OPERA-Net Results
&
OPERA-Net 2 Goals

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Optimising Power Efficiency in Mobile Radio Networks

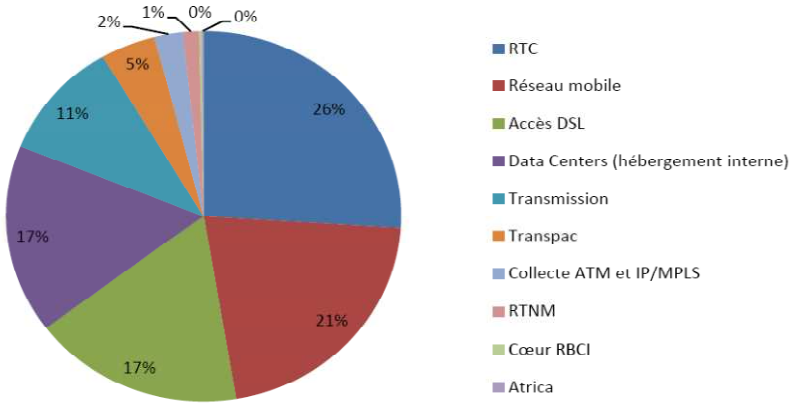
OPERA-Net : 1/06/08 to 1/06/11

OPERA-Net 2 : 1/09/11 to 1/09/14

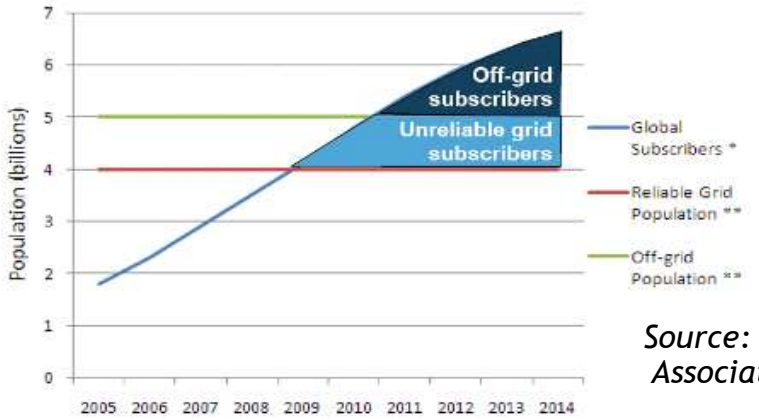
OPERA-Net Results

Opera-net

Energy consumption for France Telecom's (in France) :

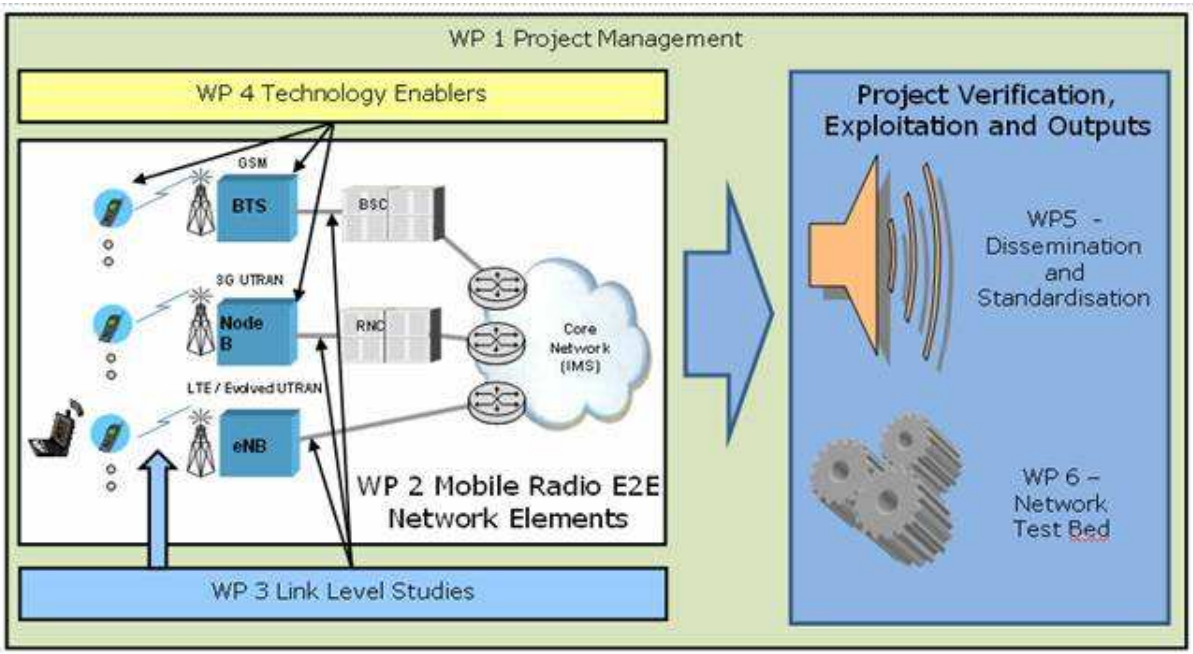


AMEA :



Source: GSM Association

Project Structure :

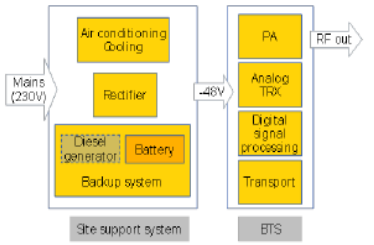


Main ideas :

WP2: KPI for energy efficiency, DC power, cooling system, sleep-mode, energy efficient of cell sizes
WP3: optimization techniques for Link-level power efficiency, energy-aware device (terminals & infrastructure) design
WP4: Energy recovery in Base Stations, improved power efficiency of Next-Generation Terminals

WP2 “E2E RAN” Results

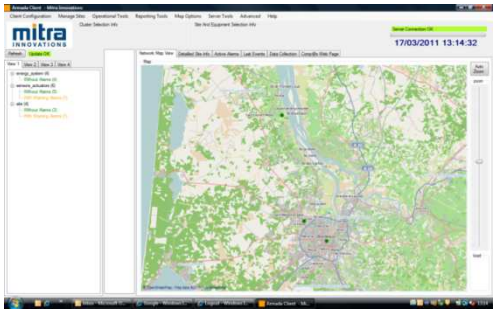
- WP2 focused on identifying E2E energy
  - BTS power consumption
  - Network power consumption
  - Practical impacts from site construction
  - Contribution to standardization (ETSI, ITU-T)



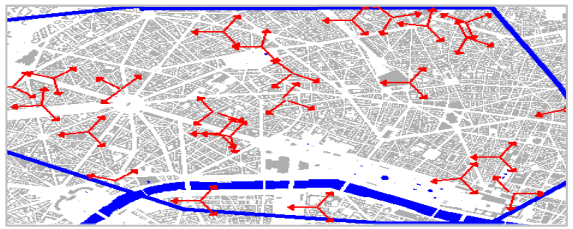
$$P_{BTS} = n*P_P + m*P_{TRX} + (k_1+\dots k_n)*P_{RF}/c$$

$$P_{BTS} = n*P_P + m*P_{TRX} + (k_1*P_{RF1}+\dots k_n*P_{RFn})/c$$

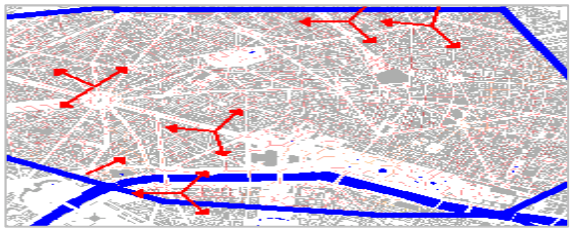
Load factor: k = 0,1 …1
BB capacity: n = installed processing capacity increment
RF capacity: m = installed antenna sectors
RF conversion: c = conversion factor for RF_{out} to DC_{IN}



- Identified savings
  - Our results identified significant savings possible on current sites with existing technologies. Requires rework of existing sites.
  - ~20% with site optimization (air-conditioning, lights, aux. equipment).
  - ~30% with network adaptivity. Partly achievable with now available SW features. Further HW development needed to improve load adaption.



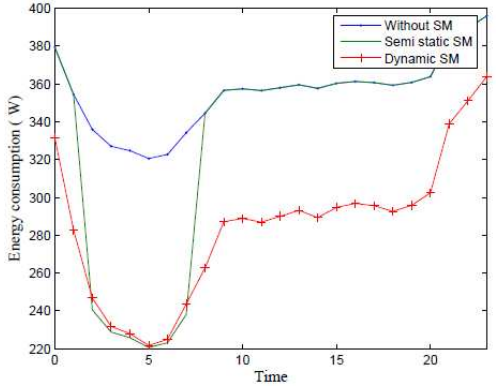
Without Sleep Mode



With Sleep Mode

QoS , coverage, Access probability

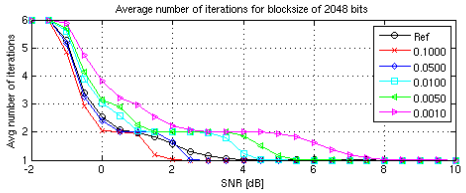
Energy consumption over the day :



WP3 « Link Level studies » Results

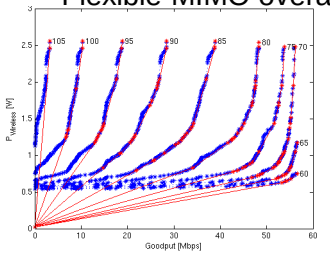
Early-stopping turbo-decoding

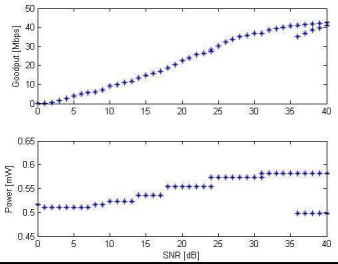
- 2 simple criteria tested
- Tuning to run-time condition
- Average 6 down to 2 iter.



System trade-offs & integration

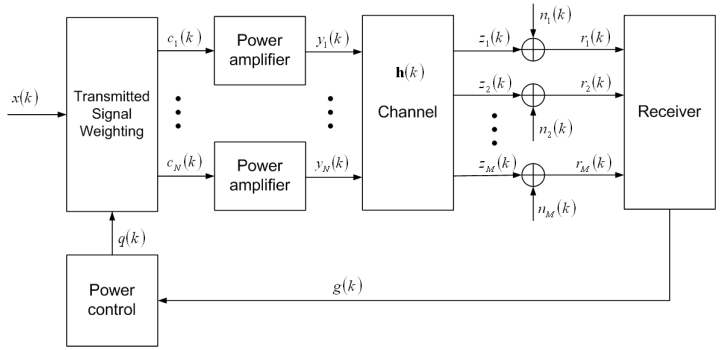
- Power-goodput Pareto curves for LTE: 70% gain over SoA
- SISO more power-efficient in DL - MIMO in UL at high SNR
- Flexible turbo overal gain: 2..12% depending on load
- Flexible MIMO overal gain: 10..35% if MIMO is used



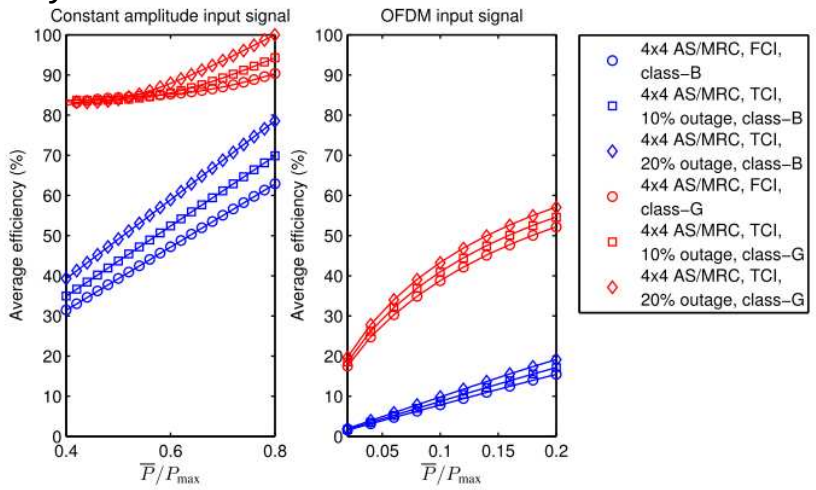


Model allows comparison of average PA efficiency in a single user system

- e.g. LTE/WiMAX like UL with iterative power control in Pedestrian A channel



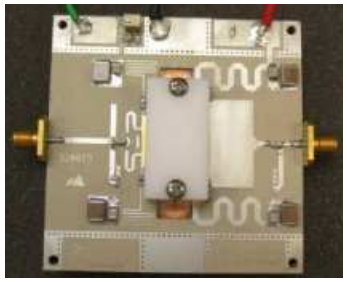
Average PA efficiency : Analyzed from transmitted power pdf and theoretical or measured PA efficiency curves

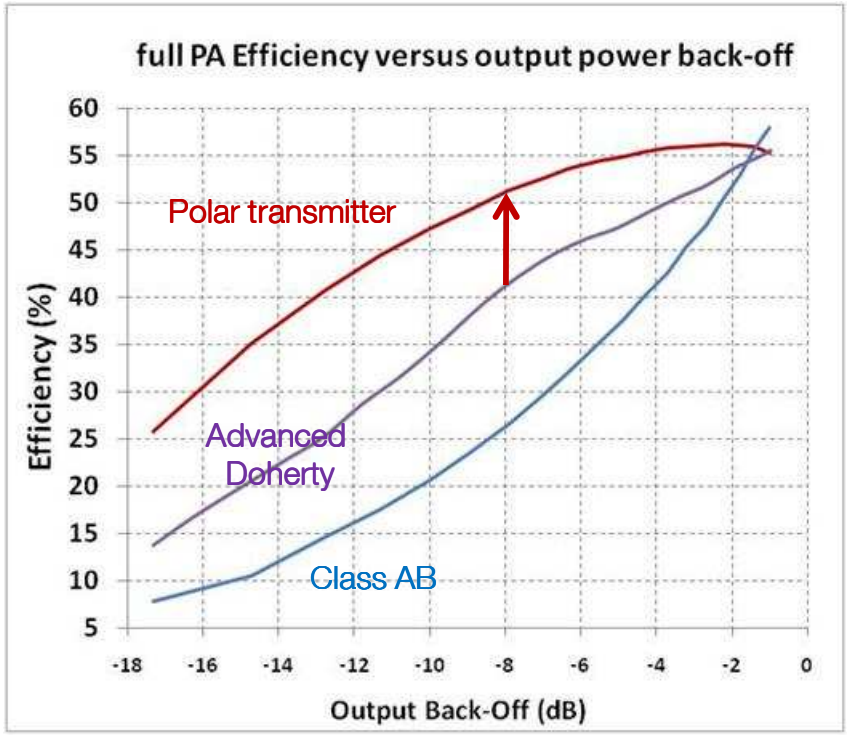


WP4 “technology enablers” achievements

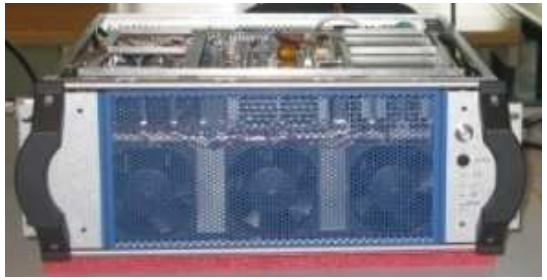
Opera Net versus state of art performance :

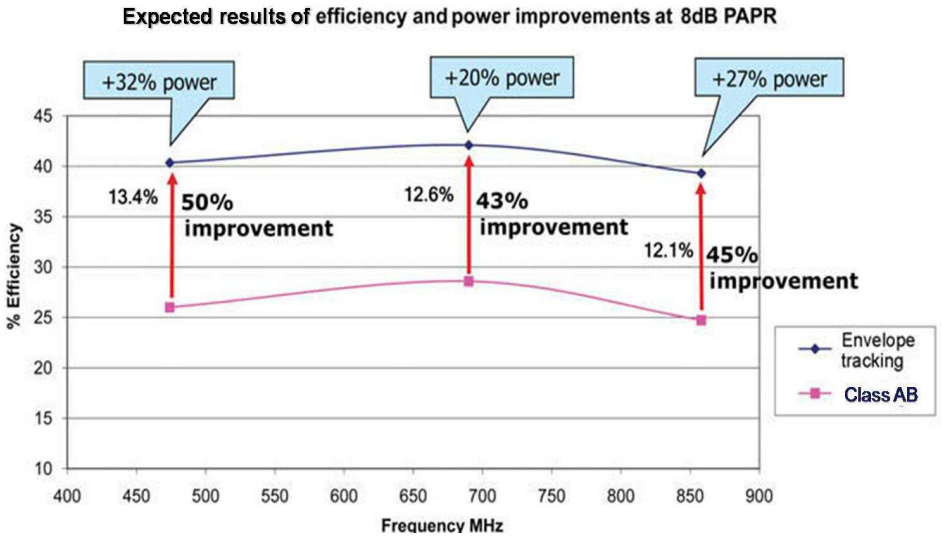
-Polar transmitter:





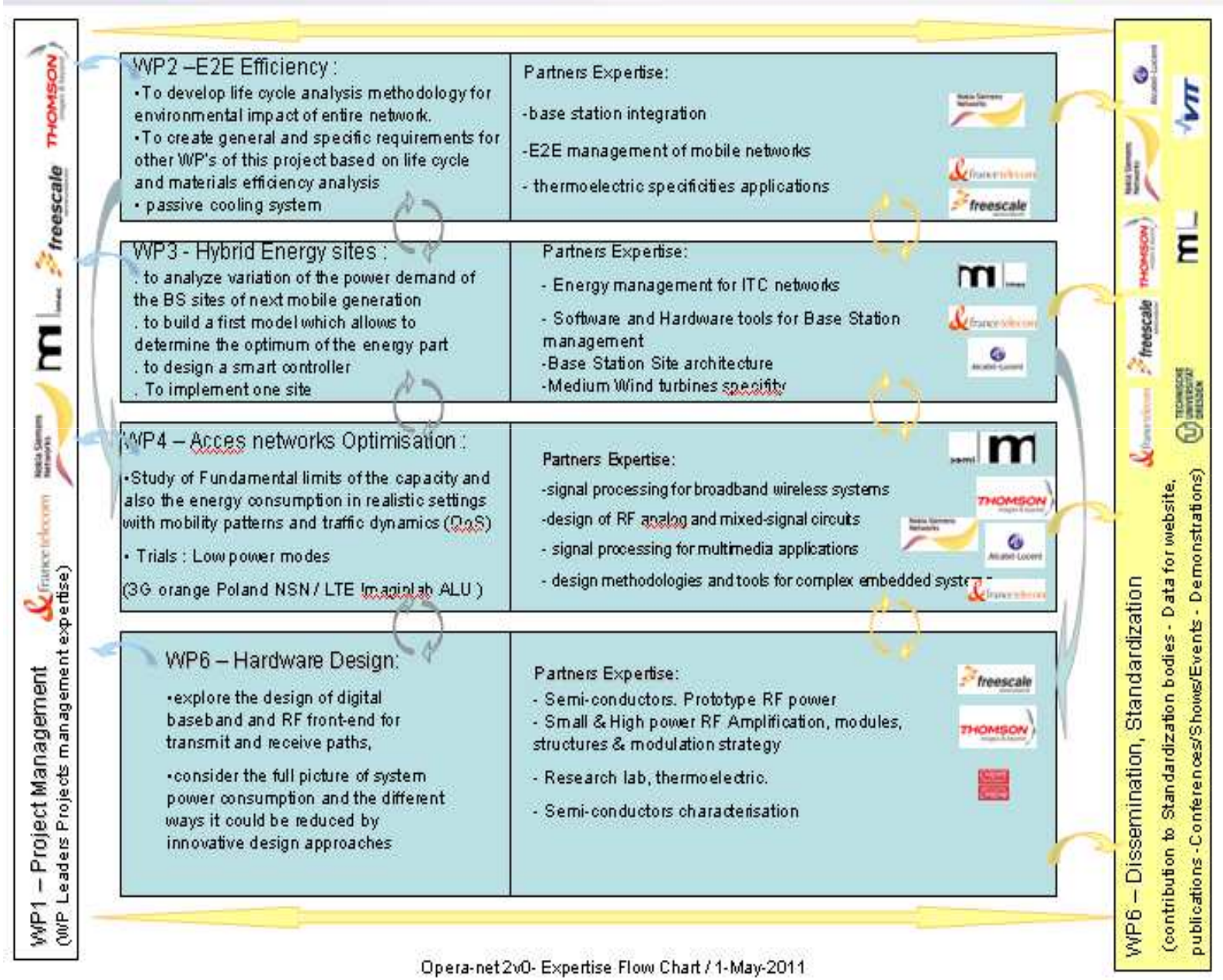
-Broadcast power amplifier with envelop tracking:





OPERA-Net 2

OPERA-Net 2 Expertise Flow Chart :



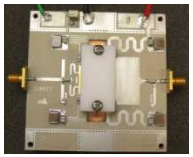
Opera-net 2v0- Expertise Flow Chart / 1-May-2011

WP2 E2E efficiency

E2E global power consumption

- ***Impact of growing data traffic on total energy consumption***

Network life cycle assessment



LTE – DVB NGH convergence

Passive Thermal studies (trial)

Material efficiency

- ***EU analysis on critical materials lists expected shortage on 41 raw materials***

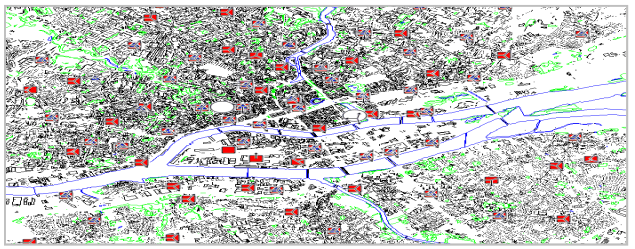
WP3 Hybrid Energy sites :

Availability analysis of different renewable power sources and their geographic variation (software)

Energy supply modelling and optimisation (wind Turbine and LIpo storage for ex) (Trial)

WP4 Access Network optimisation :

Main goal is in dense networks composed of small and macro base stations :



Link performance and energy efficiency

Distributed/collaborative MIMO methods, relays, multiuser scenarios

General network management (includes sleep mode management)

Fundamental limits for capacity and energy efficiency, centralised selection of base stations, learning with high mobility

Network optimization techniques exploiting scalability features of digital and analog components

Heterogeneous networks including small cells

Distributed mechanisms for selecting a combination of small and macro base stations (e.g. game theory)

Enhanced models for both macro and small base stations and numerical comparison of different network deployment approaches

2 majors Trials 3G + LTE :

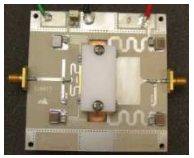
Network service management: impact of deploying different cell sizes (Poland NSN 3G)

Cells breathing and sleep mode management LTE ALU with Imagin Lab platform.

WP5 architecture optimisation and hardware design goals :

Optimizing a broadband and efficient linear transmitter from baseband to antenna connector using newest GaN 50V technology

Optimizing power system architecture



Optimizing signal generation and DPD around the transmitter

Applying mobile world type of design techniques to low power type of BTS design