Advanced Research Center on Electronic Systems for Information and Communication Technologies

- ARCES -

Elena Gnani

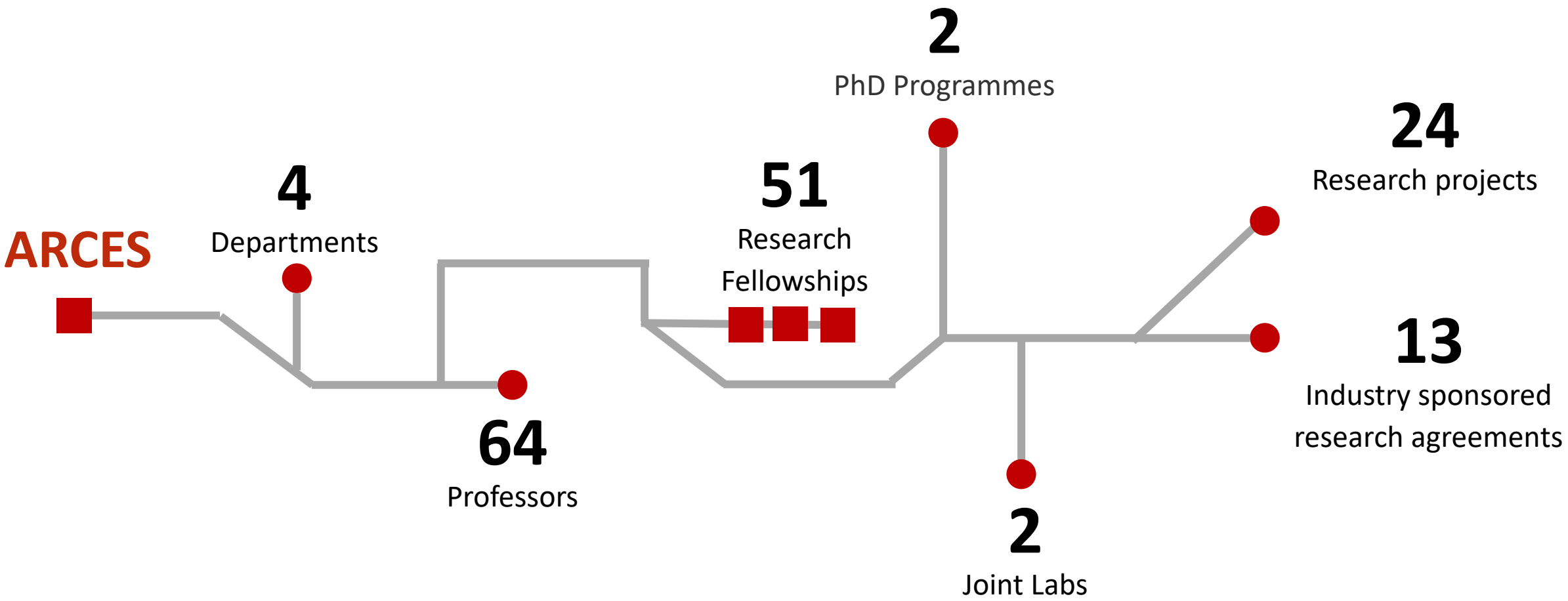
University of Bologna

Objectives of the Research Center

- Conduct research on electronic systems in the area of ICT technologies
- Enhance synergies resulting from the convergence of diversified expertise
- Develop collaborations with Industry and support to technology transfer
- Pursue a spin-off generation policy

Enhance synergy among groups through projects that require multidisciplinary skills

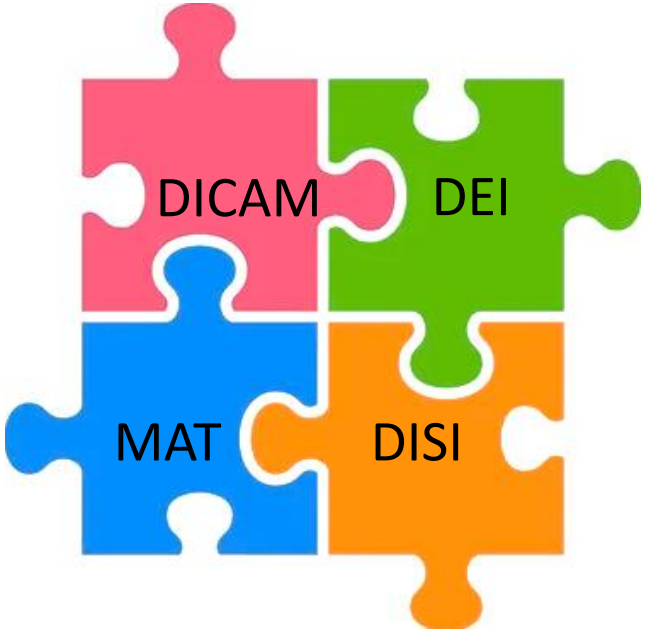
ARCES in a nut shell



ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

Constituent departments

Civil, Chemical, Environmental and Materials Engineering



Electrical, Electronic and Information Engineering "Guglielmo Marconi"

Mathematics

Computer Science and Engineering

Enhance synergies and multidisciplinary skills

PhD programmes

ARCES supports two PhD programmes:

- ETIT (Electronics, Telecommunications and Information Technology Engineering)
  - It roots in the cultural heritage of Guglielmo Marconi and projects itself in the future of the ICT world through its involvement in research and development programs funded by International Institutions, Industries, and SMEs.
  - Main research areas: Electronics, Electromagnetic fields and Telecommunications

- EIT4SEMM (Engineering and Information Technology for Structural and Environmental Monitoring and Risk Management).
  - Provides methodological and technological skills aimed at monitoring structures, infrastructures and the environment
  - Focus areas are: 1) Modeling and Analysis, 2) Sensing Technology, 3) Data Integration

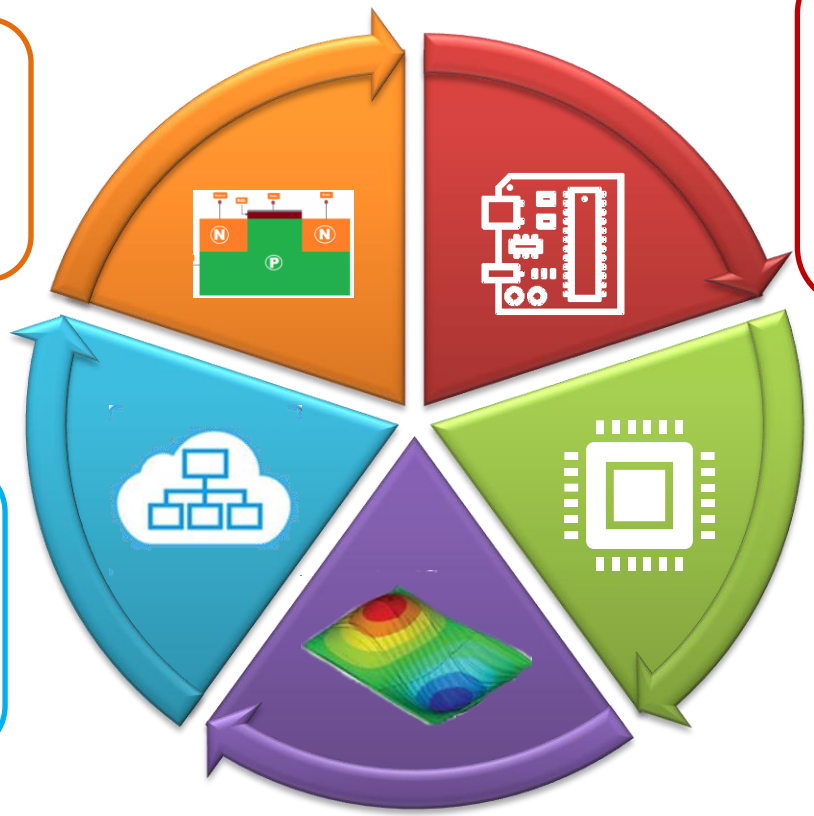
Research expertise

- Devices for HPC and QC
- Power devices
- Packaging
- Reliability

Emerging devices

- Electronic circuits
- Internet of Things
- Sensors
- Energy efficiency
- Energy management

Electronic circuits, systems and sensors for the next/emerging energy challenges



- IoT platforms
- Data analytics
- Machine learning
- Software interoperability

Data management

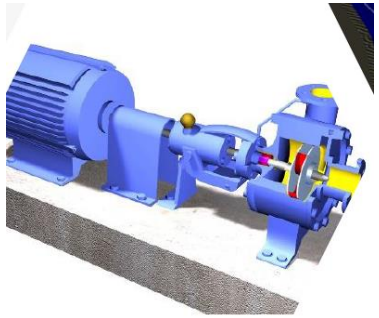
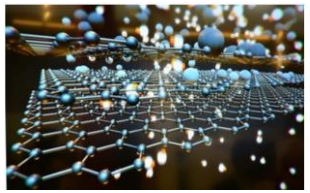
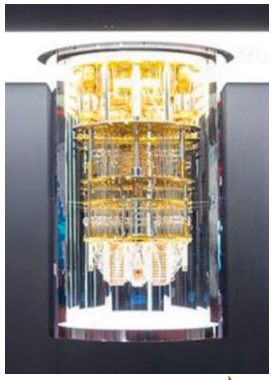
- Digital circuits and systems
- Low power digital design
- Systems on chip
- Machine learning hardware

Energy efficient computing

Modelling physics to support SHM

- Understanding coupled physics
- Development modelling codes
- Expertise in software applications
- Interface applications

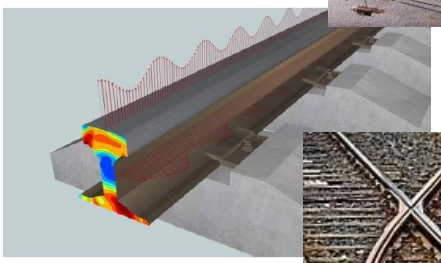
Applications

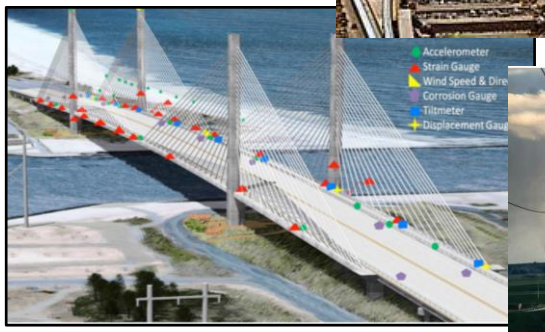














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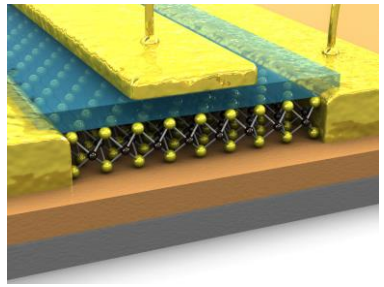
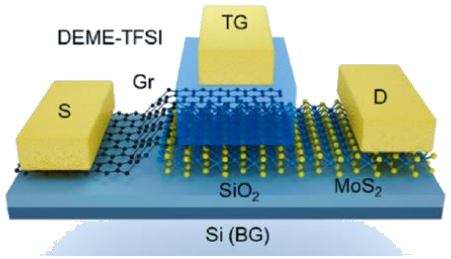
Modeling and characterization of emerging devices

Emerging devices – Beyond CMOS

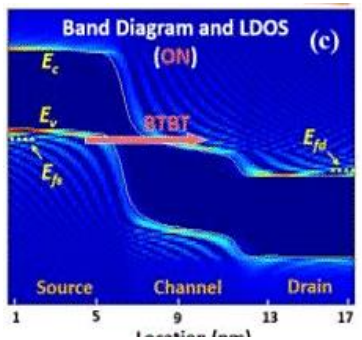
- Steep-slope devices
- 2D transistors
- Semiconductor spin qubits

TMD-based FETs



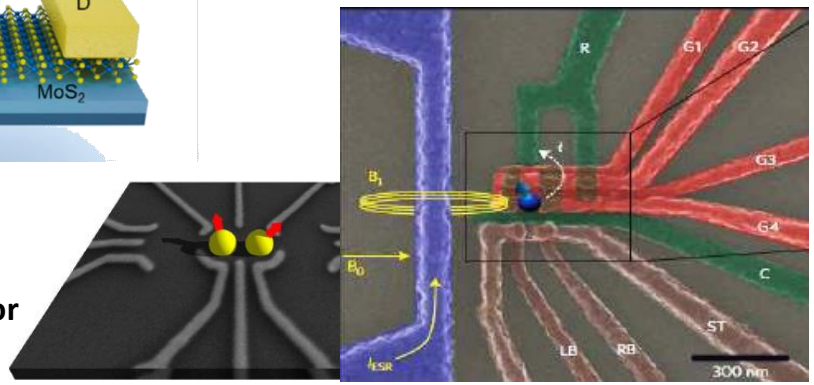


TFETs



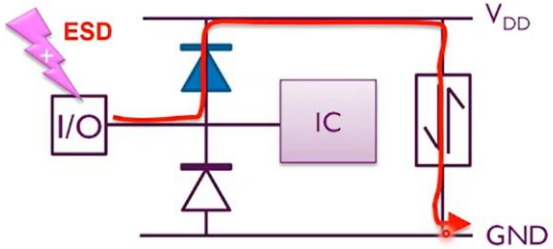
Cold Electron DIRAC FETs

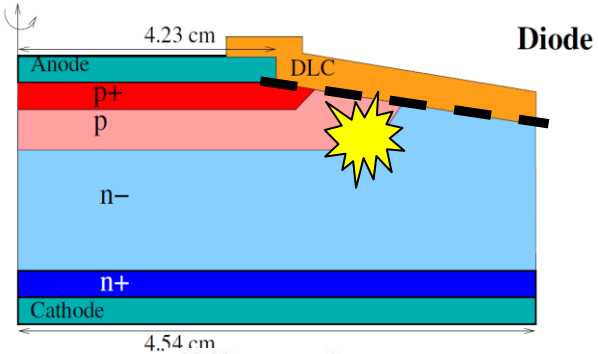
Semiconductor spin qubits

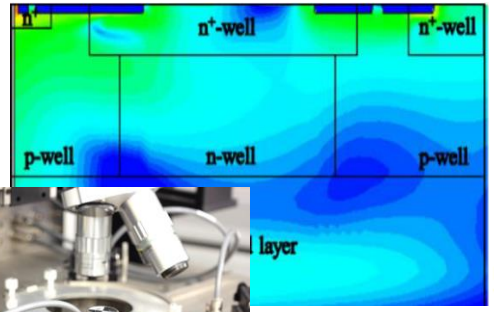


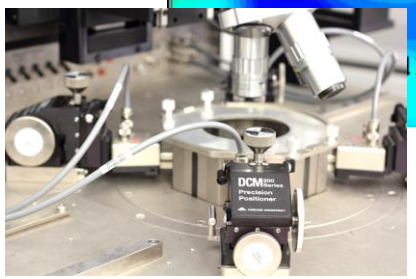
Power devices

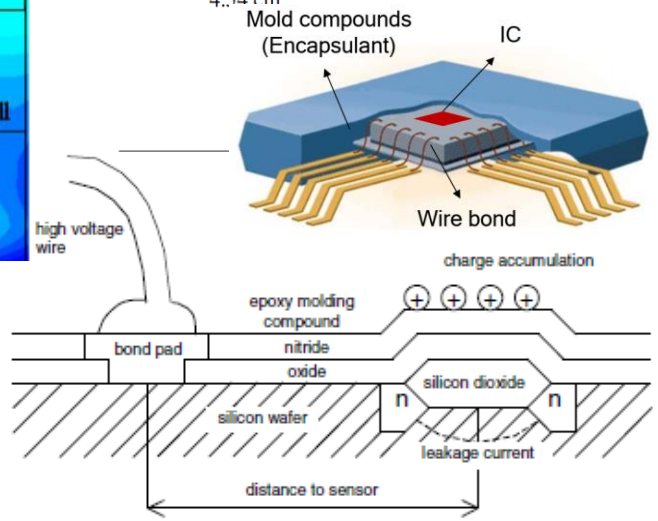
- Hot-carrier stress and gate leakage current in LDMOS
- GaN-based HEMTs and SiC MOSFETs
- Encapsulating molding compounds for electronic packaging









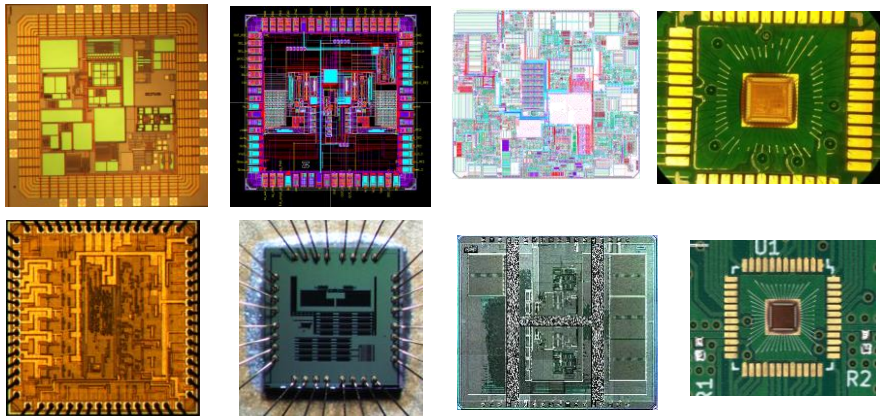


Circuits, systems and sensors for emerging energy challenges

Key components of the digital transition as building blocks of every «smart» system

Integrated Circuit Design

- Design of innovative custom integrated circuits
- *Strategic area for the EU Chips Act*
- Competence in *analog design* highly required by industry
- Experience across a wide range of microelectronic technologies for applications ranging from analog circuits for sensors, smart-power circuits, digital computation

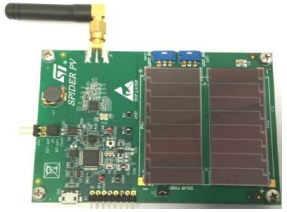


A selection of analog and power ICs developed in ARCES

System-level design

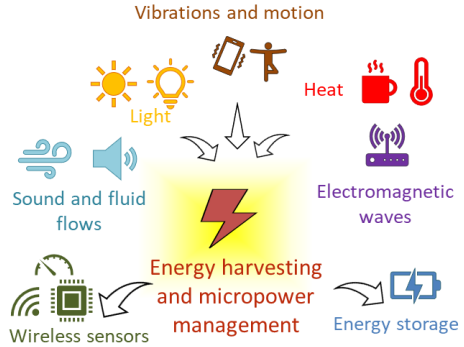
A wide range of systems is being developed:

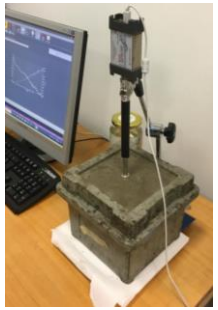
- Micropower converters
- Energy-efficient IoT
- Environmental & energy monitoring
- Sensing applications
- Wireless solutions

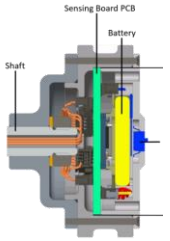


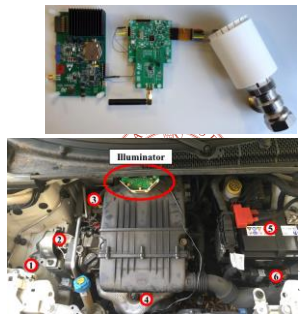
Sensors and algorithms

- Energy efficiency & efficient use of resources → ASIC design for utra-low power and ultra-low voltage sources
- Optimized micropower management
- Optimized wireless sensing nodes





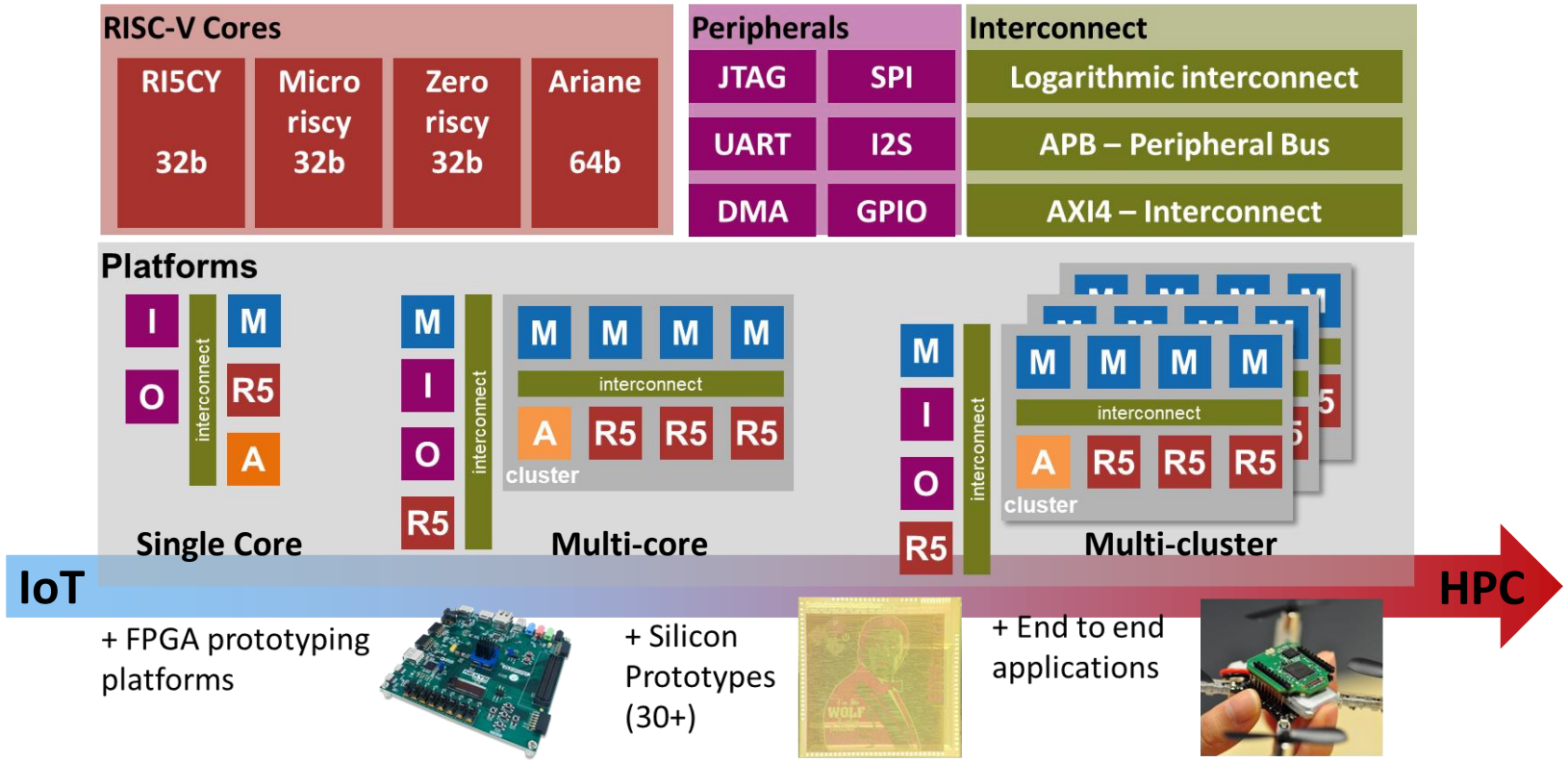




Energy efficient computing systems - PULP

PULP: A parallel ultra low power platform for next generation IoT applications

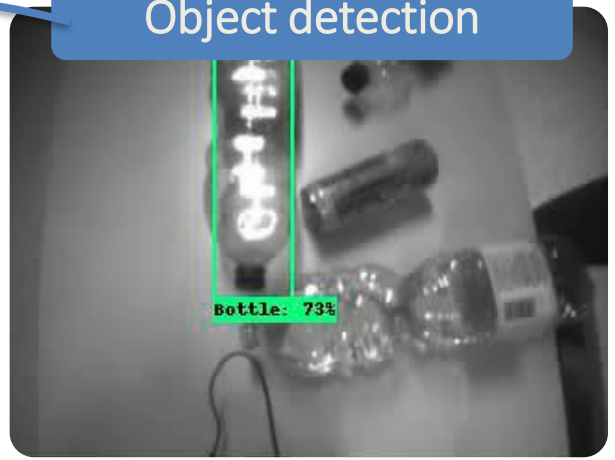
- Design Energy-efficient computing systems *from IoT to HPC*, addressing «the twilight of Moore's law»
- Create an *open compute platform* and an ecosystem used for research on digital circuits and computing systems
- Demonstrate innovation in silicon; more than 40 PULP SoCs prototyped in 10 years
- Leverage emerging technologies (2.5D, 3D, NVMs) whenever possible



Example: Achieving true autonomy on nano-UAVs

Execute complex, heterogeneous tasks at high speed and robustness **fully on board**

Object detection



Obstacle avoidance & Navigation

Environment exploration

Multi-GOPS workload at extreme efficiency → P_{max} 100mW

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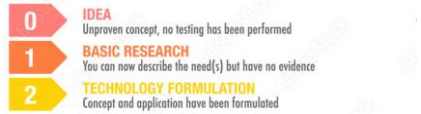
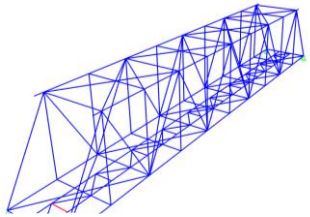
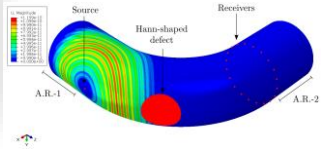
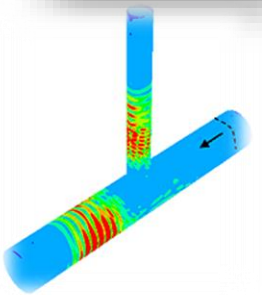
Physical modeling for structural monitoring

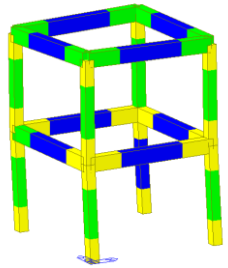
- Acoustic emission-based monitoring of composite pressurized vessels
- Industrial and Civil Digital Smart Structures
- Tank integrity monitoring
- Structural Health Monitoring of railway bridges



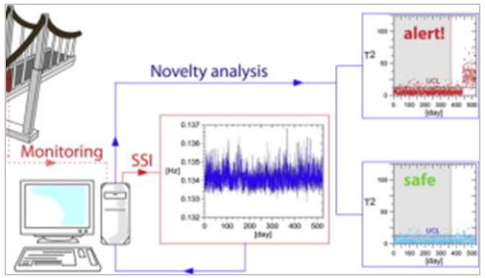




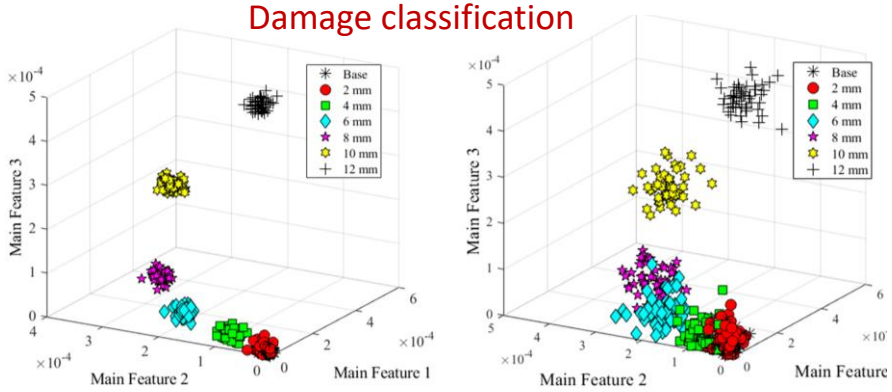




Anomaly detection

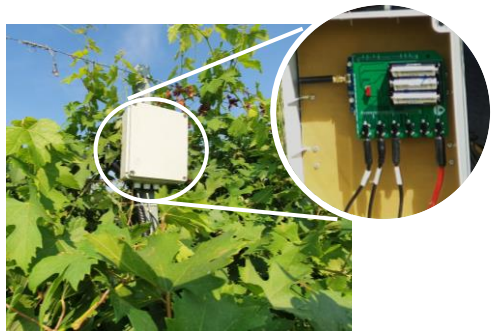


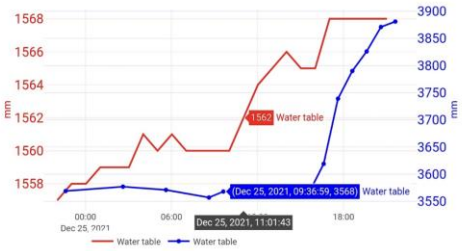
Damage classification

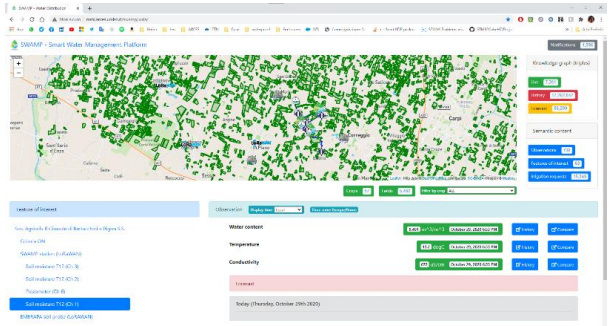


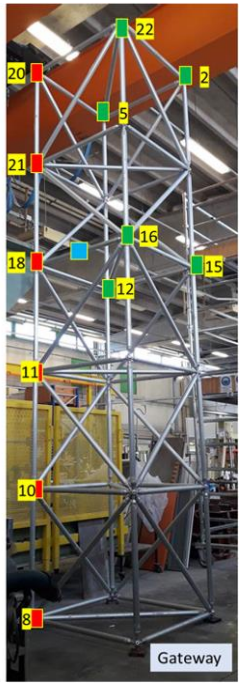
From electronics to the cloud, from data to AI

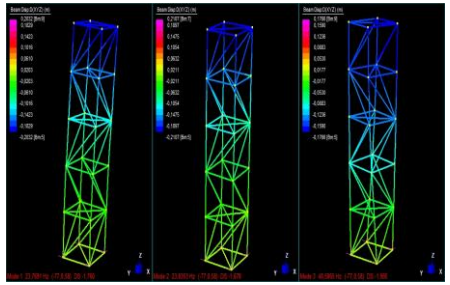
- *Software platforms* for IoT data management/validation/exploitation Data/software
- *Data analysis* using AI techniques
- *Interoperability* in distributed systems
- Integration of edge AI techniques on low-power devices

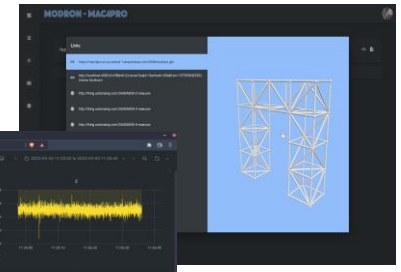


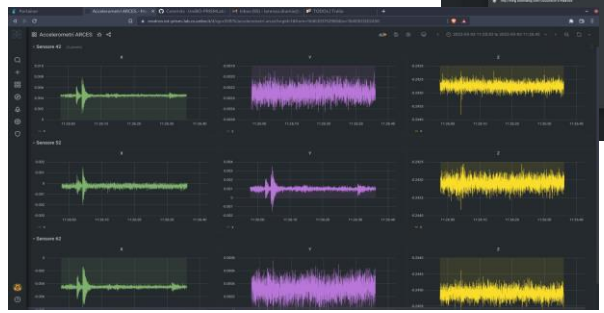






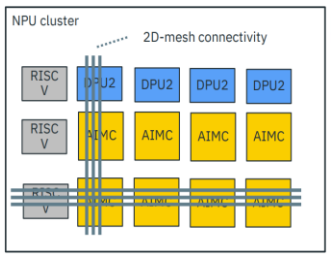




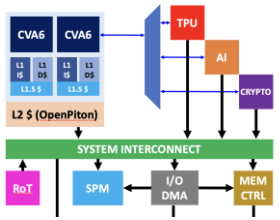


24 active research projects

GaN- and SiC-based electronic systems for zero-loss power circuits



Analog in-memory computing



Isolde

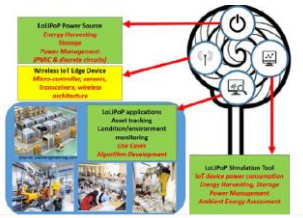
High Performance, Safe, Secure, Open-Source Leveraged RISC-V Domain-Specific Ecosystems

Reliable Powerdown for Industrial Drives

Smart and secure energy solutions for future mobility

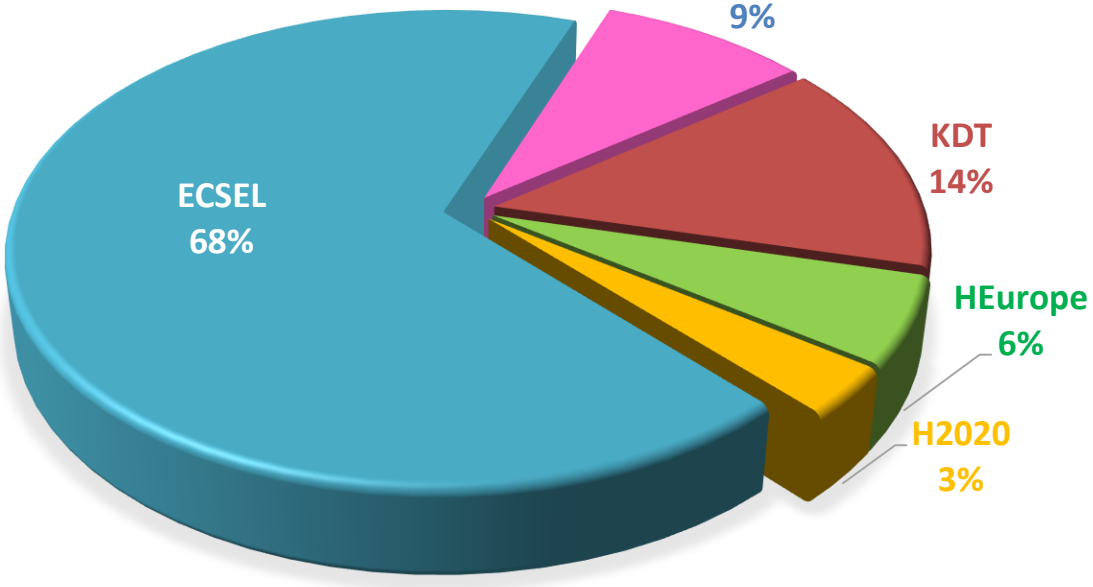
ICs reliability by reducing failure rates along the entire value chain

Highly efficient and trustworthy components and systems for the next generation energy supply infrastructure



LoLiPoP

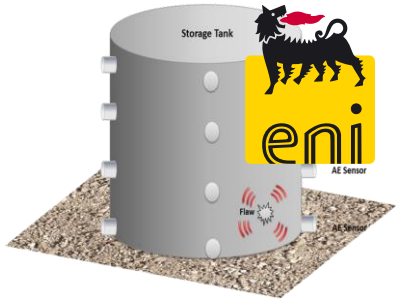
IoT innovative Long Life Power Platforms



Industrial collaborations

SAFE CERTIFIED STRUCTURE

TEXAS INSTRUMENTS



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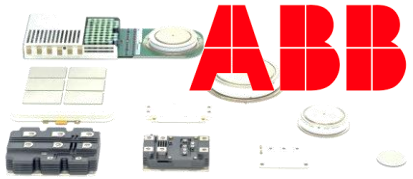
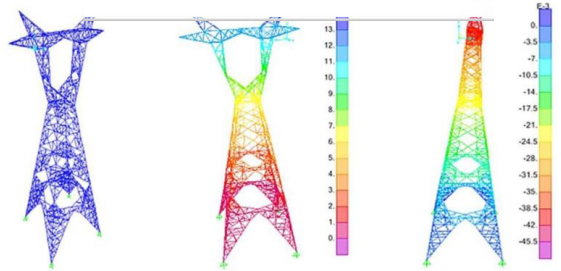


ThalesAlenia Space
a Thales / Leonardo company

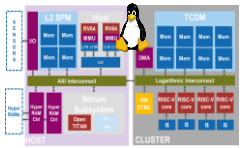
HPECOXA

DUCATI energia



TÜV AUSTRIA

TII Technology Innovation Institute



SALCEF GROUP

ARCES-STMicroelectronics Joint Lab - A Success Story

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A Successful Collaboration

- Strong interaction between industrial and academic researchers
- Access to advanced ST technologies and Design Platforms
- Excellence in teaching and education for talent development
- Multi-disciplinary expertises in different research area
- Foster sustainable innovation and technology

Results

- Continuous funding along more than 20 years: in 2022: 5 PhD grants, 9 AdR grants (**+ 80%**) , 4 industrial internships
- Joint Participation in European Projects: 6 are currently active
- Know-how and technology transfer
- Several Scientific publications
- Intellectual Property: more than 60 patents (6 patents filed in 2022)
- Several PhD and graduates hired in ST during the years (4 hired in 2022)

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ARCES-ST Joint Lab - 20 years of joint projects

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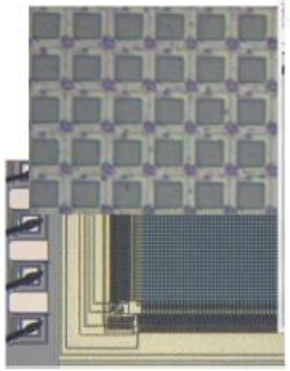
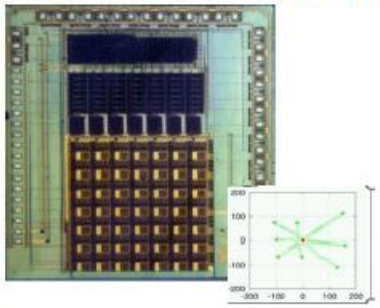
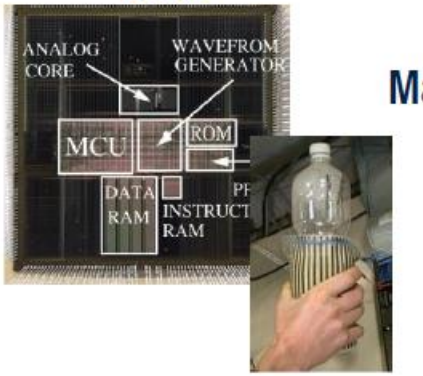
CMOS touch-pointer capacitive sensor
1998

Textile capacitive pressure sensor
2002

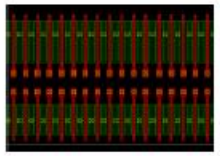
CMOS Camera
1995



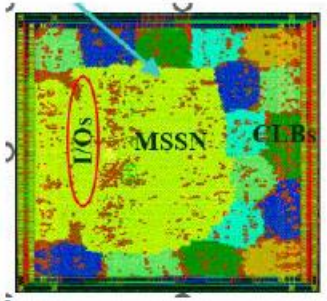




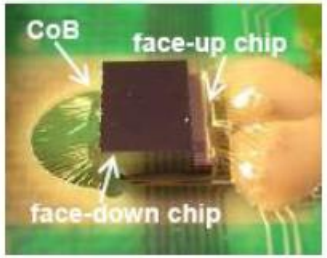
Mask Programmable ECO
2008

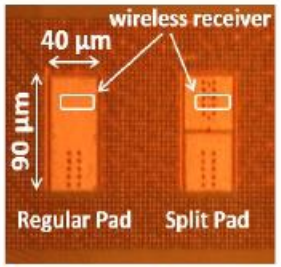


Embedded FPGA
2015



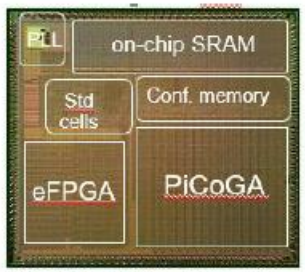
3D Capacitive coupling
chip to chip communication
2008-2013





Wireless Probing
2013

Reconfigurable Computing
2001-2005



Fingerprint capacitive sensor
1996

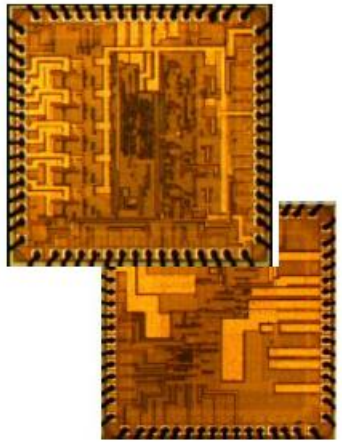
1990 2000 2010 2015

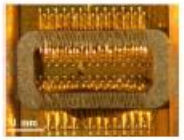
ARCES-ST Joint Lab - 20 years of joint projects

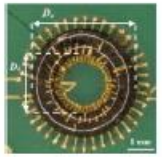
life.augmented

Nano power conversion
Energy Harvesting

2013-2016







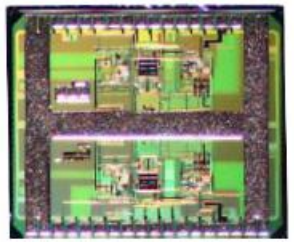
2015

Energy Autonomous wireless IoT sensor node

2016

Hall current Sensor

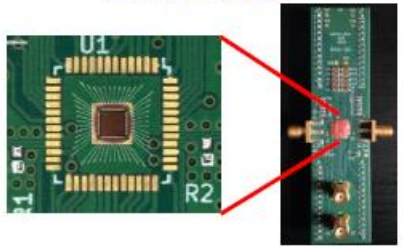
2018-2023



2020

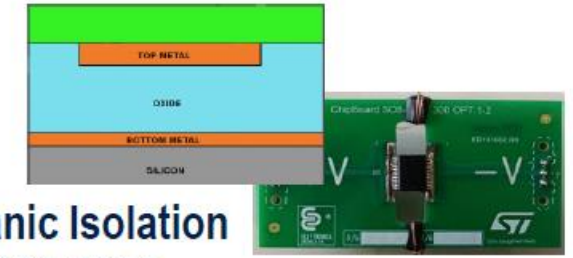
Wake up radio

2019-2023

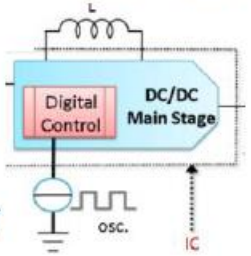


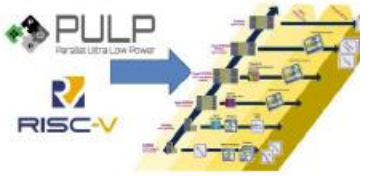
Galvanic Isolation

2021-2023

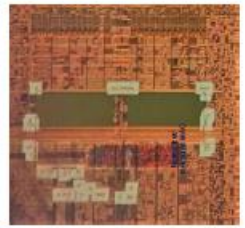


DC/DC
power converter
2023





Analog In-memory Computing
based on PCM
2021-2023



RISC-V Vector
Processor
2022-2023

2023

Joint Lab ARCES-RFI

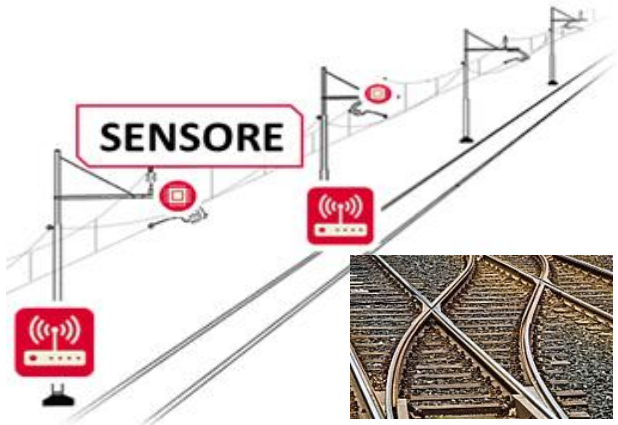
Mission: Support rail traffic safety by defining and measuring in real time dynamic performance indicators

Features:

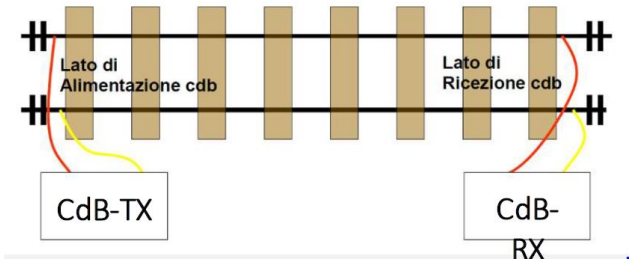
- interdisciplinary research and design of embedded systems
- acquisition of critical systems expertise and design of safety architectures
- development of “beyond state-of-the-art” demonstrators to be validated in the field, in a protected environment

Focus on:

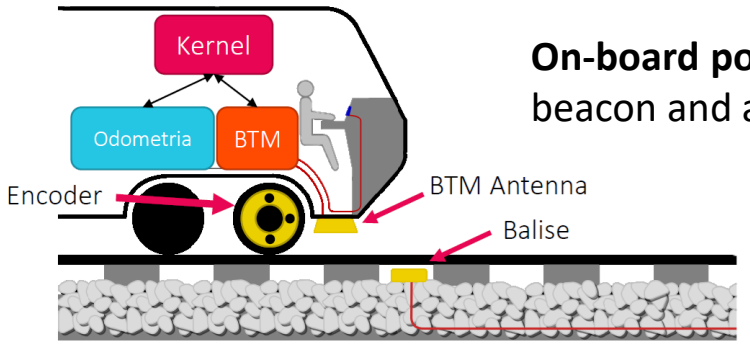
- Vibration analysis and anomaly detection with advanced MEMS sensors
- Electromagnetic simulation and Wireless Power Transfer system design
- SoC based design & Signal Processing



Monitoring and aging evaluation of overhead lines and railway switches: sensing, data collection, edge and cloud processing



Audiofrequency based track circuits: modeling and system design



On-board positioning: electronic beacon and advanced odometry

Joint Lab ARCES-RFI

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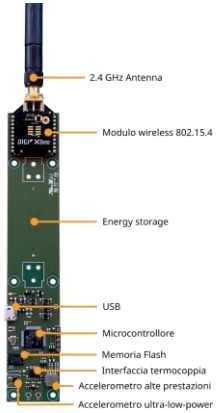
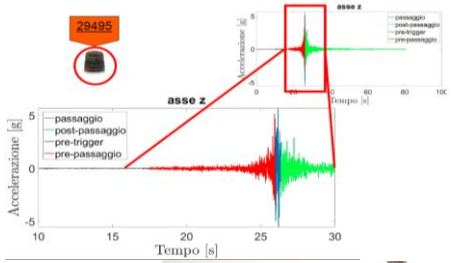
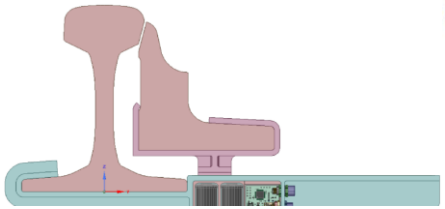
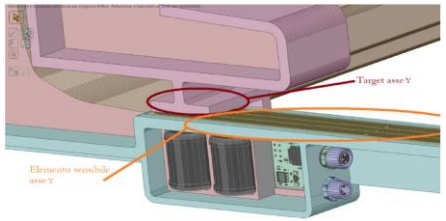
Monitoring of overhead power lines

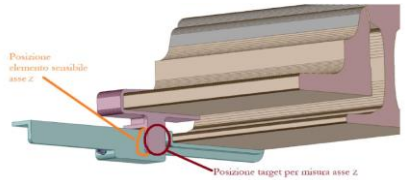


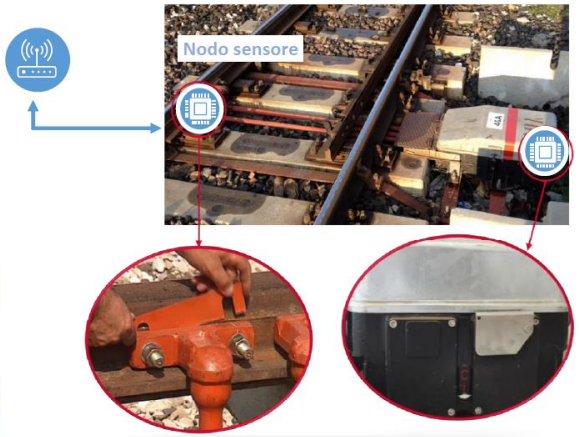


Monitoring and aging evaluation of railway switches

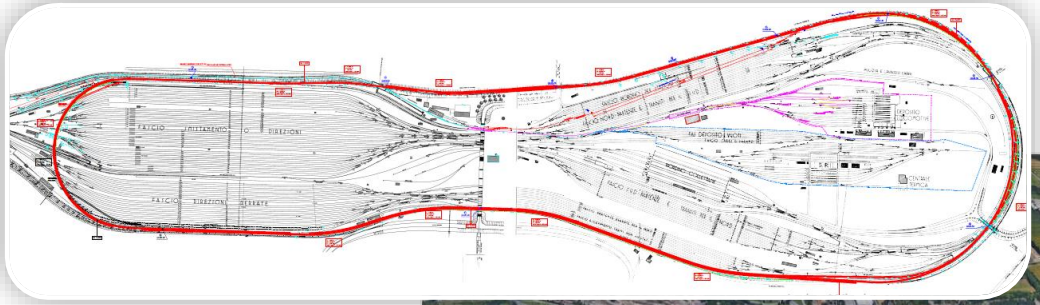


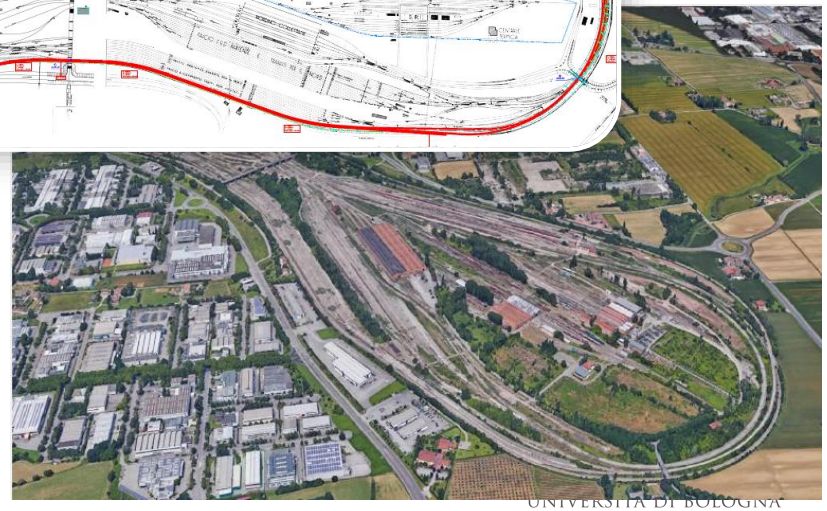






Test circuit in Bologna





Joint Lab ARCES-RFI

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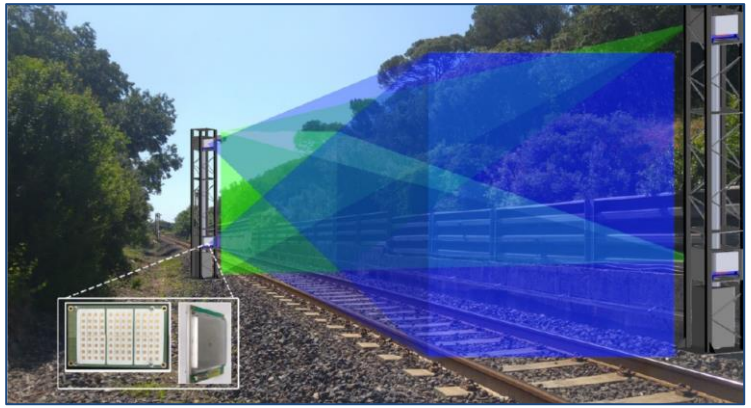
Development and testing of innovative technologies



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