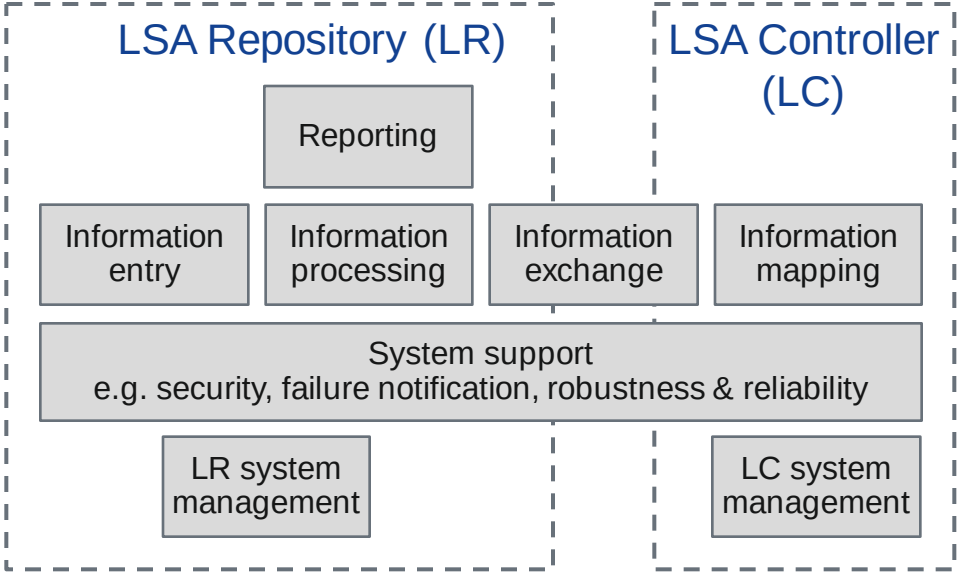


LSA high level system architecture and functional elements

ETSI RRS TS 103 235



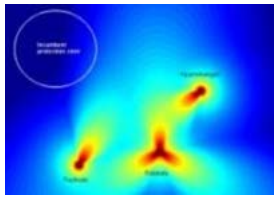
LSA architecture reference model



Mapping of high level functions to logical elements

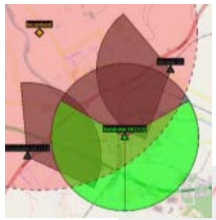
The Finnish LSA trial evolution with increasing flexibility and dynamics

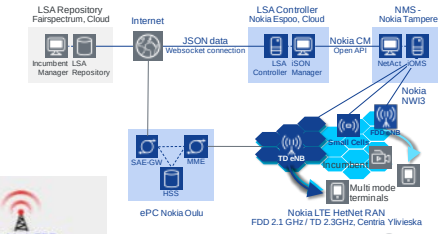
Network on-demand
(cloud CN & OSS)



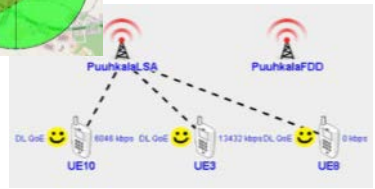
LSA evolution
& CBRS (Globecom 12/15)

LSA SON controller
(DySpan 9/15)

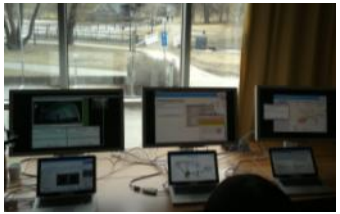




Mobile incumbent tracking
(ECC plenary 7/15)



Small cell layer (ETSI workshop 12/14)



Incumbent manager & emergency evacuation (CrownCom 6/14)

FDD TD LTE LSA load balancing (DySpan 4/14)

Trial with complete LTE LSA network (Tekes TRIAL workshop 9/13)

World's 1st LSA concept trial (WWRF 4/2013)

2013 **Tekes TRIAL** **CORE+** 2014 2015 **Tekes 5thGear** **CORE++** 2016

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World 1st LSA over the air field trials proved the concept

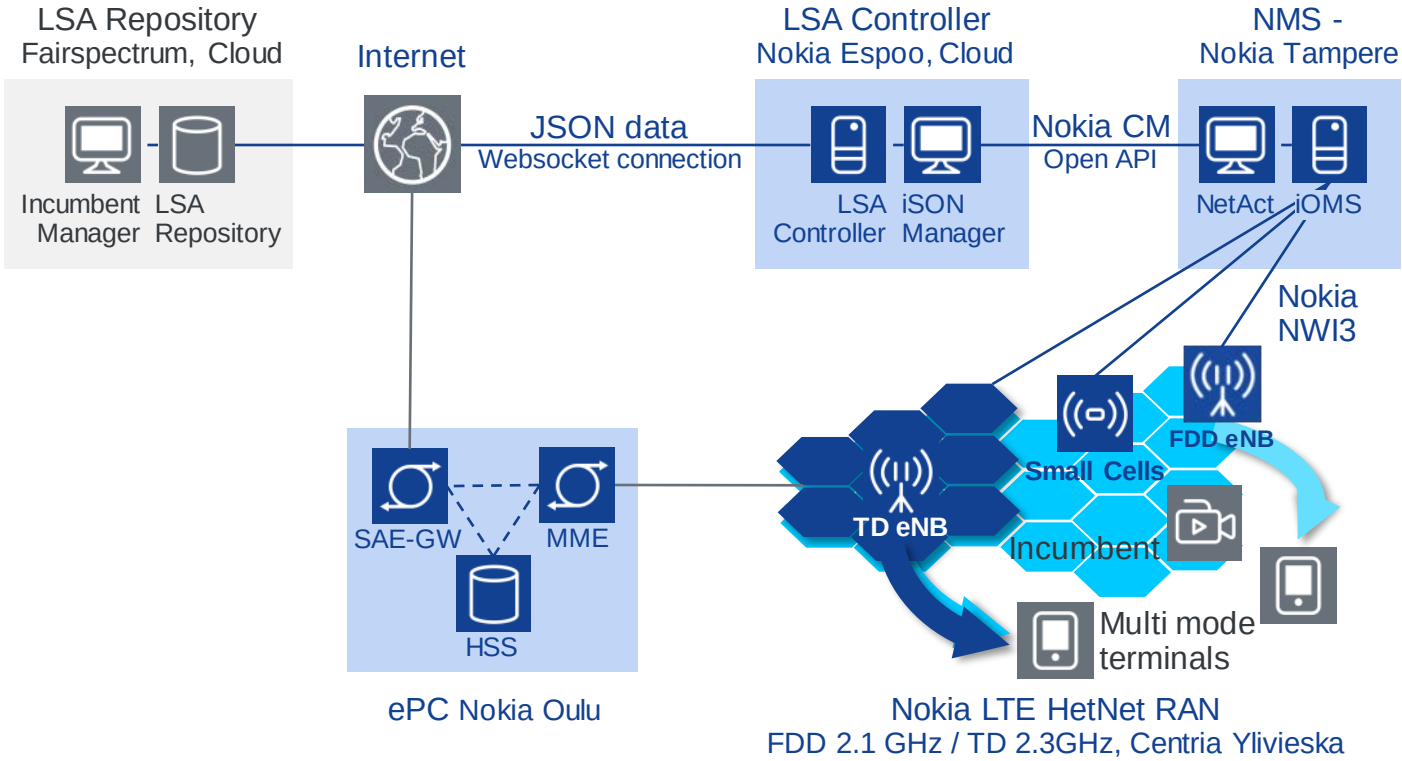
LSA TD LTE 2300 with PMSE over the air field trial with e2e Finnish ecosystem in April 2013

Trial included full e2e LSA ecosystem in Finland: regulator, incumbents, MNO and supplying industry in CORE+ project

LSA Ecosystem

Finnish CORE++ LSA trial environment 2015

Trial uses global and available LTE technologies to ensure economies of scale and early use



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LSA field Trial#5 with small cell layer, ETSI RRS Dec. 2014

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LSA field Trial#6 run system end-to-end performance evaluation, May 2015

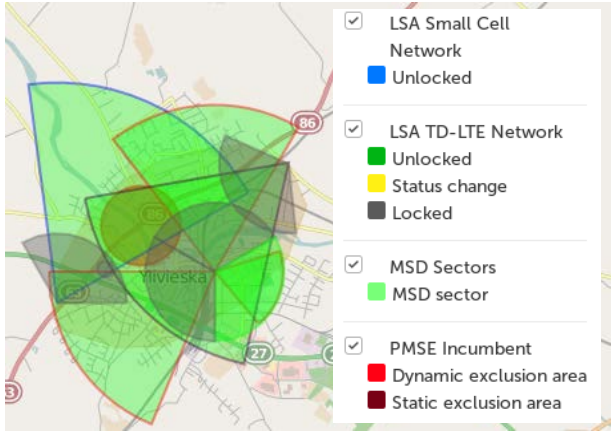
With Self Organized Network iSON LSA Controller and novel protection algorithms

Table 1. LSA band evacuation measurement results

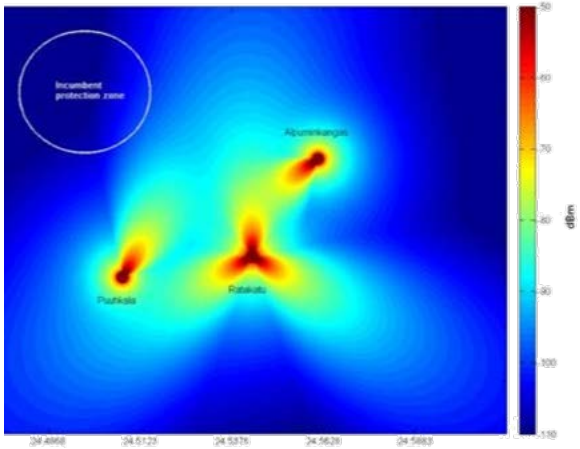
	Meas point	Evacuation MSD		Evacuation PZO	
		Time[s]	SD[s]	Time[s]	SD[s]
1. Incumbent makes evacuation request via LSA Incumbent Manager (IM)	LSA IM	0		0	
2. LC receives incumbent information from LR	LC	0,27		0,27	
3. OAM starts de-activation command	OAM	2,35	1,74	1,17	0,75
4.eNB/cell on LSA band is deactivated	LSA band	24,40	1,53	24,19	2,13
5. OAM notify LC that plan commission is completed	LC	51,30	1,54	50,88	0,75
6. Incumbent user receives confirmation on evacuation to LSA IM	LSA IM	51,57	1,73	51,14	0,68

Table 2. Total measured execution times of each trial system element

Total execution time [s]	e2e		component	
	MSD	PZO	MSD	PZO
NMS	48,49	48,78	48,49	48,78
LC	51,03	50,61	2,55	1,83
LR	51,57	51,14	0,54	0,54
Algorithm calculation	0,30	0,09	0,30	0,09



Minimum Separation distance (MSD)



Protection Zone Optimization (PZO)

On average LSA band was cleared in 24 seconds

Source: "Licensed Shared Access (LSA) field trial using LTE network and self organized network LSA Controller, S.Yrjölä , et al., WInnComm-Europe 2015

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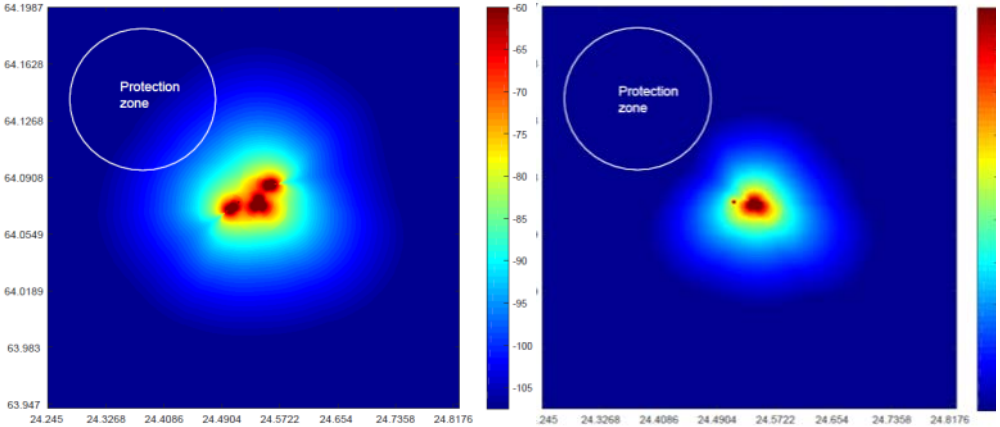
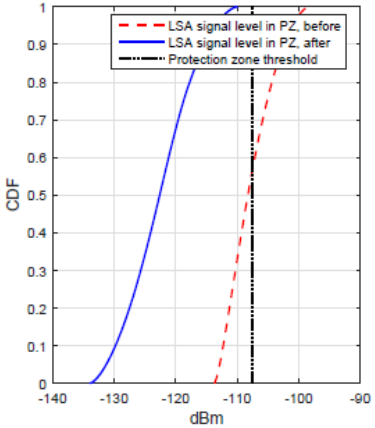
LSA field Trial#7 with power control algorithm to optimize capacity, DySpan Sept. 2015

Built on Self Organized Network iSON LSA Controller

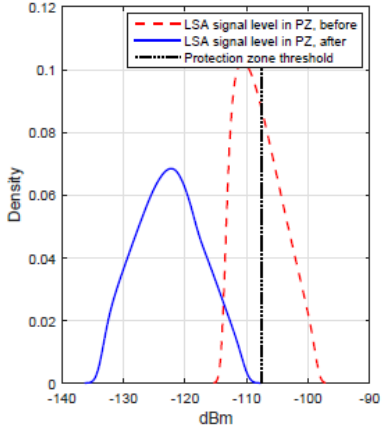


Aggregate field strength of the network when eBNs are transmitting at the maximum power level.

Aggregate field strength after applying the power control algorithm



Cumulative distribution functions of the LSA signal levels in the Protection Zone (PZ) before and after the power control.



Density functions of the LSA signal levels in the PZ before and after the power control.

Source: "Field Trial of Licensed Shared Access (LSA) with Enhanced LTE Resource Optimization and Incumbent Protection," DySpan Sept. 2015

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Scaled up OSS system end-to-end performance for LSA case

NetAct LTE radio configurator performance test results for typical network wide configuration

1 eNB HD	
MRBTS	1
LNBTS	1
LNCEL	12
LNADJ	128
LNADJL	1536
LNREL	1440
LNADJW	256
LNADJG	256
LNRELW	960
LNRELG	480

Configuration used in testing CM only and System Level PET	
Objects in one eNB	5432
Cells in one eNB	12
OMSes	4
eNBs below one OMS	1 000
Total eNBs	4 000
Total cells	48 000
Total objects	21.7 million

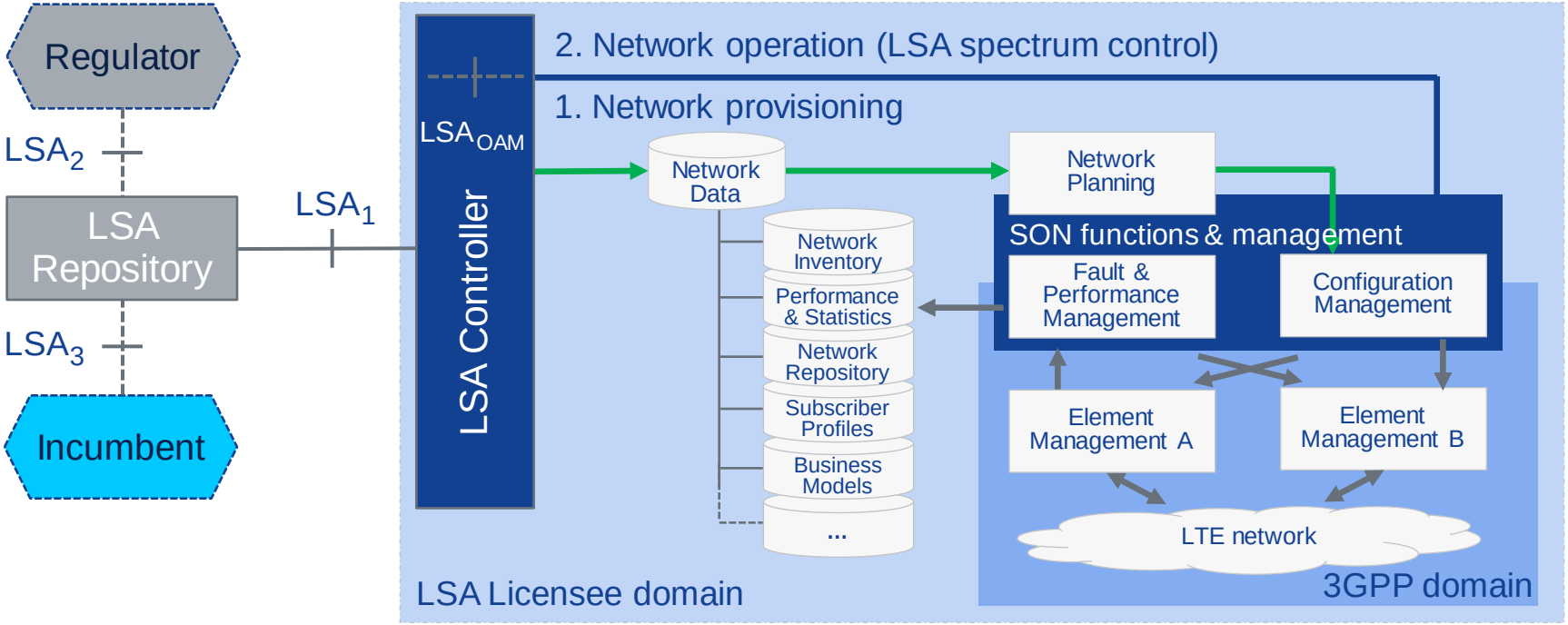
Adjacency objects per eNB and data amounts in typical configuration

Test case	
Configuration plan file download for a single eNB	< 1 min
Emergency plan download with automatic activation operation for the whole network with small amount of online modifiable parameters (e.g. access class barring case, LSA).	< 3 min

Network wide emergency plan in less than 3 minutes

LSA leverages available functionalities

of Operational Support System and Self Organizing Network platform



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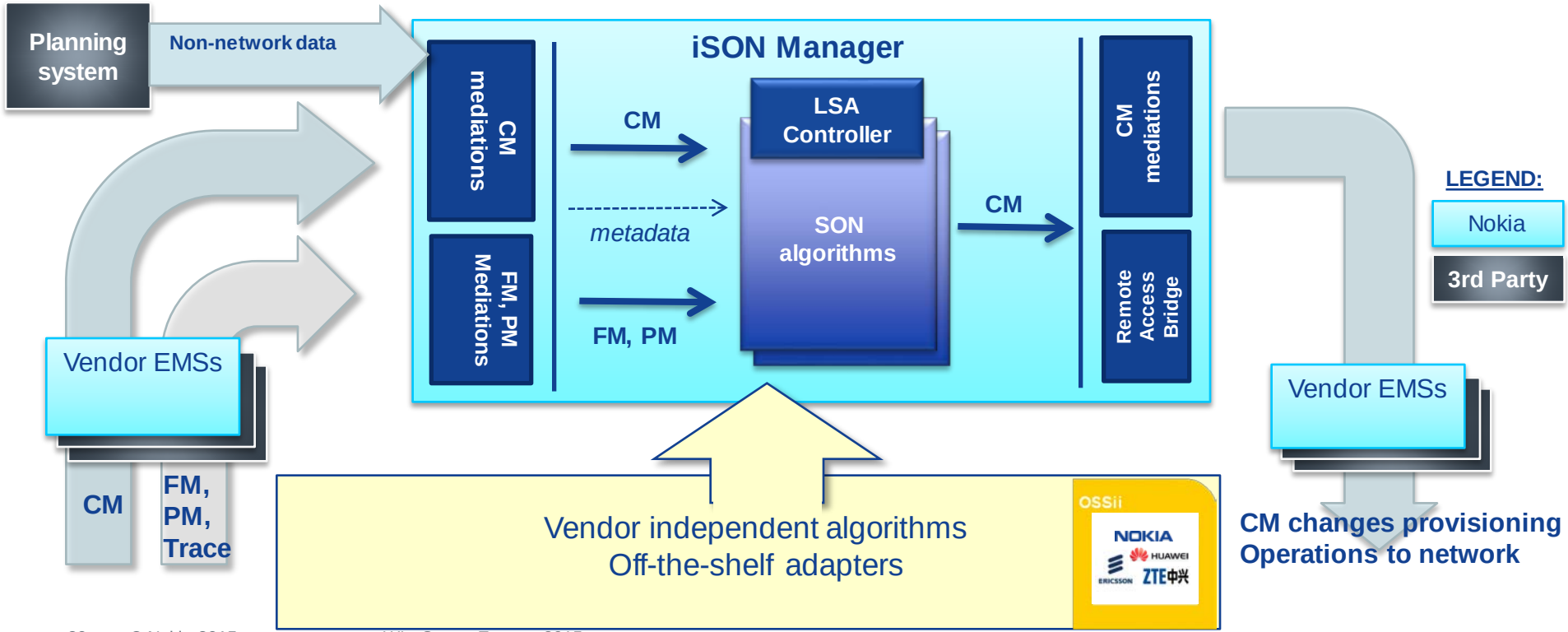
LSA Demo Controller was build on multivendor capable iSON manager platform



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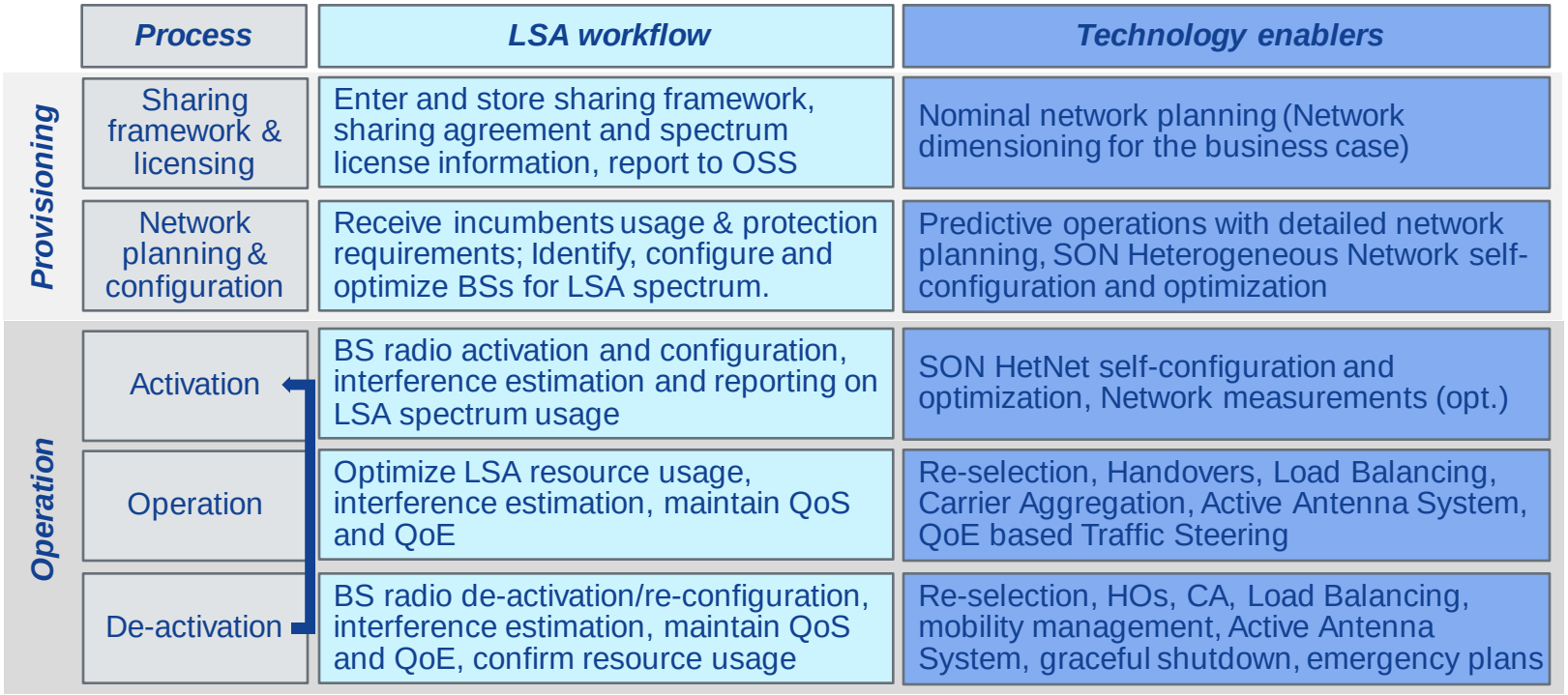
LTE-A features and SON functions automate and optimize LSA operations



LSA evolution scenarios

from static LSA to dynamic LSA (including spectrum pools for Small Cells)

LSA spectrum resource is licensed to one LSA Licensee. Multiple LSA Licensees are supported by dividing the LSA spectrum resource into several blocks. Each block is then dedicated to a LSA Licensee

Dedicated LSA resource blocks

LSA today

Pool of LSA resource blocks

LSA evolution

LSA spectrum resource is subdivided into several blocks. These blocks are shared by a limited number of LSA Licensees. A flexible set of sharing rules (policy) will guarantee that the blocks are averaged between the LSA Licensees

Dynamic Spectrum sharing support for LSA:

- Dynamic spectrum control by Incumbent
- Policies for dynamic sharing via a spectrum pool
- Adaptation of protocol between LSA Controller and LSA Repository

Solution proposal

Spectrum Management Function

- Extent defined interfaces, protocols & data model
- Flexibility in adding spectrum management function to the LSA network (Repository or independent network entity)
- Allow new roles for LSA (e.g. Spectrum Manager)

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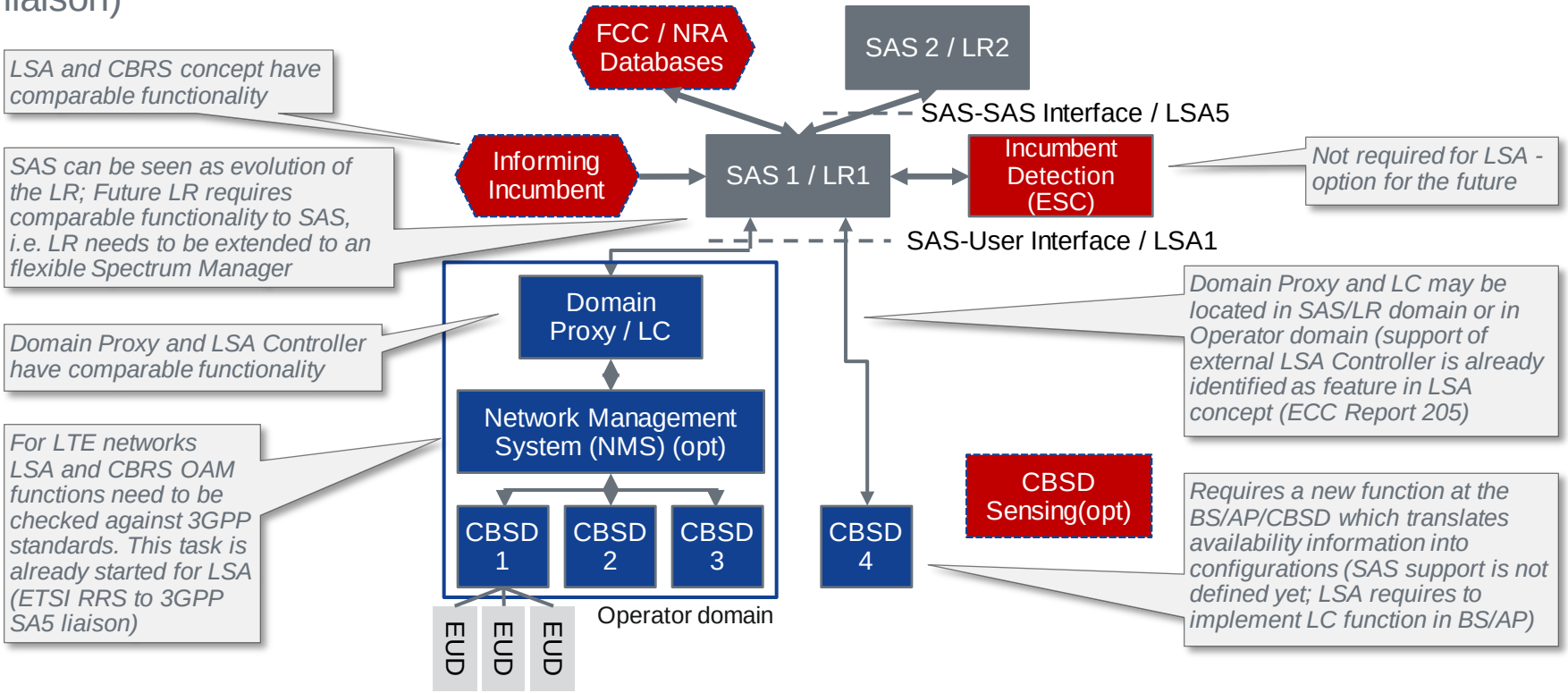
LSA – Citizens Broadband Radio Service (CBRS) functional architecture comparison

Common architecture possible when respective design is accepted (ETSI RRS & Winn Forum liaison)



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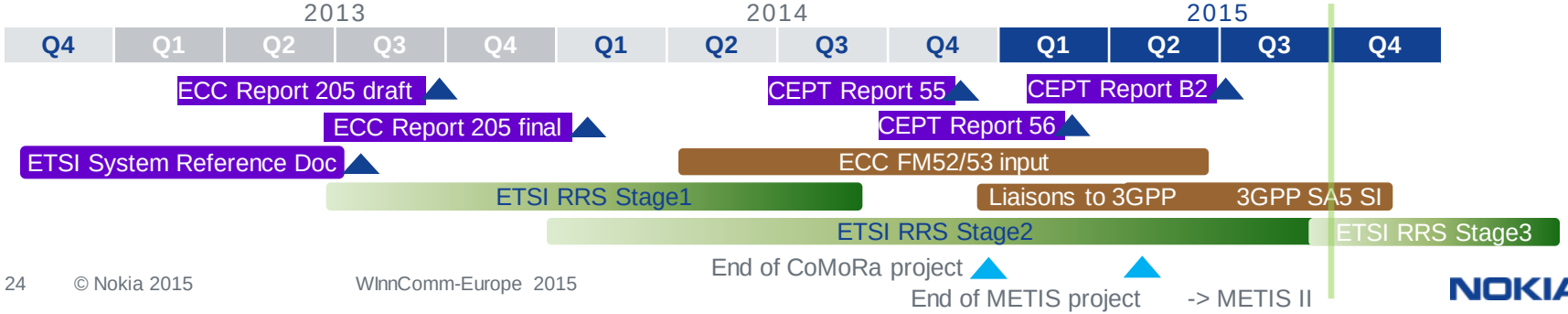
LSA is progressing on all levels in Europe

Nokia in research – standardization – regulatory bodies and administration

ETSI WINNF Liaisons

LSA 2.3 GHz timeline



Licensed Shared Access to spectrum

- LSA allows for sharing while meeting the requirements of mobile operators and incumbents for predictable conditions of spectrum use and hence predictable QoS.
- LSA opens bands otherwise locked for long time for harmonized MBB use like the 2.3 GHz band in Europe supported in commercial devices today.
- LSA is a simple concept which can be implemented today with evolution path towards dynamic use cases like spectrum pooling and the US 3tier CBRS concept.
- Finnish trials has proven above aspects testified by all stakeholders including regulator, incumbent, mobile operator and supplying industry.

Visit http://core.willab.fi/ for more information on the Finnish LSA trials with CORE consortium

Acknowledgment

This work has been done in the LASS, CORE++ and WISE2 research projects within the 5thGear program of Tekes - the Finnish Funding Agency for Technology and Innovation.

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Thank you
Questions/discussion?

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