



*Finnish Defence
Research Agency*

FIN SDR program – roadmap towards Cognitive MIL handheld radios

**WinnComm Europe 2015
Tactical Radio Workshop**

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Outline

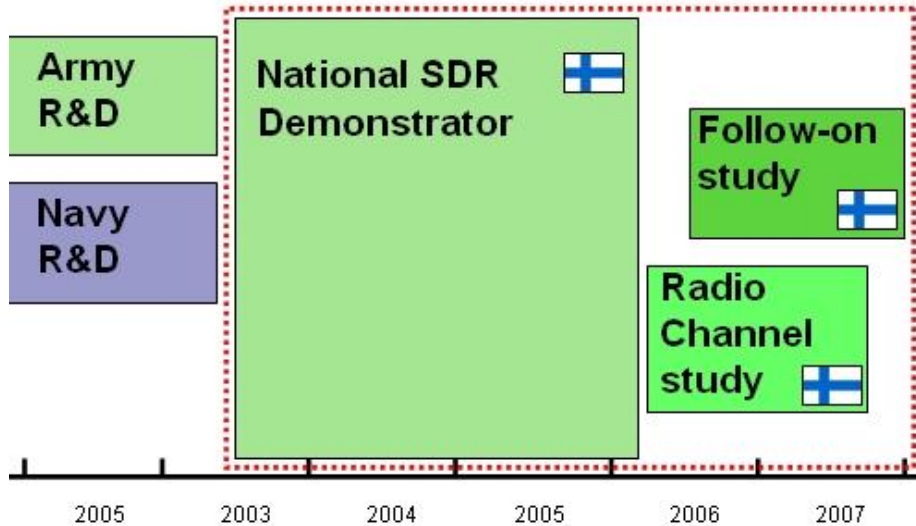
1. MIL SDR and Finland - Yesterday, Today, The Future
2. Towards cognitive radios and networks
3. On the path towards future MIL cognitive SDRs
4. Observations stimulated by Day 1
5. Conclusions



MIL SDR and Finland - Yesterday, Today, The Future

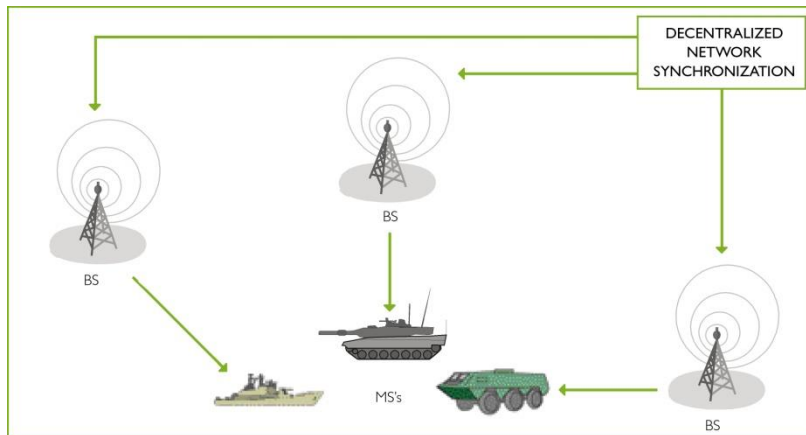


Where we started...

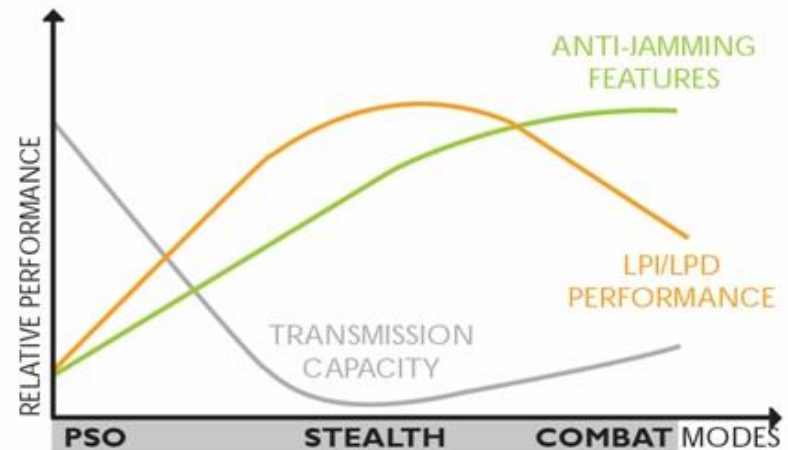


AF R&D

National Tactical Positioning Waveform

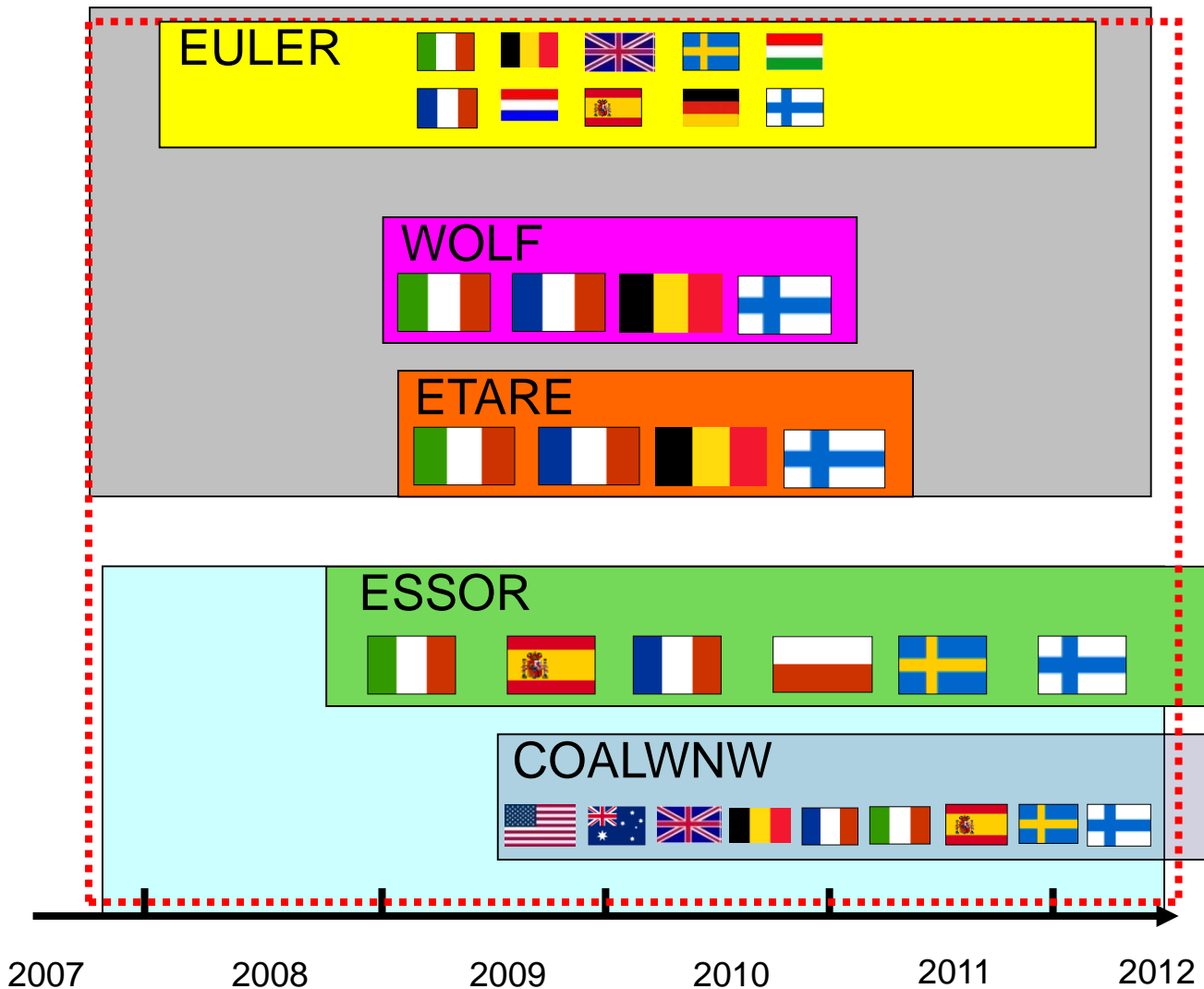


Adaptive Wideband Networking Waveform





..then went to MN cooperation...



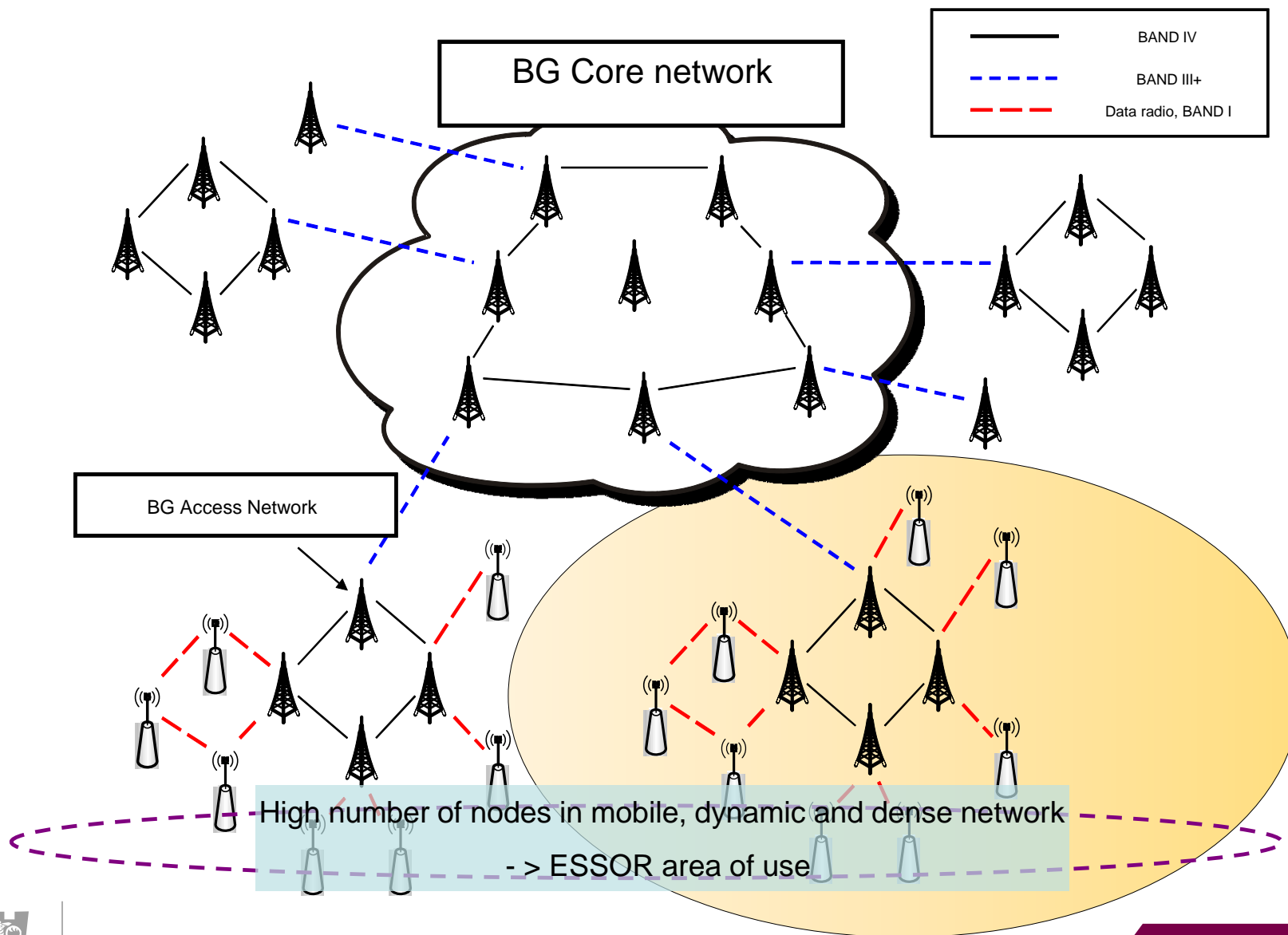


... and now being deployed ... in Army



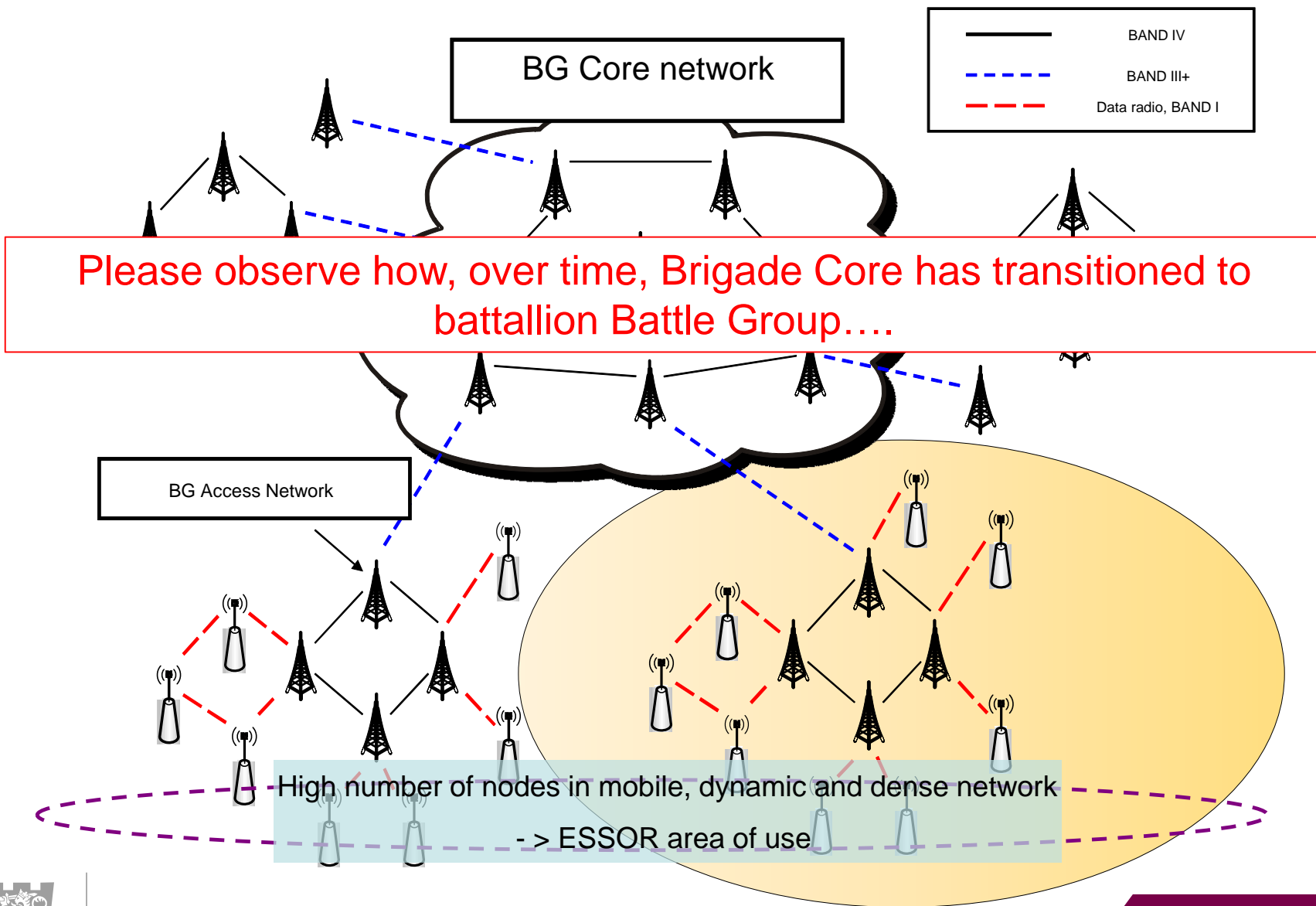


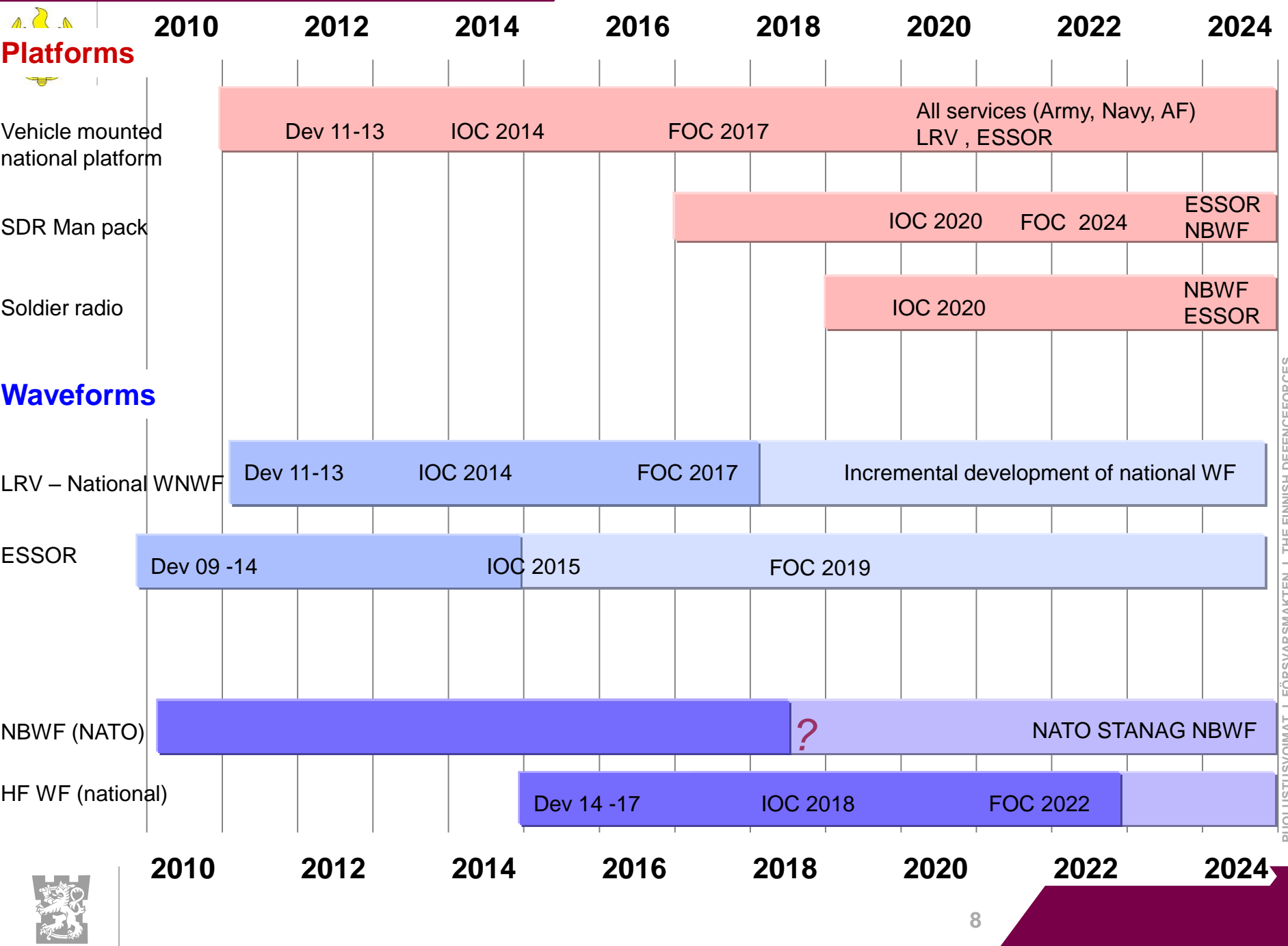
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Towards cognitive radios and networks





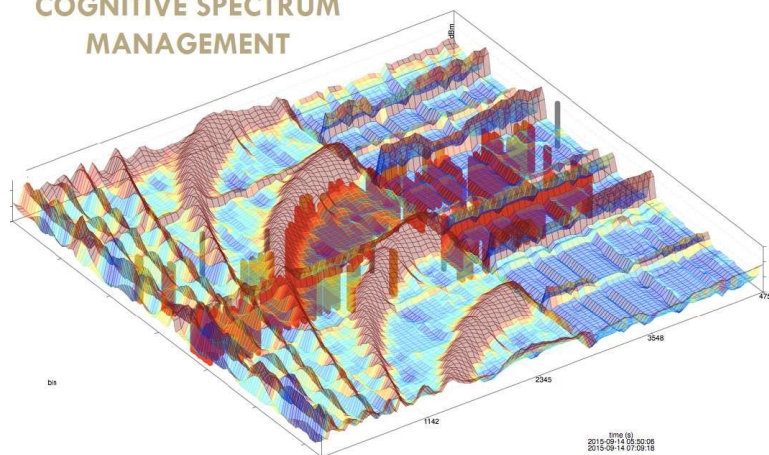
New generation CNHF-radio from Kyynel Ltd

- CNHF-radio receives the whole HF spectrum at once and has extremely fast link establishment (less than 500ms).
- CNHF-radio is fully automatic and it optimizes the frequency usage automatically using latest cognitive and software radio technology.
- Builds up an *Independent Global MESH-Network* where CNHF radio acts as a terminal or base station depending on status or location of the CNHR-radio.
- Physical layer adapts to existing conditions and provides data rates up to 153kbit/s for applications like email, IP data, VoIP and Web.
- Kyynel parcticipates in *National HF Research Project* where next generation HF-physical layer technologies are studied in order to enhance the data rate.
 - Tentative results were introduced September 2015 in NATO BLOS meeting



Kyynel Ltd, <http://www.kyynel.net/>

COGNITIVE SPECTRUM MANAGEMENT



6.10.2015

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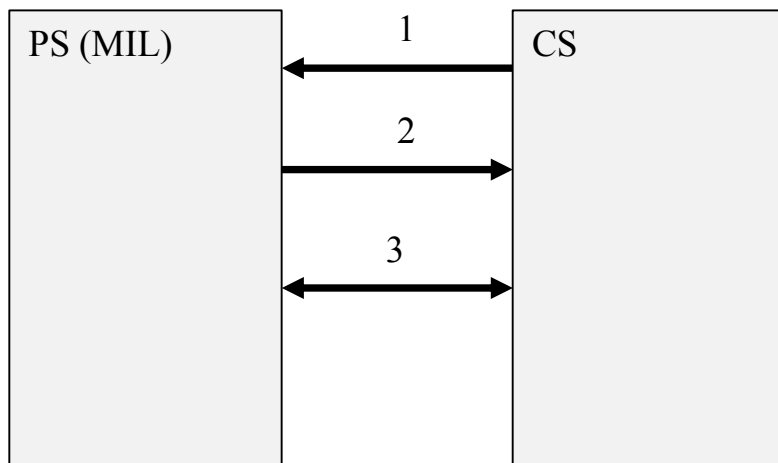
Overview of national HF research project

- Consortium
 - University of Oulu (CWC), [http:// www.cwc.oulu.fi](http://www.cwc.oulu.fi)
 - Tampere University of Technology (TUT), <http://www.tut.fi/en/>
 - VTT Technical Research Centre of Finland, <http://www.vtt.fi/>
 - Kyynel Ltd, <http://www.kyynel.net/> - **main responsibility on proof-of-concept demonstrations on real HW**
- The first phase (2013), identified technologies to be utilized in modern HF systems to increase their performance and reliability
- Demonstration and verification phase (2014-16)
 - Adaptive equalization algorithms: to be utilized with MS110C waveform
 - Non-contiguous spectrum usage
 - Different physical layer channelization architectures
 - Need for new intelligent/interference aware ALE for non- continuous spectrum usage
 - Multicarrier technologies in HF
 - Filter bank based multicarrier architecture (FBMC)



Towards shared spectrum use...

Models and incentives under investigation currently



1. Commercial Service allows spectrum to Public Safety

2. Public Safety allows spectrum to Commercial Service

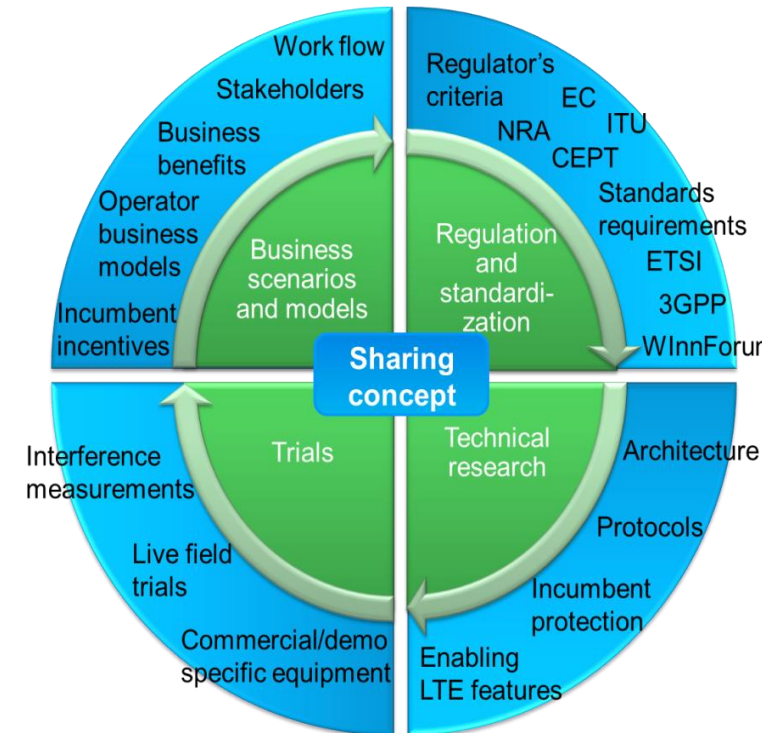
3. Public Safety allows spectrum to Commercial Service given that Commercial Service is obliged to give spectrum back to Public Safety when needed

- LSA = Licensed Shared Access (Europe)
- SAS = Spectrum Access System (USA)



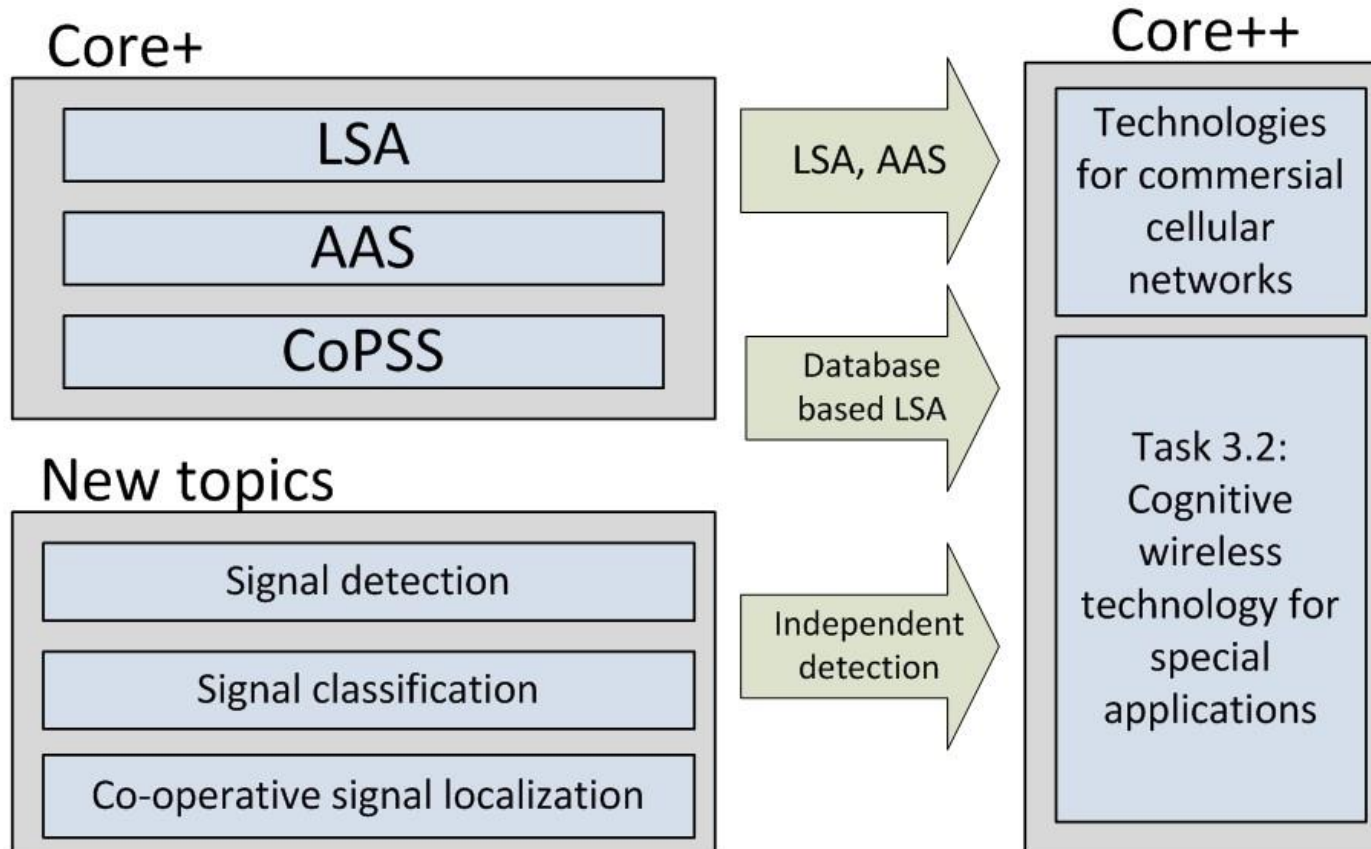
CORE++ project (2015-2016)

- ❑ CORE++ studies the influence of new spectrum sharing concepts on the mobile communications networks and required new testing solutions from business, regulation, and technology perspectives.
- ❑ CORE++ showcases the feasibility of new sharing concepts (e.g. Licensed Shared Access (LSA)) for mobile broadband networks and them to other wireless systems including public safety.
- ❑ CORE++ conducts the research in a collaborative way between with industry, research and public domains with agile/lean/iterative methods for trial development.

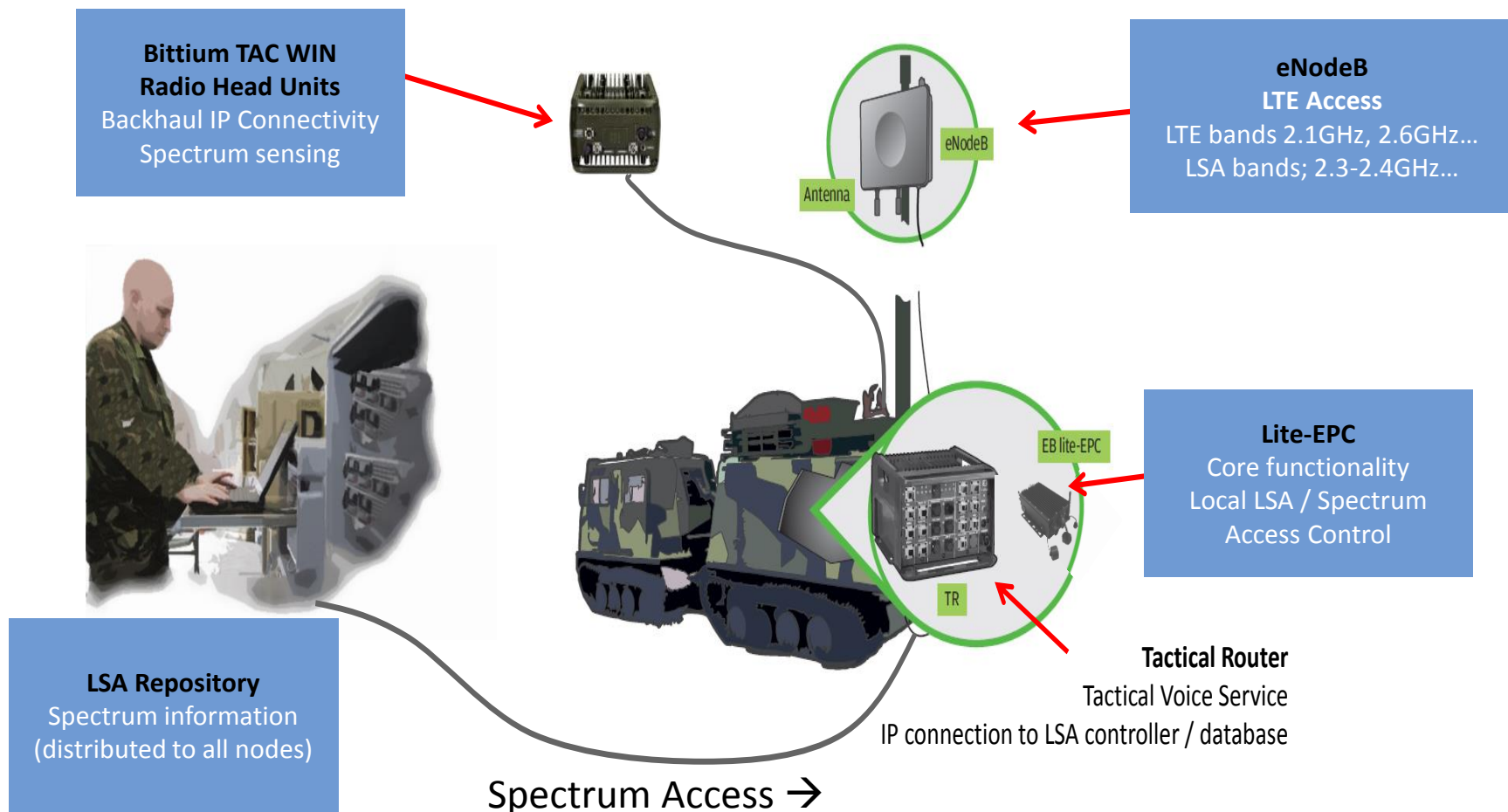




LSA for Public Safety/Military



Bittium Tactical LTE Access





On the path towards future MIL cognitive SDRs

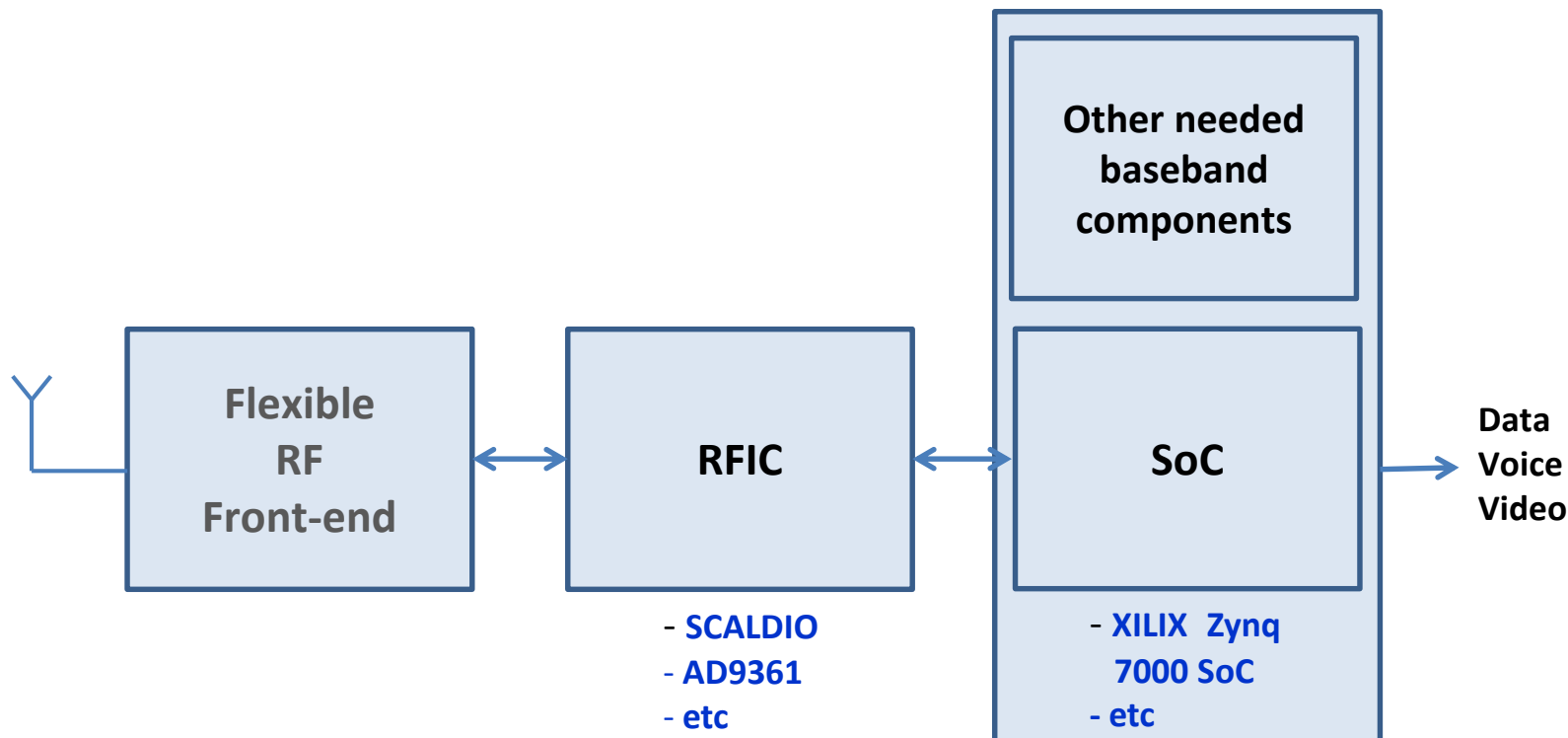
- Besides Cognitive Radio conceptual research and various research paths on spectrum sharing platform design is of interest also (not only space, power and heat constraints even in armoured vehicles)
- These technologies include among others:
 - **Programmable System on Chip (SoC)** (impressive scalability already available)
 - **other application specific programmable processors**
- Including **High-Level Synthesis (HLS) tools** that translate the functions meant to be accelerated in synthesizable code in the FPGA ie. bypassing VHDL
- Finnish Defence does not have the resources to drive these
=> monitoring

See also: www.wirelessinnovation.org/introduction_to_sdr





SDR implementation using RFIC + SoC





Observations 1

Finnish Defence Forces is committed to the study of military applications of Cognitive Radio Technology. Some studies are conducted as part of regular military officer curriculum.

However, classified military Cognitive Radio research is of limited academic value.

Furthermore the Defence Command has tasked the FDRA to conduct research but also in collaboration with academia (Aalto: 1 PhD coming shortly, Univ of Oulu: 1 PhD underway) and international bodies like NATO STO IST - research groups and selected civilian partners like VTT, Nokia, Bittium and Kyynel.





Observations 2

Implementing spectrum sharing regardless whether SAS or LSA is a national responsibility of a national regulatory authority.

Imagine a UN lead peace-keeping operation somewhere in the jungles of Africa (e.g. Tshad) where US, Finnish and Kyrgyzstan peace keeping forces deploy.... (i.e. engaging almost all ITU regulatory regions)

Imagine a national regulatory authority protecting incumbent rights in a new hybrid warfare scenario, where hostile but unrecognized and unmarked green men operate among local population and your national public safety needs to operate among the enemy as well as your own military units

=> Also military needs to rethink the way it plans to use spectrum in these kind of scenarios





Observations 3

Even a rudimentary application of Peter Checkland's Soft Systems Methods like CATWOE (Customer, Actor, Transformation, Worldview, Owner, Environment) will reveal that the military user segment is far from uniform !

Imagine a small nation with main focus on national defence relying on conscript service to produce a large wartime fighting force = modest peace time requirements, mostly centered on garrisons and exercise areas but X-fold increase in spectrum requirements in war time (scanning the spectrum to prove the point would not be a solution ?)

vs

Imagine a global superpower with access to Global Information Grid, military satellite communications and over the area 24/7 coverage and airborne radio relay by AWACSS





Observations 4

Interoperability has been proposed as one of the benefits of CR but wasn't that also the case for a SDR too? Preston Marshall pointed out yesterday that "all our communications devices are multiband devices"

Perhaps true for commercial mobiles but, we are still some way from a military SDR being capable of running true NATO and non-NATO military waveforms on the same platform, not to speak of being allowed to do so concurrently.

Militaries have yet to identify, elaborate and formulate their expectations:

E.g. Jamming recognition would be nice but would not necessarily open the military R&D budgets for research.

But how to elaborate and formulate expectations when this new technology is not at all understood? Isn't this the case with all new innovations?





Observations 5

As one professor bluntly put it: "Military does not need SDRs or CRs, they need Zero Configurable radios" - accurate yes but politically correct ?

- ⇒ *What does Cognition bring to the different military communities: ops planning, comms administration, acquisition, maintenance and logistics or to the end users?*
- ⇒ *What positive changes Cognitive Radios would induce to military capabilities i.e. DOTMPLFI => e.g. a true MIL CR would facilitate dispersed fighting mode in battalion Battle Groups but would also enable concentration / massing of forces for decisive battle (this would be more appropriate military language description to justify MIL R&D funding)*





Observations 6

Domain specific physical requirements necessitate differing radio communications solutions.

=> Even so, some commonality i.e.. interoperability could be attempted although existing solutions do operate in Silos.

=> when Systems-to-System interoperability through a backbone/gateway could be adequate? Where true direct device to device interoperability between domains is needed? Would this apply all devices in all domains or some devices in some domains (cf. Forward Air Controller, fire observer etc.)?

Military communications infrastructure, regardless whether deployed expeditionary or homeland defence relying on a national backbone is a large unfederated multi-system Behemoth. Single solution in a single procurement cycle simply is not possible (and not only because of fiscal constraints).

=> Even if a sub-system using Cognitive Radio Technology would be deployed, it would need to COEXIST with several legacy systems for some considerable time





Conclusions

SDR technologies led to waveforms being designed portable. This however proved more costlier than expected.

One could argue that in designing handheld MIL SDRs commercial approaches like implementing RFIC + SoC and advanced design tools and methods should be used. Which cognitive capabilities are to be included is yet far from resolved.

Military forces have not yet recognized full potential of Cognitive Radio Technology.

The Finnish Defence Forces continues active contribution to the deployment of SDRs and further research on CR in military domain.





Thank you !

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