CORASMA project
Main results and achievements

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Outline

- CORASMA project in a nutshell
- CORASMA approach and technical content
- Super-HiFi simulator

CORASMA project in a nushell

CORASMA consortium

Partner	Country
THALES Belgium	Belgium
SUPELEC*	France
THALES Communications &Security S.A. - France – Coordinator	France
Fraunhofer FKIE*	Germany
THALES Defence & Security Systems	Germany
Karlsruhe Institute of Technology*	Germany
CNIT – University of Florence*	Italy
Selex Sistemi Integrati S.p.A.	Italy
Selex Communications	Italy
THALES Italia	Italy
ALMAMATER (University of Bologna)*	Italy
ASSECO POLAND SA*	Poland
Military University of Technology	Poland
RADMOR*	Poland
Tekever Communications Systems	Portugal
Saab AB	Sweden

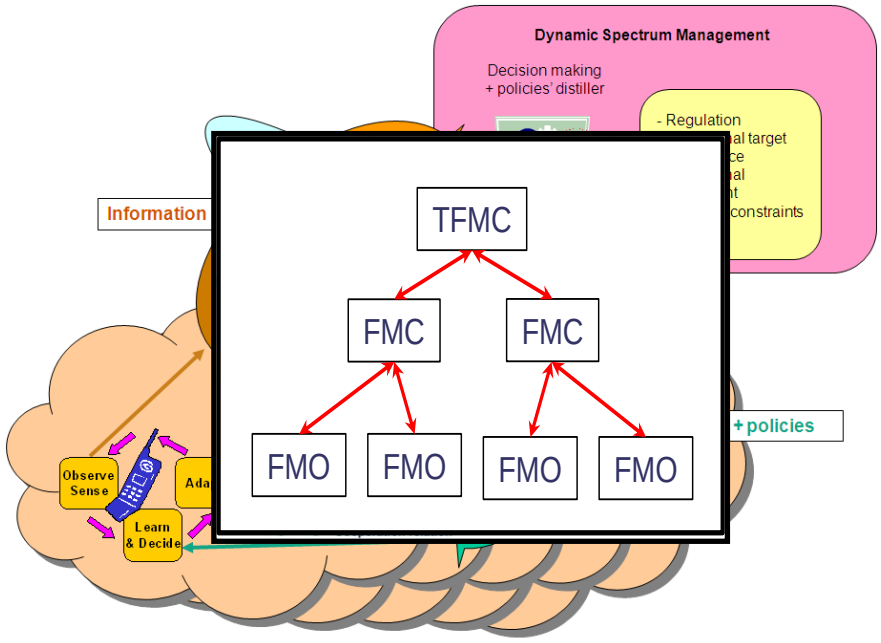
*sub-contractor

7 countries, 9 partners + 7 subcontractors

CORASMA project

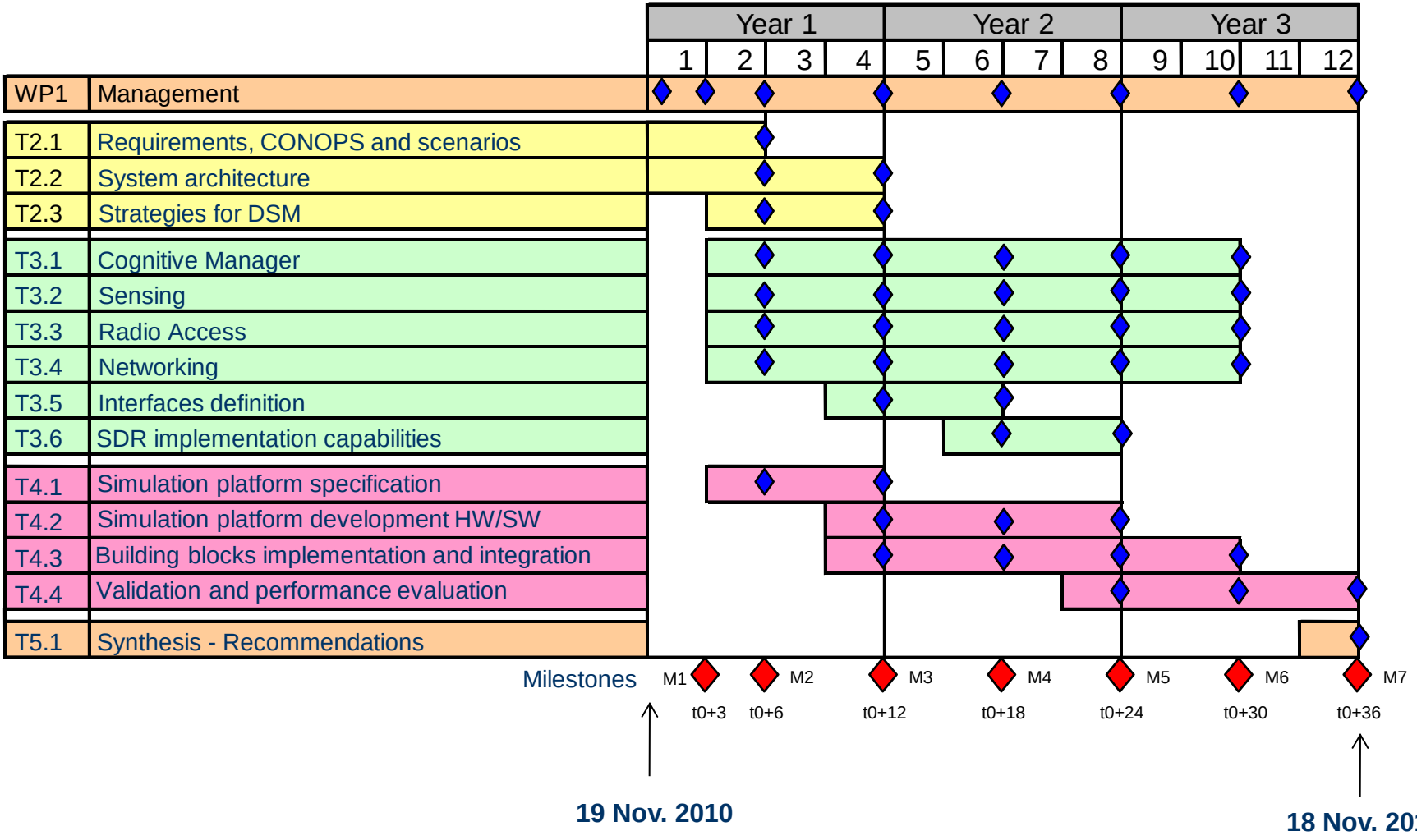
- Project main objectives
  - Study the application of the Cognitive Radio concept to military communication systems
  - Develop a HiFi simulator to evaluate the benefits of the Cognitive Radio solutions to tactical military communication networks

- **Technical topics studied**
  - **At system level**
    - System to equipment (outer) loop
    - Dynamic spectrum management
    - How to go from static planning to more dynamic spectrum allocation?
  - **At network level**
    - Inside network cognitive (inner) loop
    - Adaptive resource management
    - How to improve spectral resource usage by networks/equipment?



Networks of Cognitive Radios on theatre

Tasks and time schedule



CORASMA approach

- How to assess benefits of CR for military systems?

- Facts
  - A Cognitive Radio « waveform » does not exist
  - What is Cognitive Radio by the way?

- Approach
  - Select a non-cognitive waveform at the state of the art -> Basic Waveform (BW)
  - And add up cognitive features on top of it and then assess benefits

- Constraint
  - Each partner should be able to implement its own cognitive solutions inside the simulator (as simply as possible)

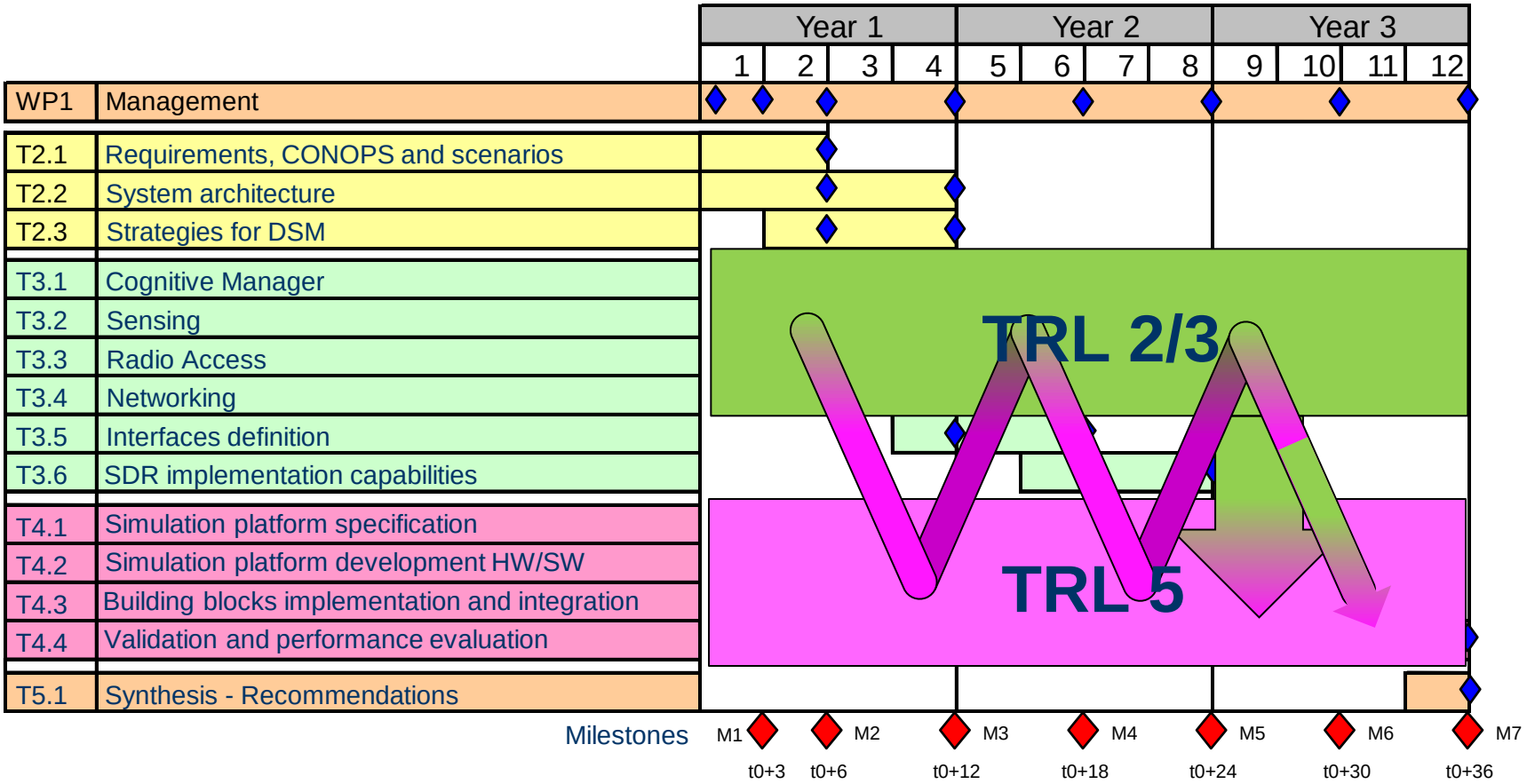
How to assess performance?

- Objective #1: Performance should be assessed from an operational perspective
  - Simulator: All layers implementation + adapted metrics (technical + operational) + operational scenarios
- Objective #2: Simulations should be as accurate as possible
  - To really capture interference effects (frequency reuse, jammers, …)
  - To assess real implementation of CR solutions in waveforms (signaling, robustness, …)
  - Simulator: High-Fidelity simulation at PHY (with I/Q), MAC, NET, Apps + digital terrain w/ propagation model
- Objective #3: enable each partner to implement its own cognitive solution smoothly and to be able to make fair comparison with other solutions of other partners
  - Simulator: Cognitive Plane architecture, common scenarios, metrics and displays
- From #1 and #2: CR solutions are validated through simulation up to TRL 5

CORASMA technical achievements

- WP2 – Paper work
  - Use cases, scenarios,
  - Strategies and system architecture for dynamic spectrum management
- WP3 – Studies to be implemented in the simulator
  - Basic waveform definition (PHY/MAC/NET) - UHF
  - “Cognitive solutions” (cluster dynamic frequency allocation, intra cluster resource allocation, clustering, …)
  - Waveform embedded sensing
- WP4 – Super Hifi simulator
  - Super-HiFi simulator architecture
  - Concept of extended planes « cognitive plane »
  - Operational scenarios implementation
  - Metrics definitions (layers/cognition/system (mission success))
  - Propagation environment (signal mixing, DTM, propag. models, …)
  - IHMs (configuration, simu launch, results exploitation)

From TRL 2-3 to TRL 5

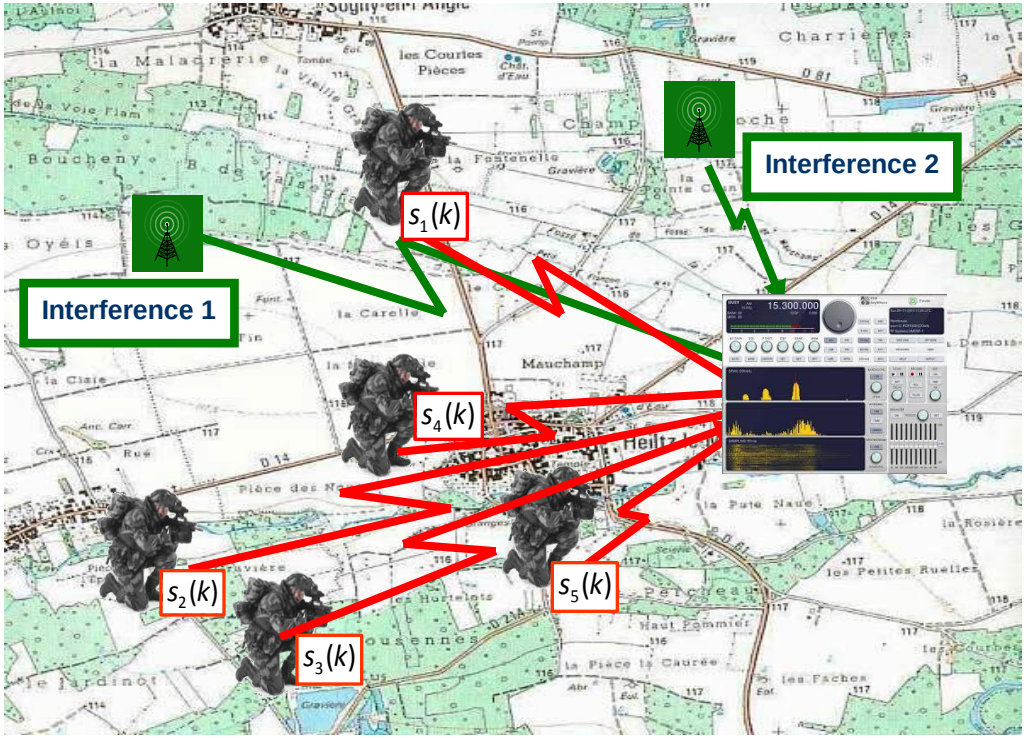


On the super-HiFi simulation

- Conventional simulations: two steps approach
  - -1/ HiFi PHY simulation (layer 1) -> abstractions
  - -2/ HiFi network simulation (layer 2/3) with layer 1 abstraction
- Claim 1:
  - Step 1/ followed by 2/ (often referred to as HiFi) cannot lead to high TRL validation due to layer 1 abstraction
- Claim 2:
  - To validate a communication system at high TRL, a super-HiFi simulation is compulsory
  - Fact: accurate abstractions of new radio access are becoming more and more difficult to elaborate
  - Super-HiFi includes all layers HiFi implementation (PHY/MAC/NET/…)
  - It allows
    - To evaluate the benefits of low layers solutions at operational system level
    - And in particular to evaluate the scaling behavior of the network
- Drawback: complexity and simulation duration

J. Mittag, S. Papanastasiou, H. Hartenstein, and F. G. Ström, "Enabling Accurate Cross-Layer PHY/MAC/NET Simulation Studies of Vehicular Communication Networks, Proceedings of the IEEE, Vol. 99, No. 7, July 2011

Super-HiFi simulation – IQ modelling



Principle

Each receiving node receives the contribution of all other nodes + interferences through propagation **in baseband**:

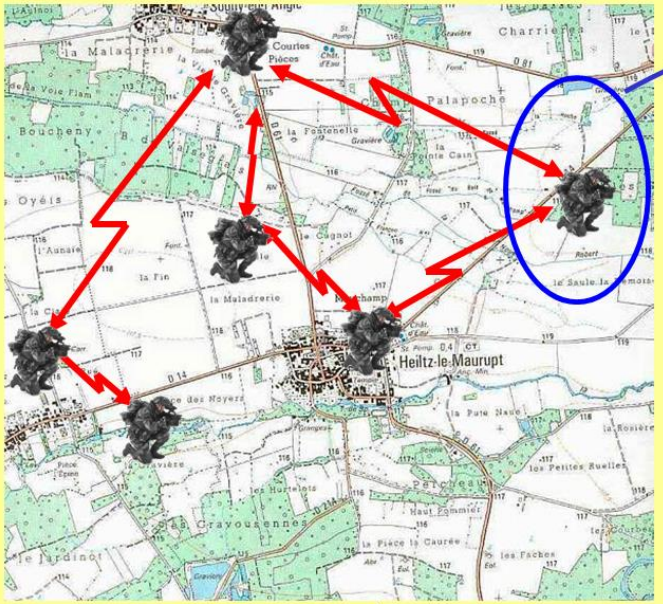
$$r_j(k) = \sum_{\substack{i=1 \\ i \neq j}}^{6} \Gamma_{i,j}\left(s_i(k)\right) + \sum_{n=1}^{N_I} \Gamma_{n,j}\left(I_n(k)\right)$$

other nodes **jammers**

$\Gamma_{i,j}(\bullet)$ **: propagation filtering function**

Samples are IQ baseband signals

CORASMA Distributed Simulation Initial Idea



Intensive computing PCs
with RT Linux HW

High speed bus

Simulation
Master PC

Scenarios
From WP2

Building blocks
From WP3

Digital terrain
+ Propag. Model

Super-HiFi simulation vs. R-T mockups

- Conventional real-time mockups

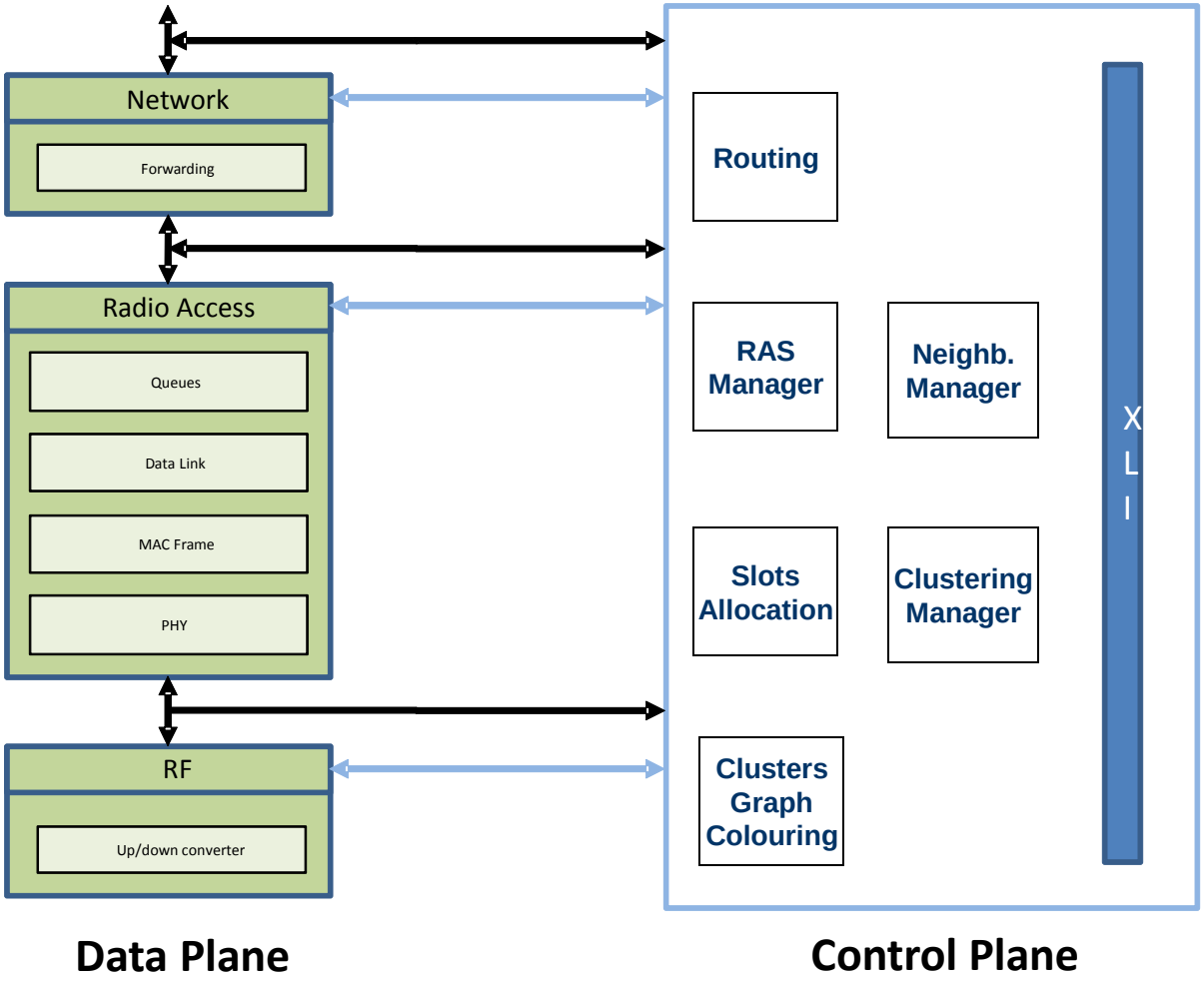
  -1/ Involve usually only a few nodes (< 10)

  -2/ Implement real time PHY layer and usually simplified MAC (layer 2) with a real time app. on top

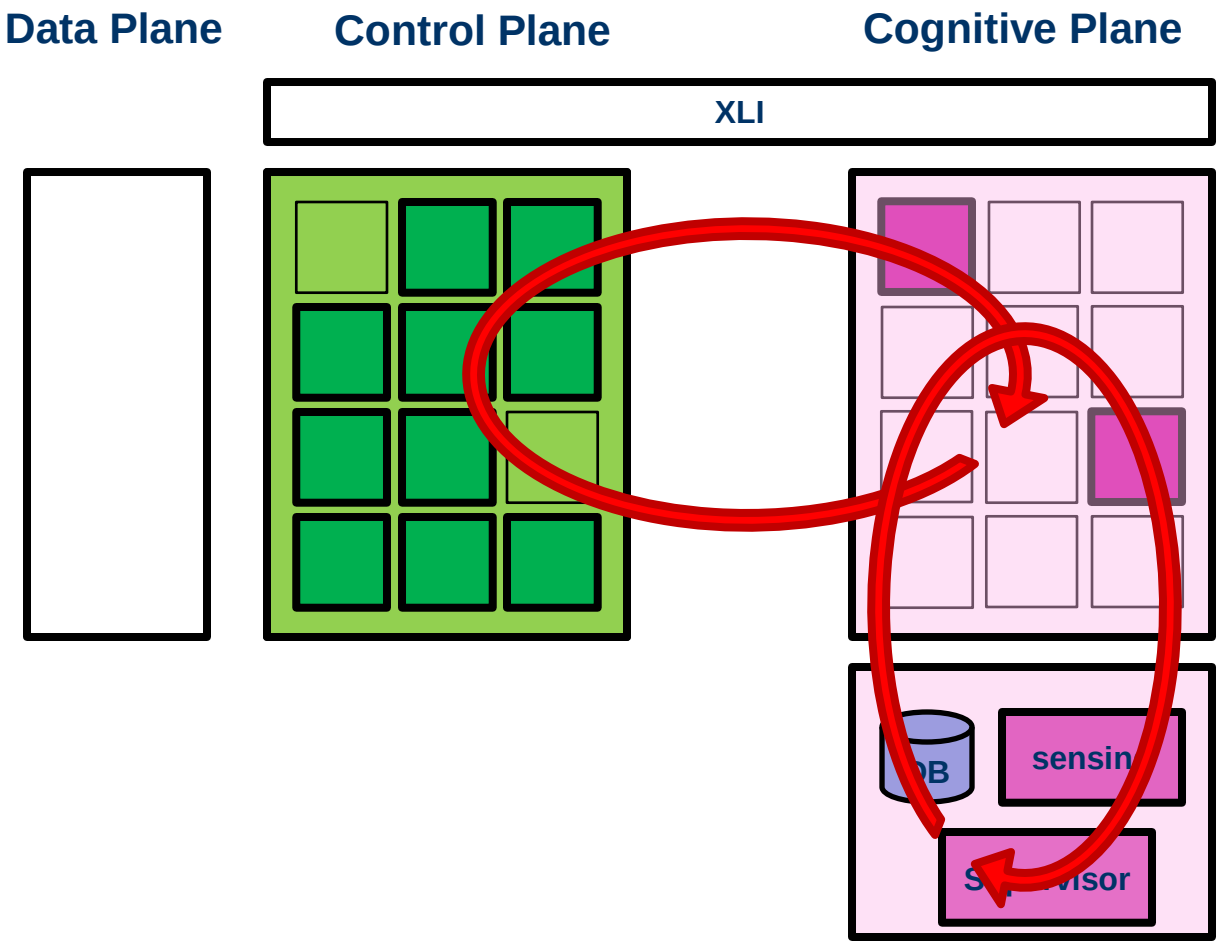
- Drawbacks
  - Validates only PHY layer at high TRL (provided propagation is accurate)
  - Usually short range demos, propagation/mobility environments are limited
  - Do not allow to test scalability (10s, 100s, … of nodes) -> interference effects/management, clustering, mobility, …
  - Do not permit to evaluate benefits of new schemes at operational levels
  - On field trials are very time and person consuming

- Thus, do not allow to validate the communication networks at high TRL

Data plane and control plane of the BW

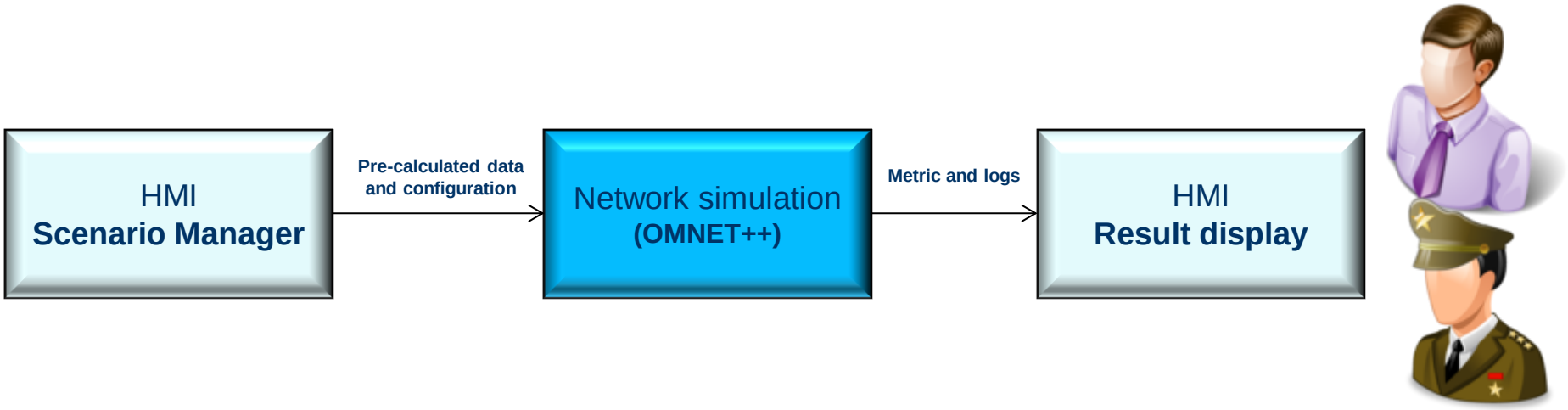


Cognitive plane

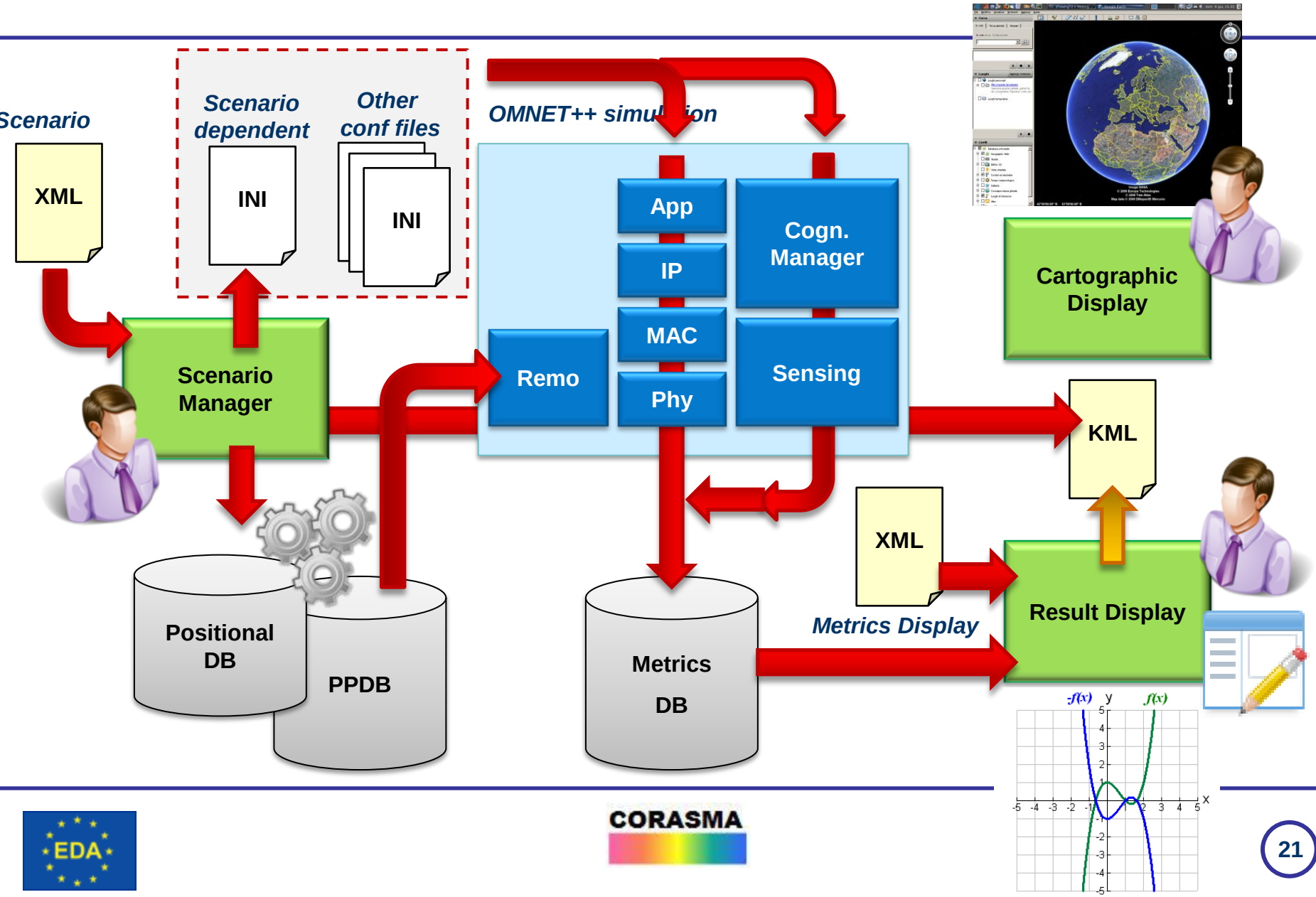


Basic Waveform Mirror Blocks (BWMB)

Simulator architecture



Simulation workflow

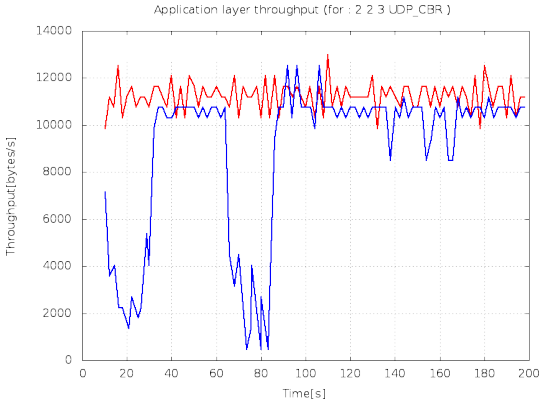


Metrics – general

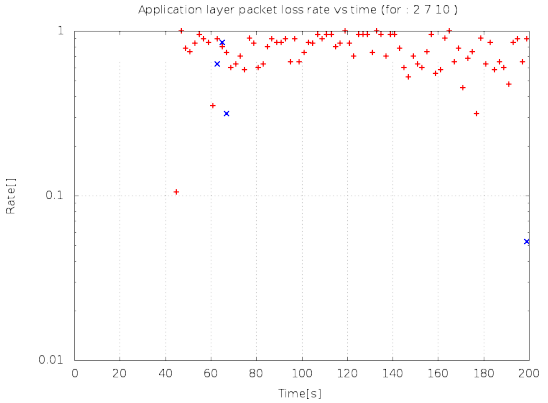
- Layer-specific metrics
  - PHY/MAC/NETWORK → Detailed lower layers metrics
  - CM → Cognitive plane specific metrics
  - APPLICATION → Mission oriented metrics
- Metrics category
  - Global
  - s2d (source to destination)
  - Node
  - Link
- Metrics visualization with results display tool
  - Standard 2D graphs
  - Dedicated tables for global mission oriented metrics

Some metric results

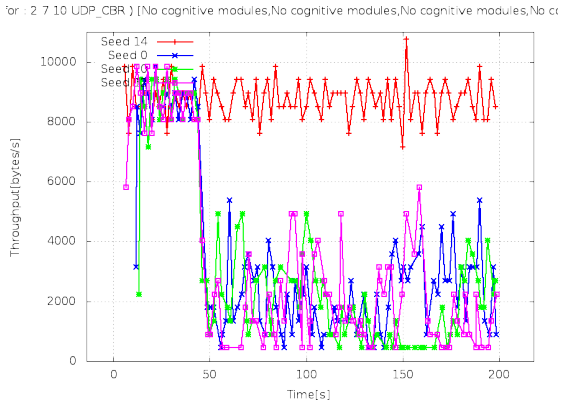
Application layer throughput



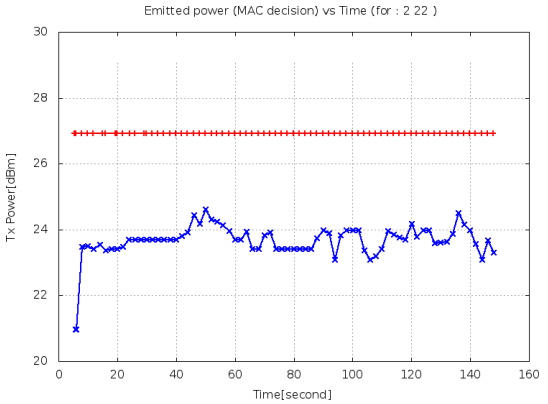
Application layer packet loss rate



Application layer throughput



Transmit power



Global metrics

Global Metrics Dialog

	[No_CR]	[CR_Solution]
Utility functions summary		
Global utility function	0.19	0.46
Global RT utility function	0.01	0.48
Global NRT utility function	0.39	0.44
Service summary		
NRT services		
C2m : Success / Expected (% of success)	544/2447 (22.20%)	742/2447 (30.30%)
BFT : Success / Expected (% of success)	1608/2447 (65.70%)	1909/2447 (78%)
Email POP3: Success / Expected (% of success)	7/288 (2.40%)	14/288 (4.90%)
Email SMTP: Success / Expected (% of success)	11/193 (5.70%)	37/193 (19.20%)
Alert: Success / Expected (% of success)	1034/2447 (42.30%)	1062/2447 (43.40%)
Chat : Success / Expected (% of success)	62/875 (7.10%)	124/1575 (7.90%)
RT services		
VoIP : Success / Attempt (% of success)	0/29 (0%)	16/29 (55.20%)
VioIP : Success / Attempt (% of success)	0/0 (0%)	0/0 (0%)
PTT : Success / Attempt (% of success)	0/0 (0%)	0/0 (0%)

Video

Conclusions

- Cognitive solutions implementation
  - All the partners succeeded to implement their cognitive solutions -> Cognitive Plane is good tool! (easily generalized to non-cognitive)
  - Various sensing algorithms were implemented and are working
- Super-HiFi simulation
  - Compulsory to validate global solutions at TRL greater or equal to 5
  - Very valuable put in the early stages of the V cycle development
  - Already have pinpoint issues that could not have been seen using conventional simulation nor mockups
  - Computational time drawback can be mitigated by using distributed simulation
  - Next EDA project (FM2RN) using super-HiFi simulation is on good tracks!
- Not sure still what is a Cognitive Radio…

Thanks

Kiitos

Tack

Danke

Grazie

Trugarez

Gracias

Merci

Ευχαριστώ

Obrigado

谢谢

Thank you

ありがとう

Dziękuję