

## COGNITIVE RADIO SYSTEMS: MARKET ASSESSMENT OF SELECTED VALUE PROPOSITIONS

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## □ Partners

- ⇒ Manufacturers
  - Alcatel-Lucent, Motorola, NEC
- ⇒ Operators
  - France Telecom
- ⇒ Regulators
  - ANFR (FR), BNetzA (GE), OFCOM (UK), RA/AT (NL)
- ⇒ Consultancy
  - IDATE (FR)
- ⇒ Academics
  - Fraunhofer (GE), Surrey University (UK), Athens and Pyraeus University (GR), IBBT/VUB (BE)

## □ Structure – 2 main activities

- ⇒ **Market assessment & Business model**
  - Identification of long term and short term market opportunities
  - Business modeling



### Market assessment

#### □ Objective

- ⇒ Get operators' and equipment vendors' feedbacks on main value propositions developed within E3 (CPC, Self-x functionalities, FSM)
- ⇒ Assess the impact of Cognitive radio systems (CRS) adoption by the mobile ecosystem.

#### □ Method

- ⇒ Interviews held at the end of 2008 and in H2 2009. This market survey work revealed market needs regarding the most recent conceptual and technological developments of E3.



### Quantitative analysis

#### □ Output and main conclusions

⇒ 2 scenarios for specific instantiations selected and discussed within the consortium:

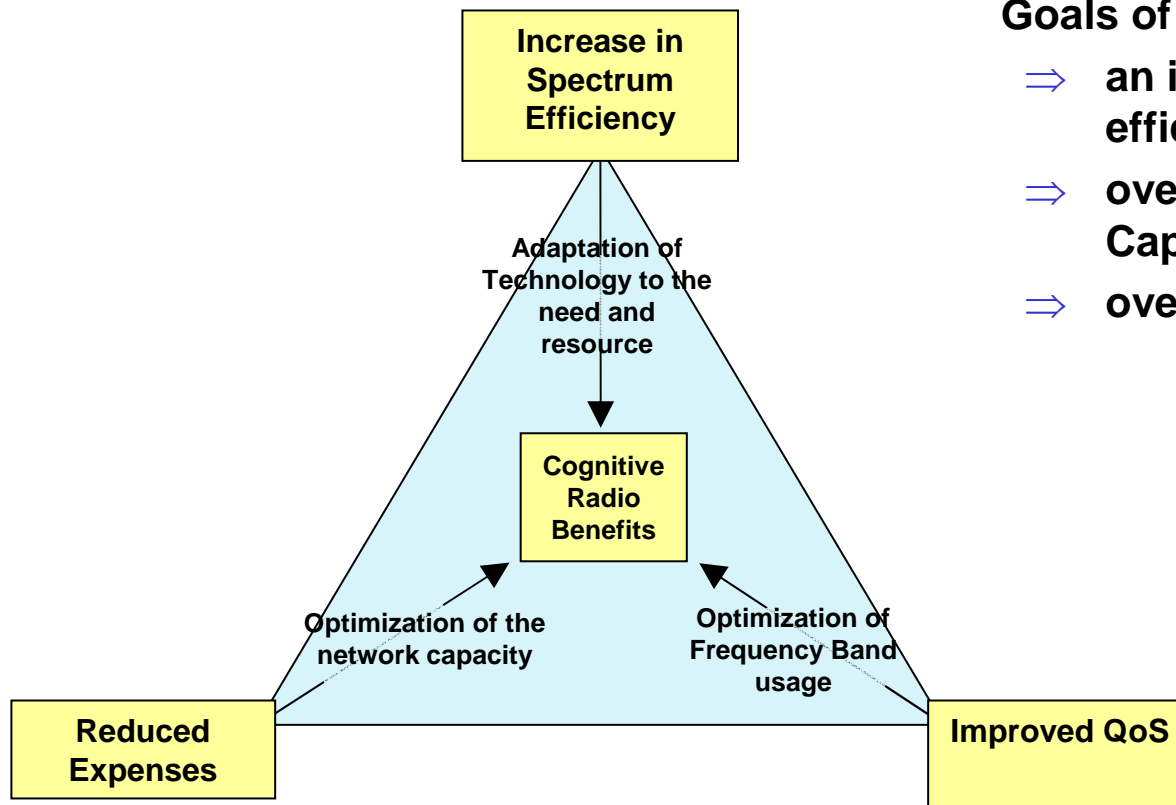
- Adoption of the Cognitive Pilot Channel by the Mobile Network Operator
- Integration of self planning and self optimization elements within Mobile Network

⇒ Expected result:

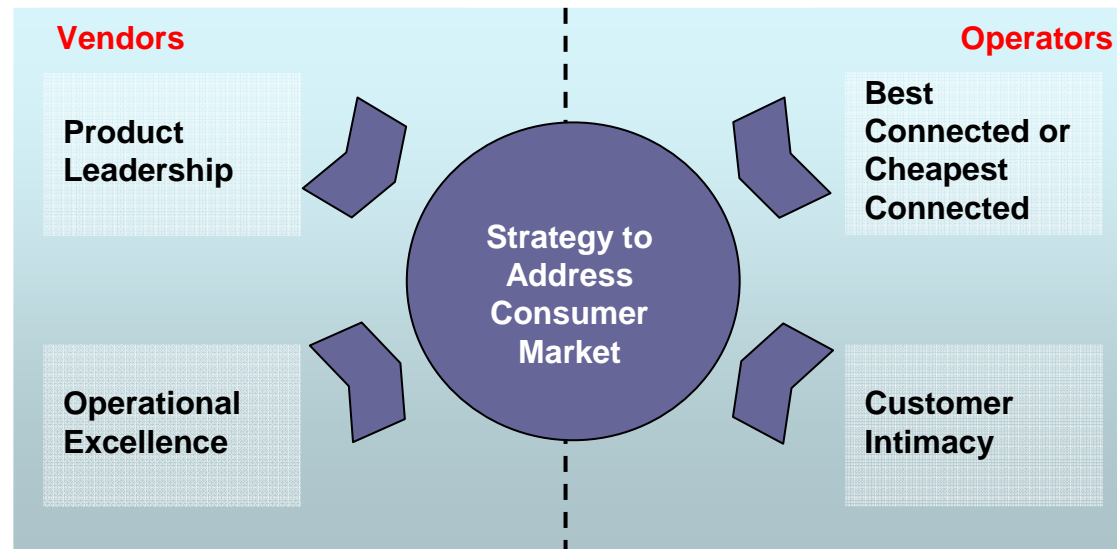
- OPEX and annualized CAPEX (i.e. with amortization)
- Network Revenues

# Primary Goals of Cognitive Network and Cognitive Radio Elements

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- To Mobile Operators, the primary Goals of Cognitive Network are:
  - ⇒ an increase in spectrum efficiency
  - ⇒ overall reduced expenses (both CapEx and OpEx).
  - ⇒ overall QoS improvements.



- ❑ Always best connected and always cheapest connected (depending on the tariff paid by the subscriber) are ideal consumers value propositions
- ❑ *"always best connected schemes and always cheapest connected schemes are a consequence of the choice of multiple, competing (substituting) or complementary RATs".*
- ❑ Send the device to the network that is most suited based on cost, loading, etc...

## □ Market assessment and Business model

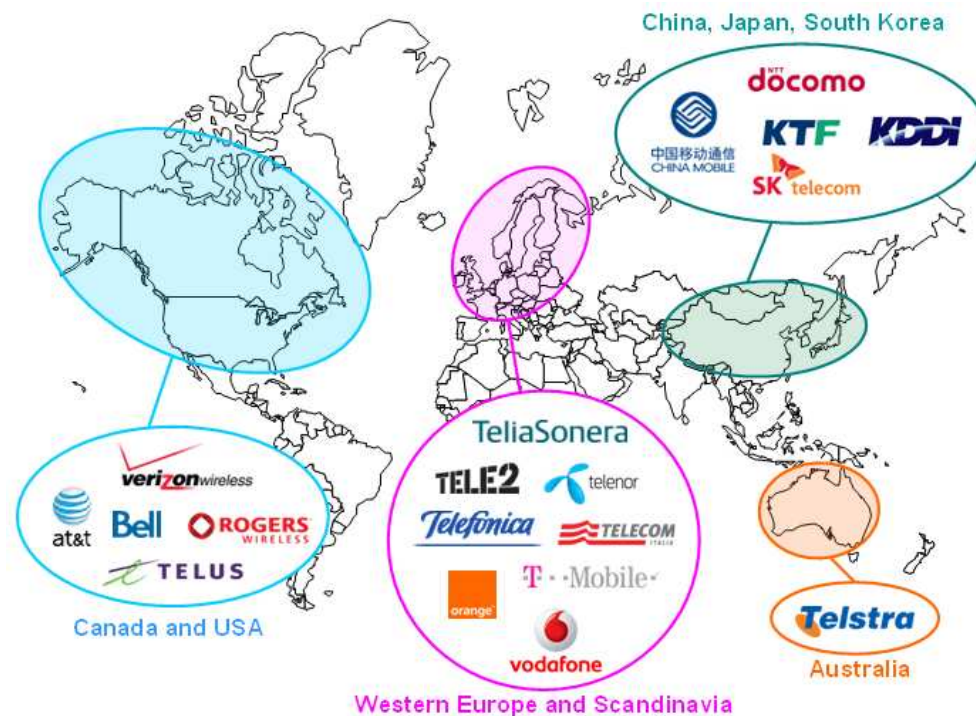
⇒ Self-X functionalities

⇒ Cognitive Pilot Channel

# E<sup>3</sup> Self-X functionalities (1) –Market drivers

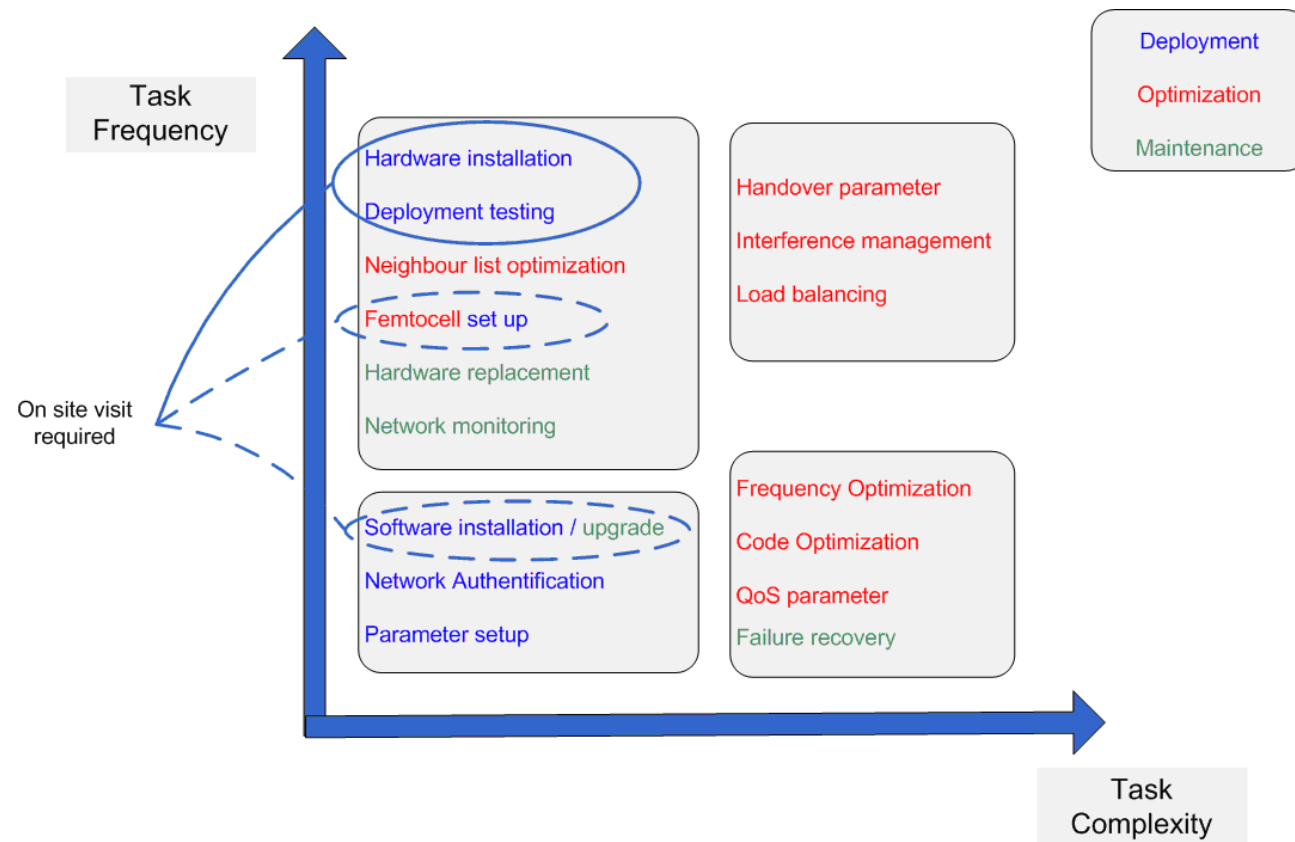
- Main drivers:
  - ⇒ Deployment of femtocells (3G or next generation femtocells)
  - ⇒ Deployment of LTE eNodeBs: operators expect plug & play deployment features
- LTE rolled out over existing 2G and 3G networks adding complexity during deployment phase and during operational phase..
- Fixed-mobile convergence and capacity issues: new network topologies, leading to integration of smaller cells into the network.

Geographical mapping  
of early LTE commercial deployment





# E<sup>3</sup> Self-X functionalities (2) – Use cases



- ❑ Three phases over the network lifecycle : deployment, optimization and maintenance.
- ❑ Most optimization tasks are perceived as complex and generally require high skilled engineers.
- ❑ Short term gains are expected for high frequency, low complexity tasks.
- ❑ Self-deployment to be integrated in coming LTE releases from scratch.
- ❑ Self optimization and self-healing features to be integrated in LTE standards \_ but require more standardization work.



## Self-X functionalities (3) – distributed or centralized approach

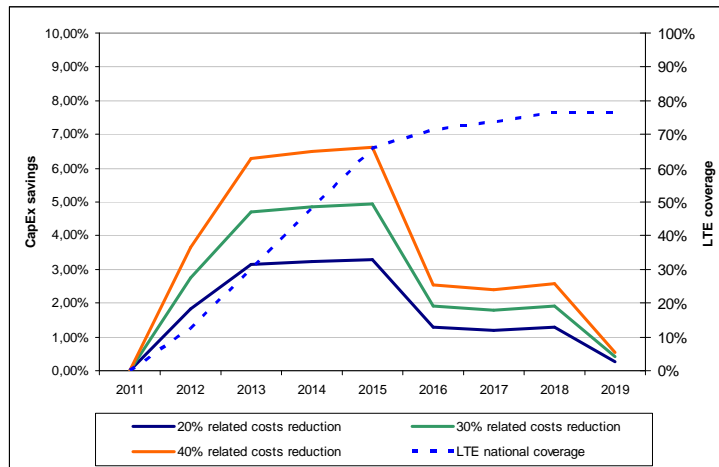
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- **First step: distributed approach of self-x functionalities**
  - ⇒ **Equipment vendors will have their own SON functionalities integrated in eNodeBs.**
  - ⇒ **Does not require a high level of standardization.**
  - ⇒ **A lot of commonality but specificities will remain between different vendors.**
  - ⇒ **Associated with deployment use cases.**
  
- **Higher hierarchy SON implemented into the core network will demand even higher standardization levels**
  - ⇒ **Require standardisation of parameters for reporting and decision making.**
  - ⇒ **For instance standard interfaces to set eNodeB parameters (e.g. power levels, interference management, handover thresholds...)**
  - ⇒ **Linked to optimization phase (both at the RAN and core network levels).**



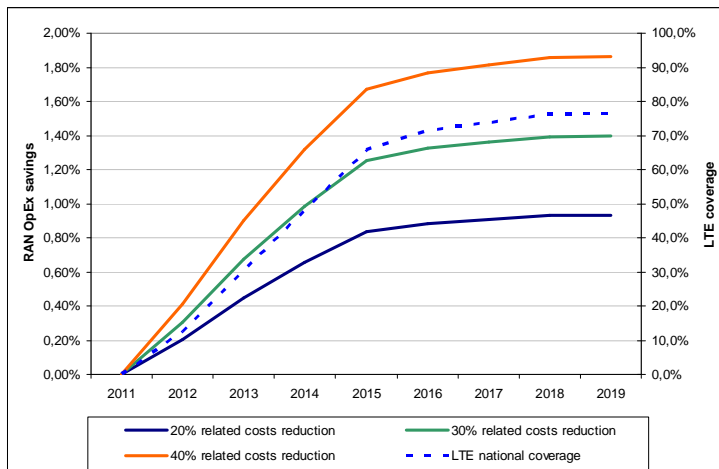
## Self-X functionalities (4) – High impact on expenditures

### Total CapEx savings with different hypothesis of reduction of deployment and optimisation costs induced by self-configuration and self-optimisation functionalities adoption



- CapEx savings range from 3.3% to 6.6 % depending on the hypothesis of RAN deployment and optimization costs reduction (20% to 40%).
- These values are observed for the period 2013 – 2015 when LTE network is deployed at high pace.

### RAN annual OpEx savings with different hypothesis of RAN maintenance & optimisation costs reduction induced by self-planning and self-optimisation functionalities adoption



- Allowing up to 1.8% of costs savings, self-deployment and self-optimization impact on RAN OpEx seem lower but it is important to underline the following facts:
  - ⇒ RAN OpEx also include GSM and UMTS networks for which no gains are achieved
  - ⇒ A great portion of RAN OpEx is composed of cell site location rental, cell site power supply and mast maintenance cost
  - ⇒ OpEx savings are repeated every year unlike CapEx. Their accumulations over the entire equipment life-span represent a substantial gain for the operator



## Self-X functionalities (5) – High impact on expenditures

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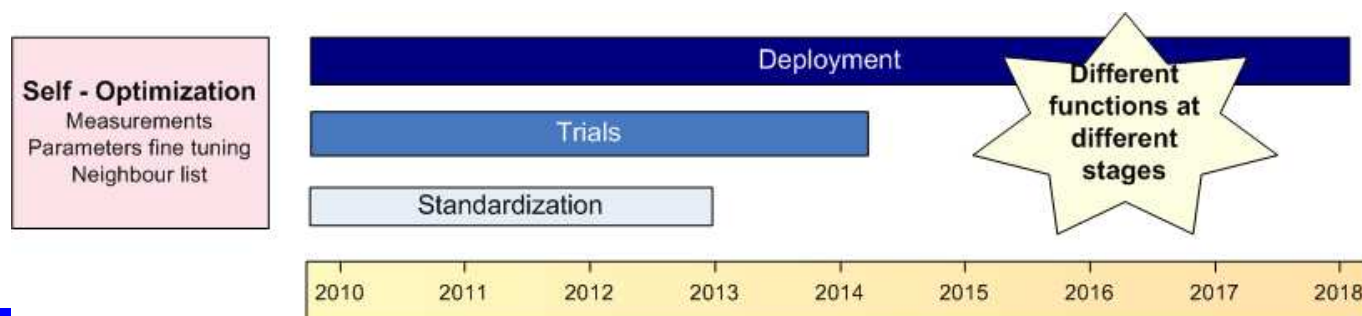
- ❑ **LTE implementation of SON potentially enables reduced OpEx and CapEx**
  
- ❑ **Main comments about quantitative analysis of CapEx and OpEx savings:**
  - ⇒ **SON roadmap might be delayed if LTE is delayed**
  - ⇒ **Savings for various tasks might be higher than considered in the model**
  - ⇒ **LTE layer will mean additional costs anyway (CapEx & OpEx). It will also require revenue drivers.**
  
- ❑ **Planning, deployment, operating, and optimizing current radio access networks already accounts for a large part of operators' total operational costs**
  
- ❑ **Self-X solutions mean operators have a great opportunity to learn about the new and compelling methods to manage their networks more efficiently and with a lower total cost of ownership**

# Self-X functionalities (6) – Roadmaps

- Time to market of self-deployment features is a key issue.
- Delayed standardization and development of plug & play eNodeBs would pose a threat



- Calendar for self-optimization functions is less critical → contrasted situations
- Some functionalities (e.g. neighbour list optimization) are already used by operators.
- Others are still being investigated: require heavy standardization efforts at a high level in the architecture. Development of these features is likely to take time.

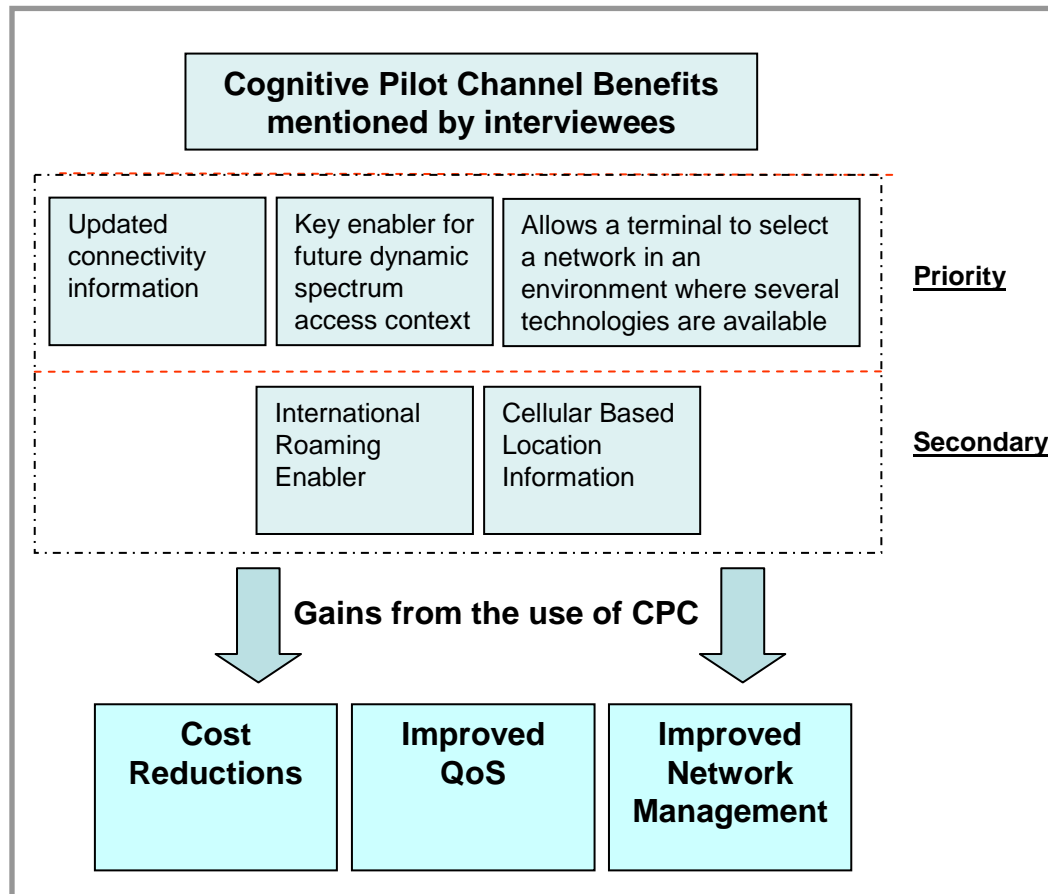


## □ Market assessment and Business model

⇒ Self-X functionalities

⇒ Cognitive Pilot Channel

## Cognitive Pilot Channel Potential benefits



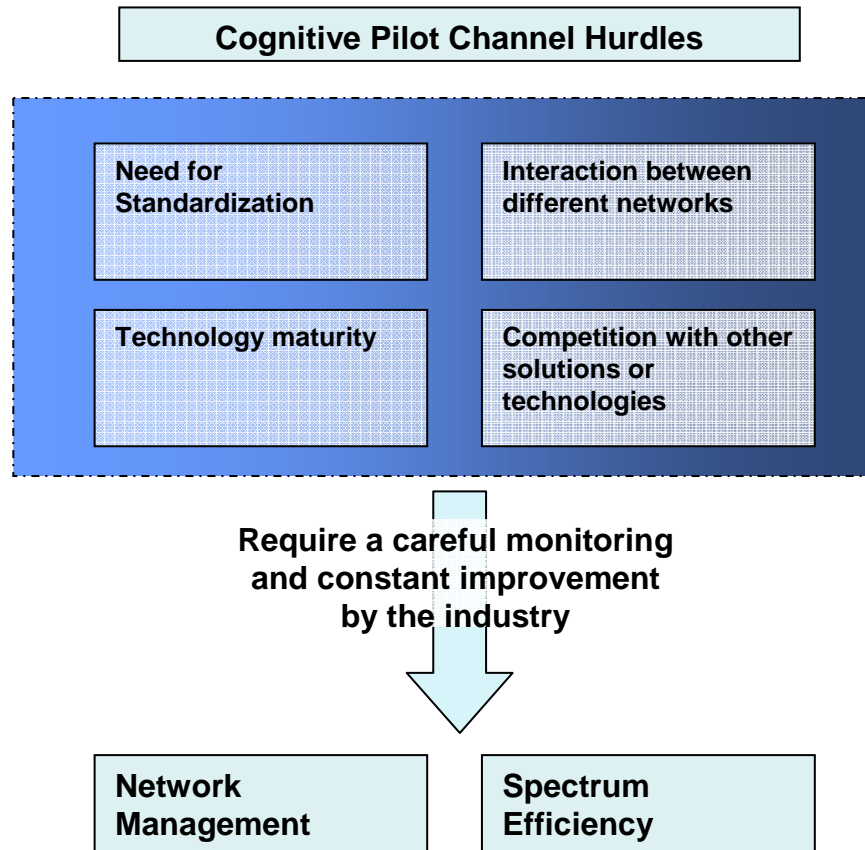
⇒ Key enabler for future dynamic spectrum access context

⇒ Key gain compared to a terminal centric approach is energy saving at the terminal level

⇒ Updated connectivity information: real time information should provide service innovation



### Cognitive Pilot Channel Hurdles

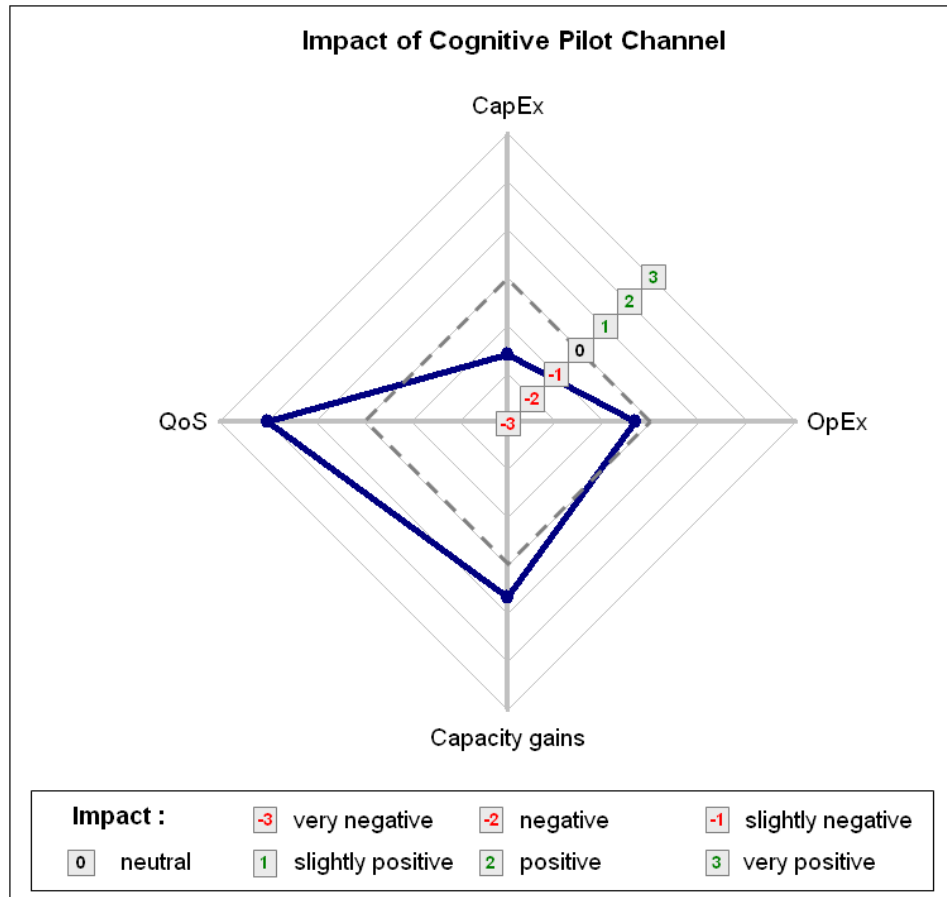


- Need for technology maturity, standardization and reduced additional cost to drive adoption and implementation of the CPC.
- CPC is in competition with other solutions.
  - ⇒ Discovery by terminal \_ sensing
  - ⇒ Control by the network, based on capabilities sent by UE, with a centralized RRM
- Centralized, distributed or hybrid?
  - ⇒ Hybrid approach: most promising paths towards efficient multi-RAN environment operations.
  - ⇒ Radio environment info updated with data sent by terminals. The cognitive engine and RRM then processes this information and broadcasts it through a standardized outband CPC

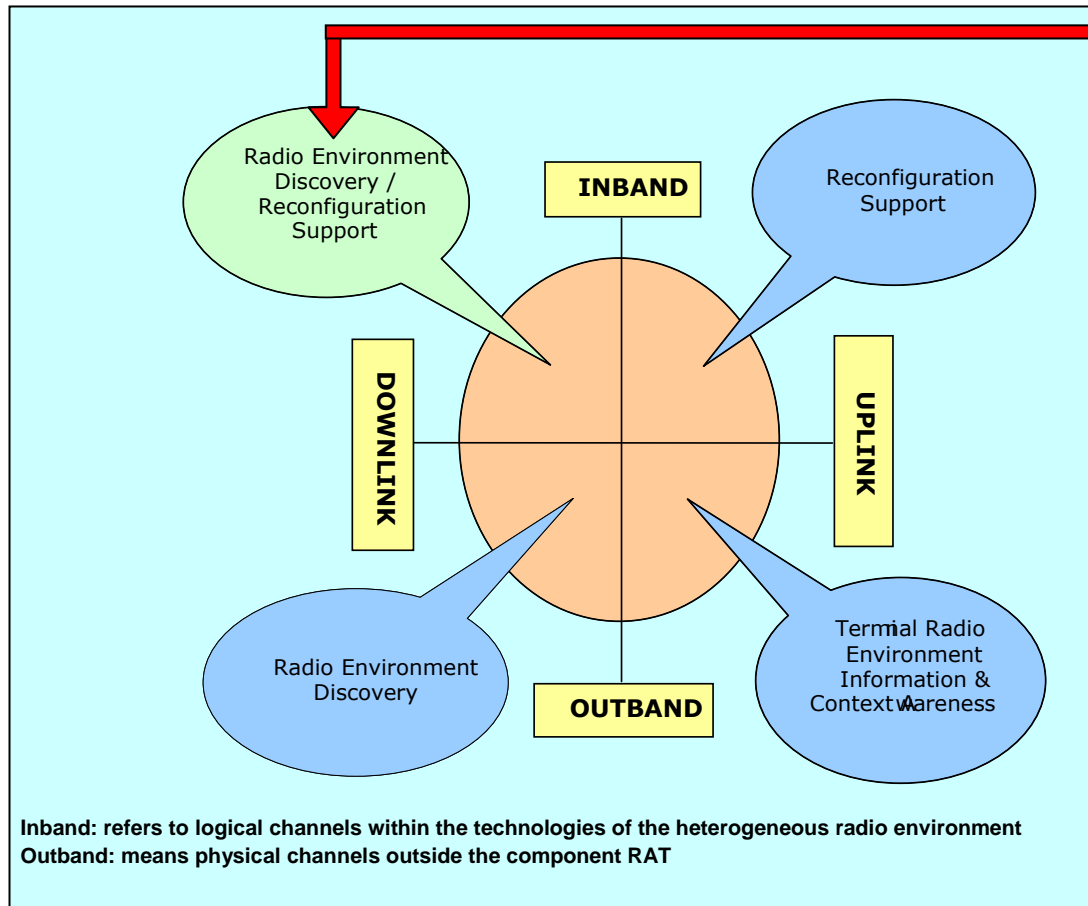




## Cognitive Pilot Channel (3) – Expected impact



- Impact on QoS and capacity rather than on expenditures.
- Both vendors and operators consider that CPC will impact negatively economics (CapEx and OpEx) and impact positively quality of service, capacity gains and service innovation.
- To several mobile operators, "it is a bit early to have a complete understanding on OpEx/CapEx impacts". However they generally expect *"that CR will increase terminal complexity"*.



## CPC Scenario considered

- ⇒ Radio environment discovery / Reconfiguration support
- ⇒ Data broadcasting
- ⇒ Inband / downlink only
- ⇒ CPC operated in the operator's domain
- ⇒ Reuse of existing GSM infrastructure
- ⇒ Use of GSM channel
- ⇒ 200 kHz channel (With spectrum efficiency of 1 bit/Hz/s)
- ⇒ Data base with networks information (Coverage of different RATs: GSM, UMTS, LTE, WLANs..)

- The first handsets that enable CPC are launched in 2015 and two years later 20% of the subscriber base benefit from this functionality. The CPC feature equips all devices in 2025 which is 10 years after commercial launch.



## Cognitive Pilot Channel (5) – Quantitative analysis

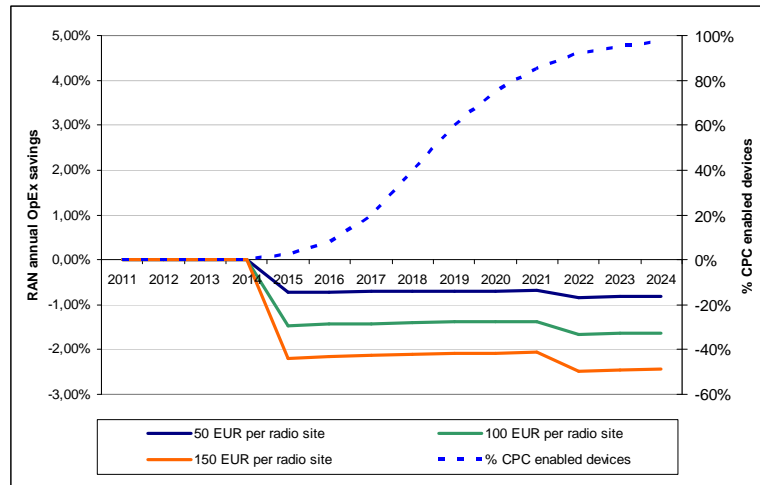
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- **Costs considered:**
  - ⇒ Operational costs related to software updates in GSM base stations
  - ⇒ Cost of GSM spectrum used
  - ⇒ Cost of building and operating the data base containing network information
  
- **Preliminary potential gains identified:**
  - **Qualitative:**
    - ⇒ Improvement of operations in multi RAT environments
    - ⇒ Improved QoS for end users
    - ⇒ Reduced time to market for innovative services
  
  - **Quantitative:**
    - ⇒ Capacity gains on cellular networks due to transfer offload to WLAN networks when possible: Cost per Mbit lower on WLAN networks than on cellular networks.
    - ⇒ Reduced churn rate and increased market share (due to improved QoS and reduced time to market) → higher revenues.



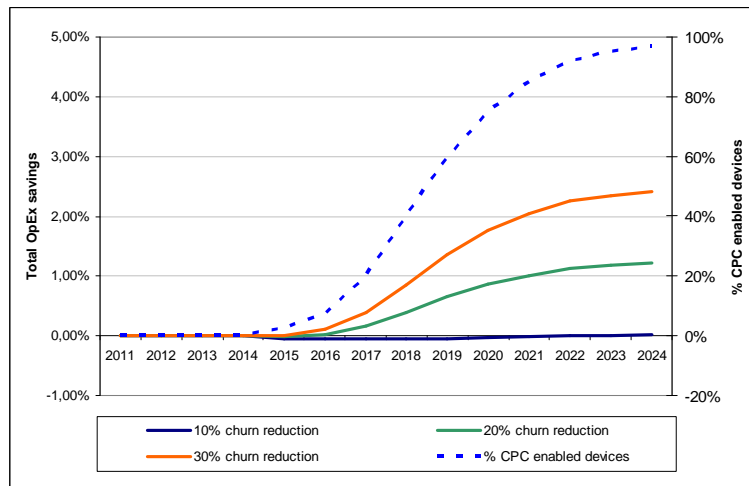
## Cognitive Pilot Channel (6) – quantitative analysis

### RAN annual OpEx increase with different hypothesis of CPC related annual cost per radio site



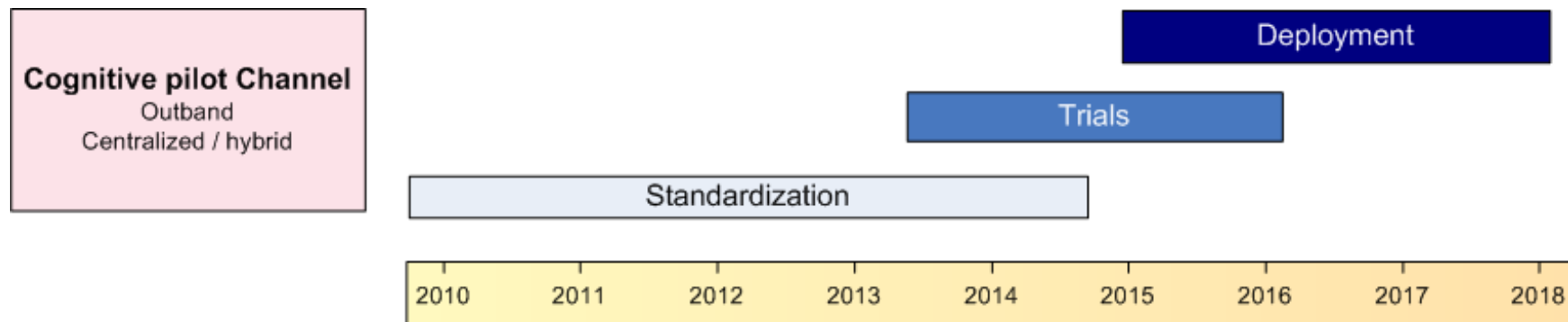
- In terms of OpEx, CPC adoption will have a negative impact due to the cost of software licensing and the cost of construction and update of the RAT information database. We have considered an annual additional OpEx per radio site that we have varied from 50 EUR to 150 EUR.
- In our simulation, RAN annual OpEx are impacted negatively with a 1 to 2% cost increase.

### Total OpEx savings with different hypothesis of churn reduction among CPC users



- The results of the simulation show that a 10% churn reduction is sufficient to cover all the additional costs related to CPC implementation which are:
  - ⇒ 100 EUR of annual costs per radio site
  - ⇒ 10% increase of SAC per subscriber acquisition related to higher CPC enabled device cost

- A tentative roadmap for CPC features
  - CPC is associated with longer-term use cases allowing flexible spectrum management and truly cognitive operations





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# Thanks!

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