SUSTAINABLE PLACES 2024

LUXEMBOURG INSTITUTE OF SCIENCE AND TECHNOLOGY | LIST

R2M RESEARCH TO MARKET SOLUTION

WORKSHOP

Integrating Environmental Considerations in Next-Generation Mobile Networks

SEPTEMBER 23-25, 2024 *Luxembourg*

Towards Sustainable 6G mobile networks

6G TWIN | BEGREEN | Coalesce | IN2CCAM | CENTRIC | 6Green | ZEROSWARM | 6G4SOCIETY

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6G, you said?

6G, you said?

ERICSSON

NOKIA

Figure 9: Global mobile network data traffic

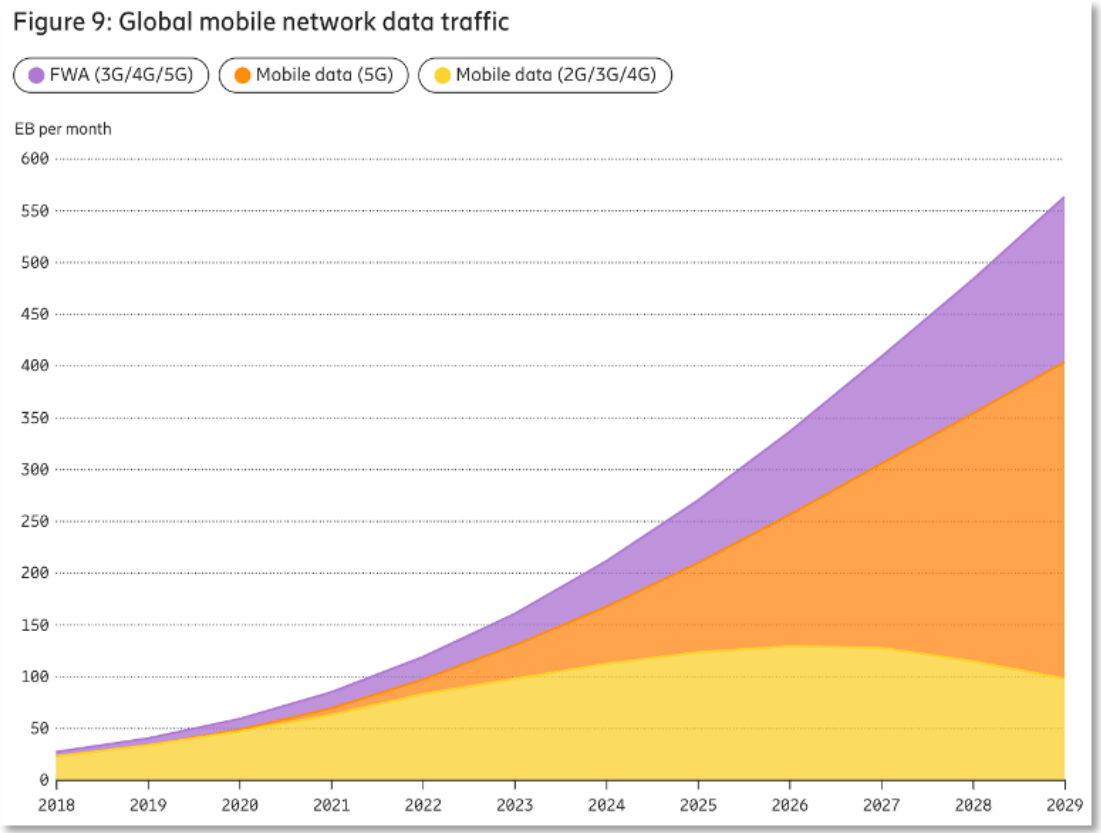
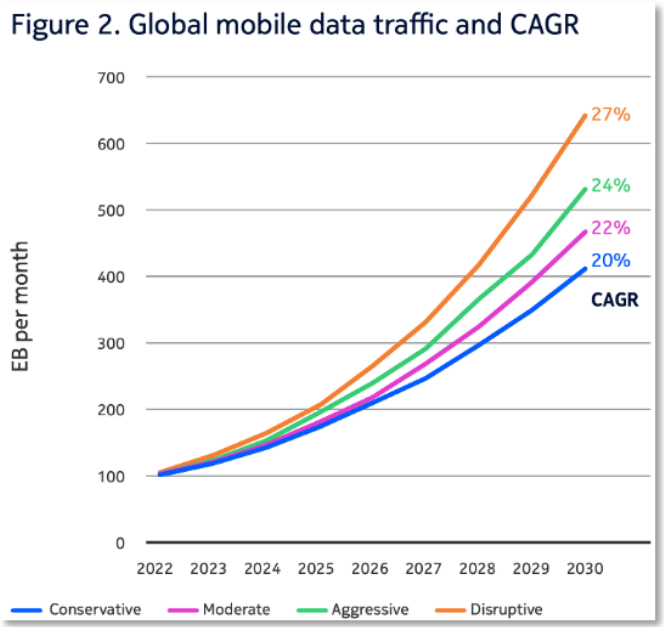
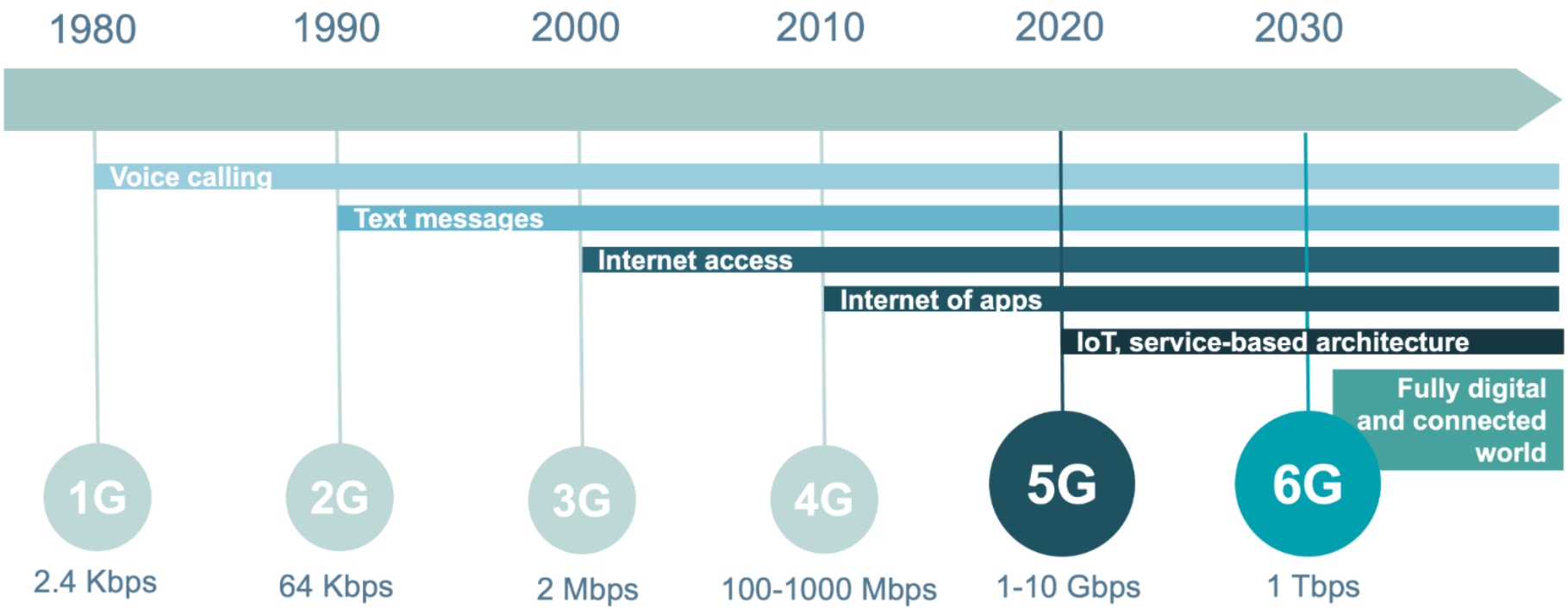


Figure 2. Global mobile data traffic and CAGR



6G, you said?


1980
1990
2000
2010
2020
2030
Voice calling
Text messages
Internet access
Internet of apps
IoT, service-based architecture
Fully digital and connected world
1G
2G
3G
4G
5G
6G
2.4 Kbps
64 Kbps
2 Mbps
100-1000 Mbps
1-10 Gbps
1 Tbps

Toward Sustainable 6G networks

14:00 - 14:10 | Opening Remarks | **Sébastien Faye, LIST**
14:10 - 14:15 | **6G4SOCIETY** | **Dr Monique Calisti, Martel Innovate**
14:15 - 14:20 | **6Green** | **Chiara Lombardo – Cnit And University Of Genoa**
14:20 - 14:25 | **BeGreen** | **Simon Pryor, Accelleran**
14:25 - 14:30 | **CENTRIC** | **Francesco Malandrino, CNR**
14:30 - 14:35 | **Coalesce** | **Dr. Indrakshi Dey, Walton Institute**
14:35 - 14:40 | **IN2CCAM** | **Maria Pia Fanti, Polytechnic University of Bari**
14:40 - 14:45 | **ZeroSwarm** | **Pouria Khodashenas, Huawei**
14:45 - 14:50 | **6G-TWIN** | **Sébastien Faye, LIST**
14:50 - 15:20 | Q&A / Networking | **Régis Decorme, R2M Solution**
15:20 - 15:30 | Closing Remarks

Towards a Sustainable and Accepted 6G for Society

Dr Monique Calisti (Project Coordinator)

CEO, Martel Innovate

13.09.24

Co-funded by the European Union

Project funded by

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
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Swiss Confederation

Federal Department of Economic Affairs, Education and Research EAER
State Secretariat for Education, Research and Innovation SERI

6G4Society
Towards a sustainable and accepted 6G for Society
Grant Agreement no 101139070

6G4SOCIETY

6G4SOCIETY is an SNS JU project at work to ensure that **societal, environmental and economic values** are embedded into the design, development and adoption of **6G**, bringing a **sustainability perspective** to technological development.

- ➔ A Coordination and Support Action - **Jan 2024/Dec 2025**
- ➔ **6 Partners** from 6 Different countries

MARTEL innovate

CyberEthicsLab.

NOVA

PSCEurope Public Safety Communication Europe

eBOS Engineered for Excellence Driven by Passion for Innovation

DIGITAL FOR PLANET

6G4SOCIETY OBJECTIVES

1

Generating a **better understanding and shared knowledge** on the aspects influencing public acceptance of 6G technologies

2

Supporting the conception and development of a unified EU consensus framework on a **value-based, sustainable and ethics-driven** approach towards 6G, and to support its promotion through the 6G EU and global standard-setting process

3

Engaging and reaching out to public audience to help **build 6G awareness and social acceptance**

4

Empowering the 6G community on how to **reflect EU policy and legislation into technology solutions** for future networks' development and services

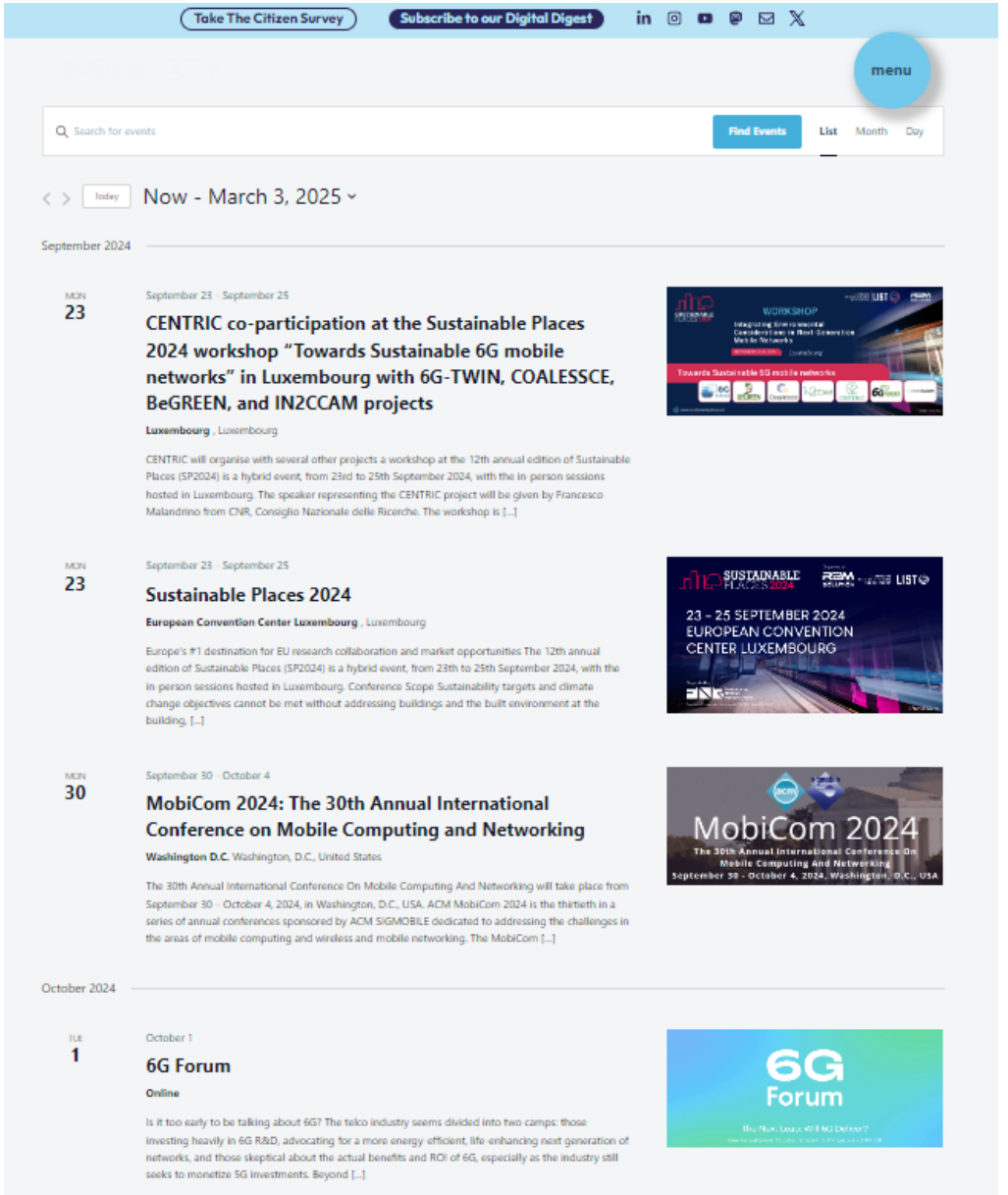
THE 6G4SOCIETY SCOPE

- Generating a better understanding of aspects influencing public acceptance of 6G technologies
- Supporting the conception and development of **a unified consensus framework on a value-based, sustainable and ethics-driven approach**
- Engaging and reaching out to public audience to build **social acceptance**
- Definition of a **Technology Acceptance Model** for 6G
- Definition and promotion of a common **Set of Key Value Indicators** (KVIs)
- Definition and promotion of a common **Set of Key Sustainability Indicators** (KSIs)
- Empowering the 6G community on how to reflect EU policy and legislation into technology solutions for future networks' development and services
- Contribution to **policy and standardisation** at global level

UPCOMING WEBINARS

Next Workshop in collaboration with HEXA-X II (06 Nov 2024):
Goals: Present lessons learnt and the potential identified so far f
the integration of social sustainability and social acceptance into the development of 6G and foster a discussion on how to integrate it into future projects

- ***From KVIs to KSIs - Aligning across the SNS JU projects*** *Oct 2024 (second half)*
- ***Green next generation networks: sustainability challenges and initiatives in mobile networks*** *- Nov 2024 (second half)*
- Roadmap webinar series: ***Ecological sustainability, reusability, resource reduction, CO2 footprint*** *- December 2024 (tbc)*
- Roadmap webinar series: ***Equity, Diversion and Inclusion of 6G*** *- January 2025 (tbc)*
- KSI roadmap webinar series: ***Trustworthy and Privacy-preserving networks*** - February *2025 (tbc)*



CITIZEN SURVEY

The insights from the survey will feed into the Social Acceptance Model and help refine further policy development for sustainable and human-centric 6G.

Scan the QR code and let your voice heard!

THANK YOU

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The 6G4Society project received funding from the European Union's Horizon Europe Research and Innovation Programme under Grant Agreement No 101139070.

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Swiss Confederation

Federal Department of Economic Affairs, Education and Research EAER
State Secretariat for Education, Research and Innovation SERI

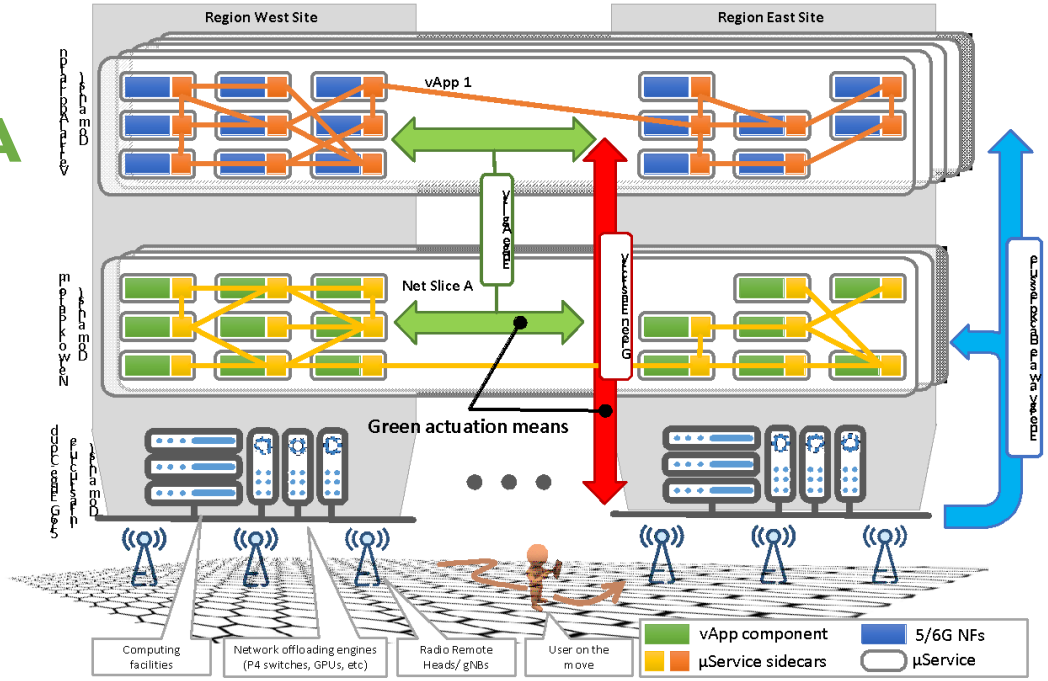
6GREEN - GREEN TECHNOLOGIES FOR 5/6G SERVICE-BASED ARCHITECTURES

CHIARA LOMBARDO – CNIT AND UNIVERSITY OF GENOA

TOWARDS SUSTAINABLE 6G MOBILE NETWORKS – 25TH SEPTEMBER 2024

THE 6GREEN PROJECT

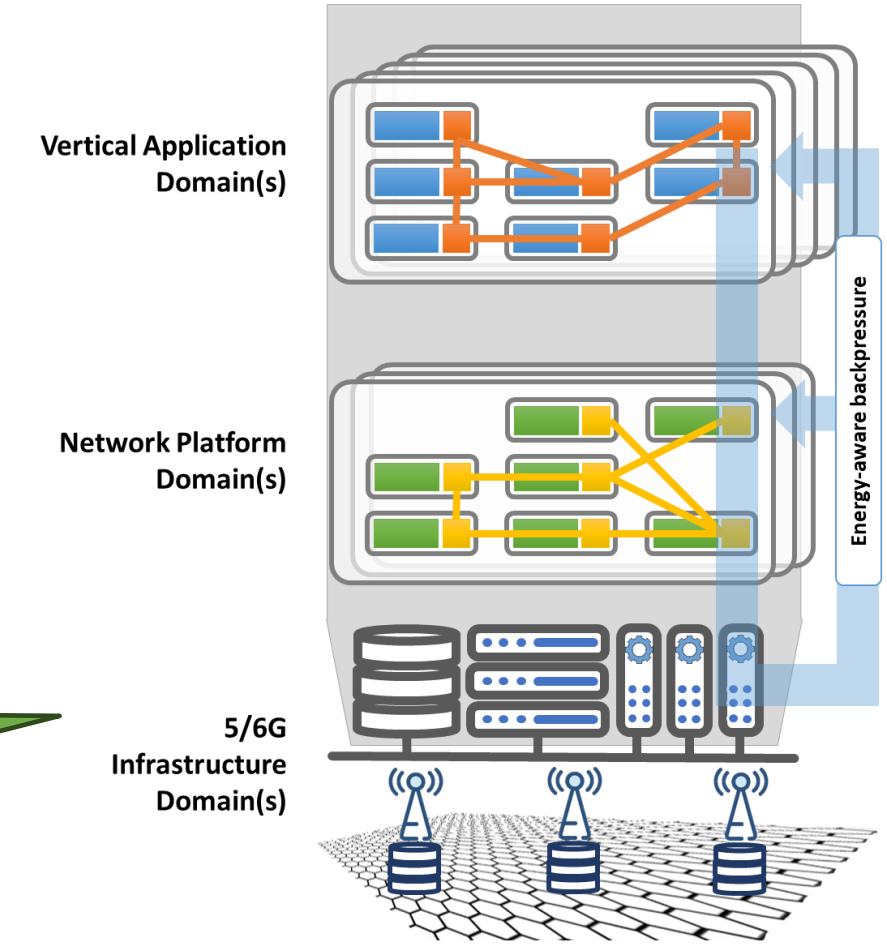
- Objective: **promote energy efficiency** across the whole **5/6G value-chain** and enable **5/6G networks and vertical applications** to reduce their carbon footprint by a factor of 10 or more.
- How? Exploit and extend state-of-the-art **cloud-native technologies and the B5G SBA** with new cross-domain enablers to:
  - boost the global ecosystem flexibility, scalability and sustainability
  - enable all the 5/6G stakeholders reducing their carbon footprint by becoming integral parts of a win-win green-economy business.

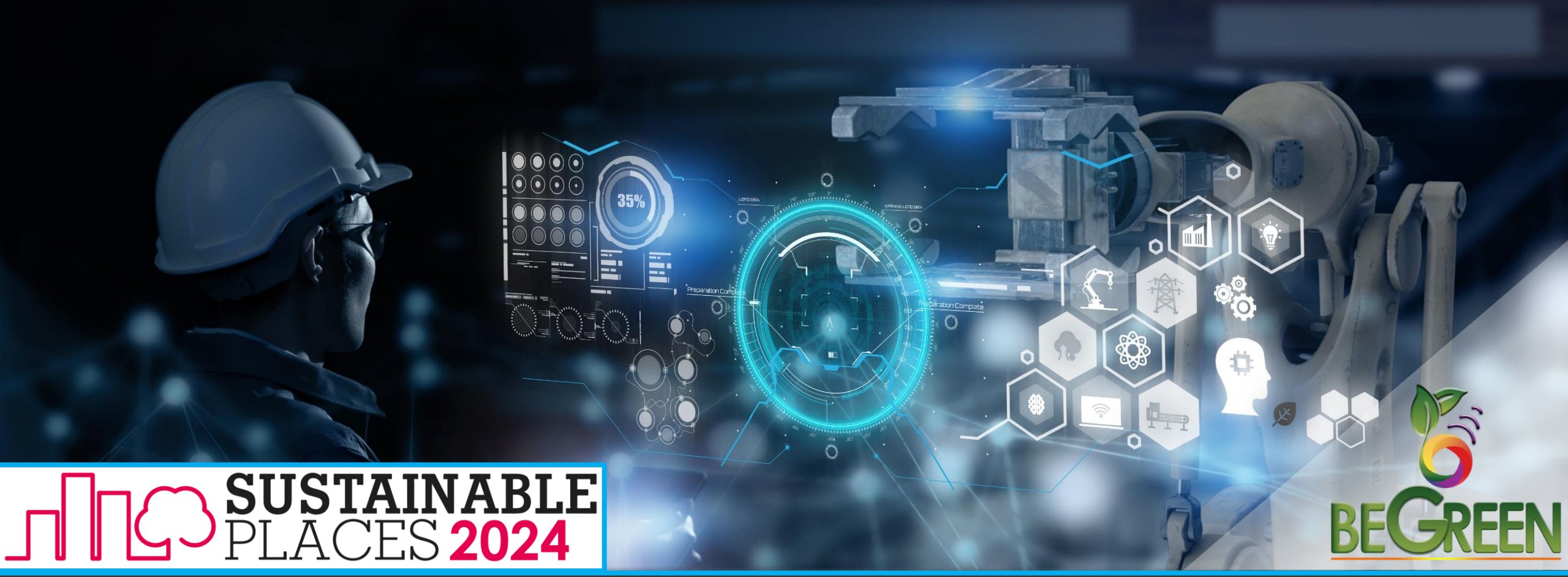


ENERGY-AWARE BACKPRESSURE

- A set of **cross-domain observability** mechanisms and **analytics** to evaluate the energy and the carbon footprint that a vertical application, a slice, or the overall 5/6G network **induce onto the edge-cloud infrastructure**.
- Suitably **process, infer, and expose** this information at both the 5/6G SBA and vertical application (and their network slices) levels thanks to an extended SBA.
- **Win-win-business models** to promot
  sustainable behaviors in the sc
  Decarbonization L

Challenge: let the market self-regulate or have regulation bodies enforce DLAs?





SUSTAINABLE PLACES 2024

BeGREEN

SP24: Towards Sustainable 6G Mobile Networks

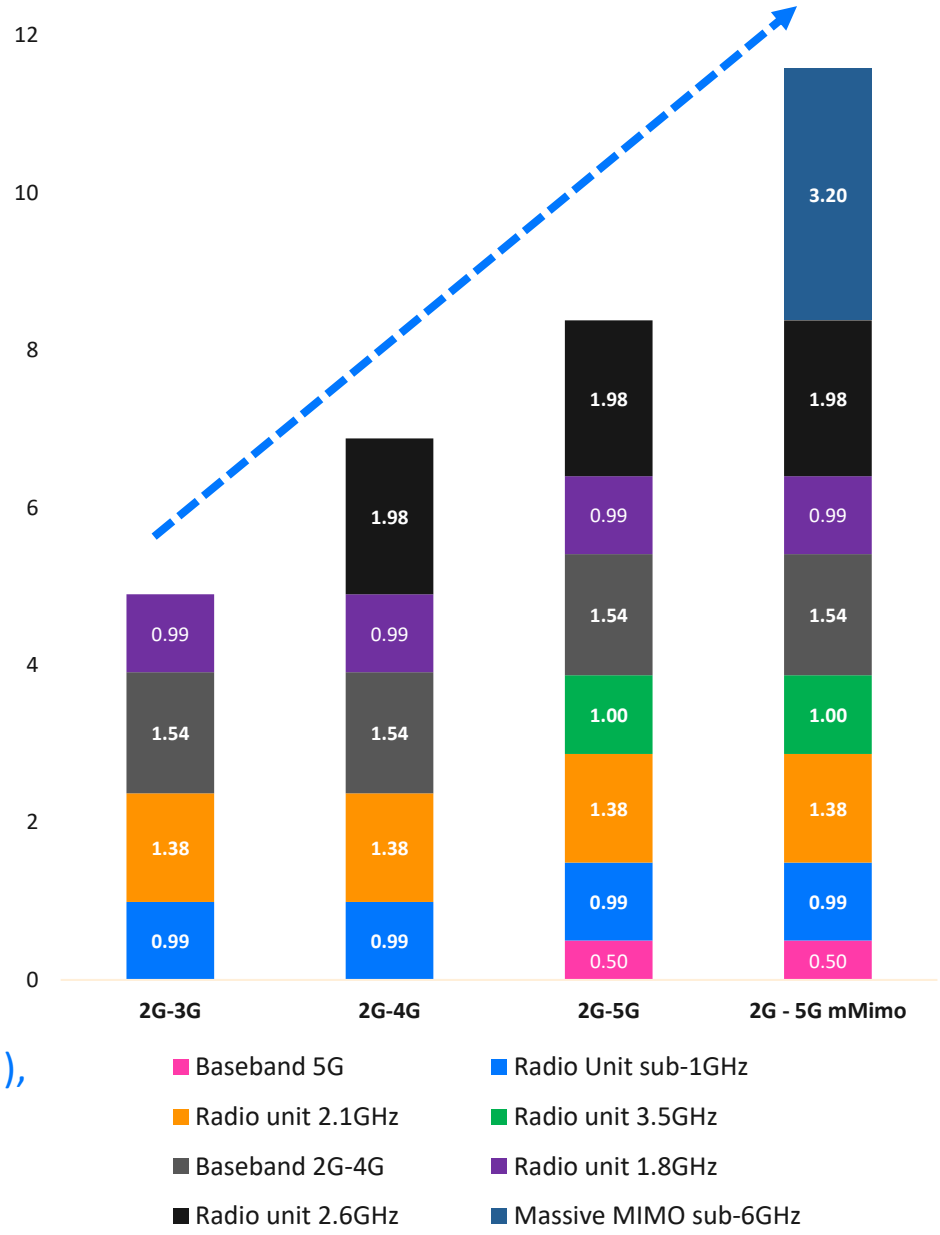
BeGREEN: Simon Pryor, Accelleran (BeGREEN coordinator)

www.accelleran.com
info@accelleran.com

Accelleran

Why save energy in 5G?

- Mobile networks have a global impact
  - ICT consumes **4-9%** of global electricity, contributing **1.4%** of greenhouse gases (2020)
  - Mobile networks drive **18%** of ICT energy use (0.7% globally)
- It's a big cost for mobile operators (MNOs)
  - Power represents **20-40%** of operating costs
  - Pressure on operators to cut costs as margins shrink
- 5G is more energy efficient than 3G/4G, but…
  - 5G is 90% more efficient than 4G, 10-15x more than 2G/3G (watt per bit)
  - Yet, 5G uses 140% more energy than 4G due to higher frequencies and more devices
  - Even as 2G/3G phases out, every "G" consumes power
- UN SDG net-zero by 2050, 45% reduction in carbon emissions by 2030
- Next phase of 5G->6G increasingly adds Private 5G (NPN), beyond Public 5G (PLMN), more networks, more devices, more energy consumption



Source: Analysys Mason

Beyond Public 5G & Smartphones: Private 5G Use Cases

Construction Sites

Ubiquitous connectivity for people and equipment

Transport & Logistics

Reliable connectivity for fluent operations

Offshore

Connecting people and infrastructure in no-coverage areas

Sports & Event Venues

Assured communications for staff and terminals during mass events / sports games

Enterprise

Secure and guaranteed network for critical communications

Hospitals

Single device for personal and professional communications

Manufacturing

Secure, low latency, guaranteed network for mission critical communications

Education

Single device, managed campus networks

Retail

Flawless connectivity for point-of-sales and payment terminals

Government

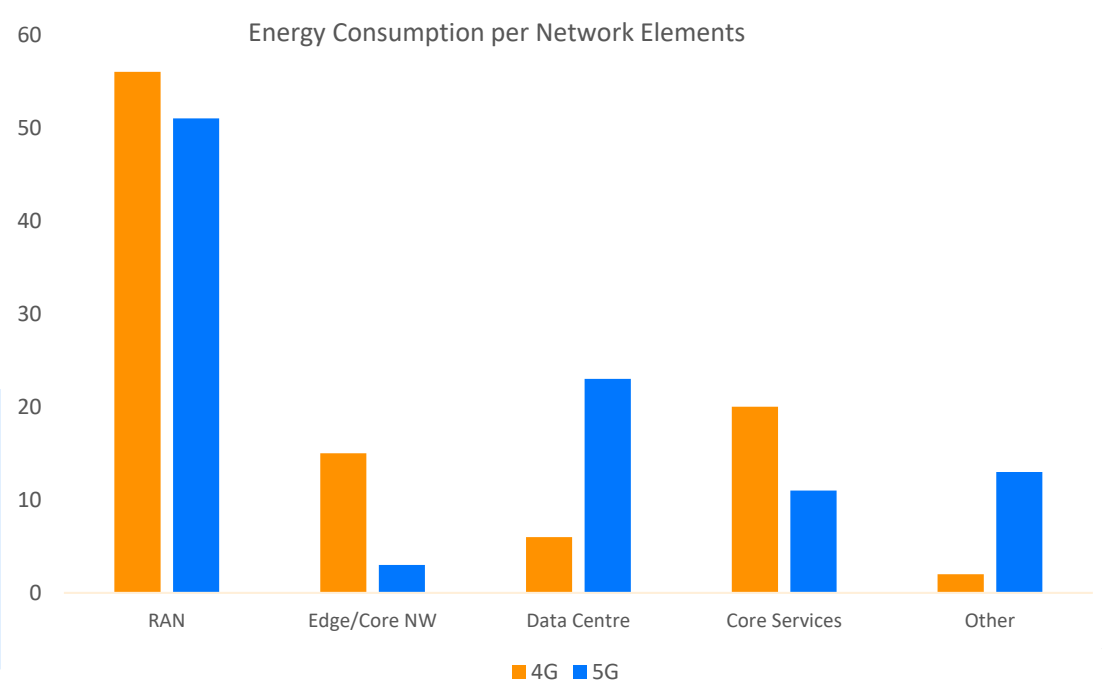
Secure comms for confidential operations

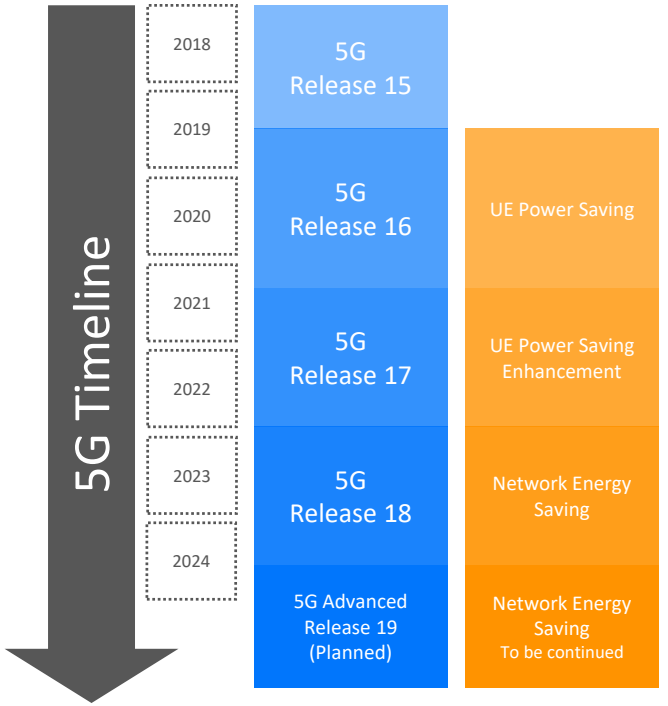
Motivation for BeGREEN

- The majority of 5G's energy use comes from Radio Access Networks (RAN)
- Ongoing efforts in 3GPP standards and the industry are **pushing for greater energy efficiency**
- But we must go further— **we owe it to ourselves and our planet**
- Together, we knew we could do better
- And we did—partnership of vendors (big & small), operators, and academia

BEGREEN

Accelleran, GigaSys Solutions, i2cat, iHP, arm, Telefónica, BT, NEC, Parallel Wireless, UPC, KunEL





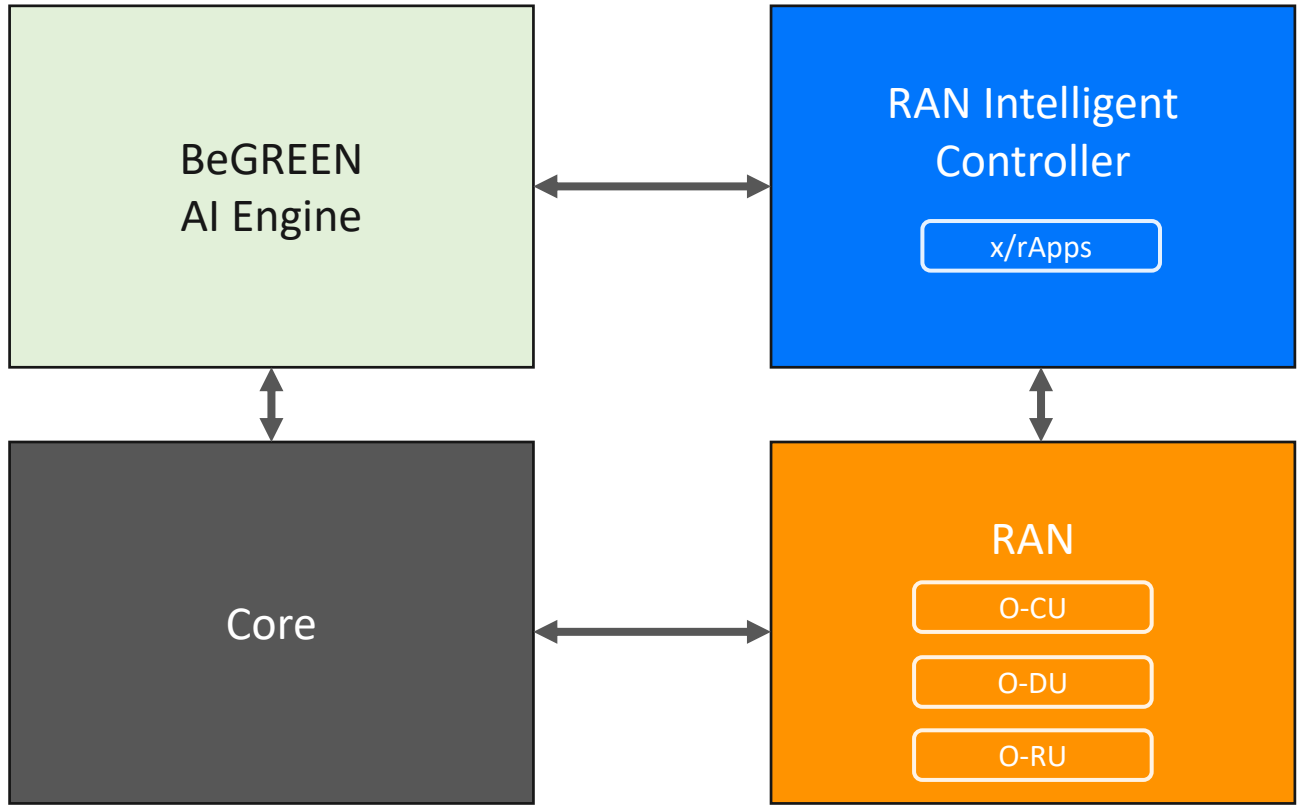
What does BeGREEN do?

Our Focus: The RAN

- **The Radio Access Network (RAN) is where most energy consumption happens**
- **There's no single solution—we're improving multiple components, from AI/ML innovations to Open RAN adoption**

Part of Horizon Europe, SNS (Smart Networks & Services)
Started Jan 2023, end next June.

See our results:
https://www.sns-begreen.com/



www.accelleran.com
info@accelleran.com

BeGREEN is supported by the Smart Networks and Services Joint Undertaking (SNS JU) under the European Union's Horizon Europe research and innovation programme under Grant Agreement N° 101097083. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or SNS-JU. Neither the European Union nor the granting authority can be held responsible for them.

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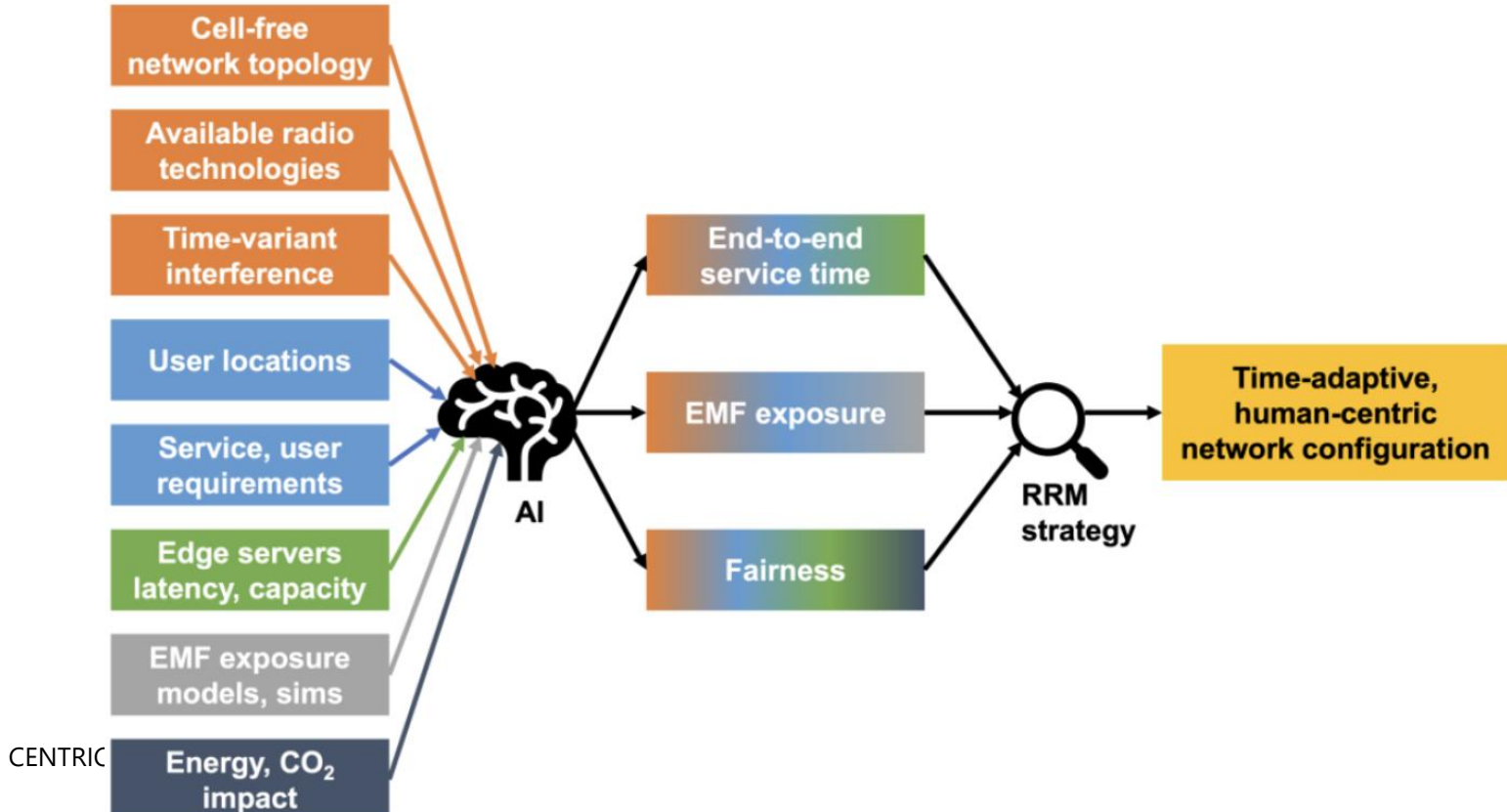
The CENTRIC SNS project

High-level goal and vision

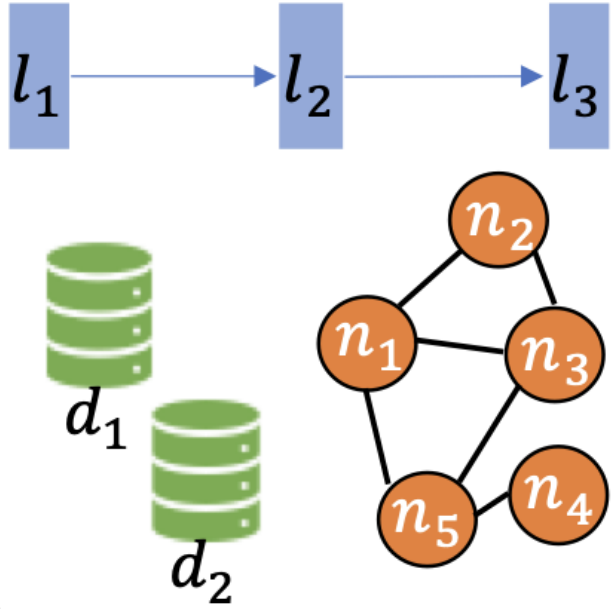
- Leverage Artificial Intelligence (AI) techniques to improve wireless connectivity
- Start from user- and application-specific requirements
- Develop tailor-made waveforms, transceivers, protocols and resource management procedures
- Vision: AI-based air interface (AI-AI)
- Human-centric approach,
  including a focus on sustaibability
- Energy, CO2, fairness,
  quantity of information,
  EMF exposure*
- All integrated into
  the resource management problem
- As objectives rather than constraints!

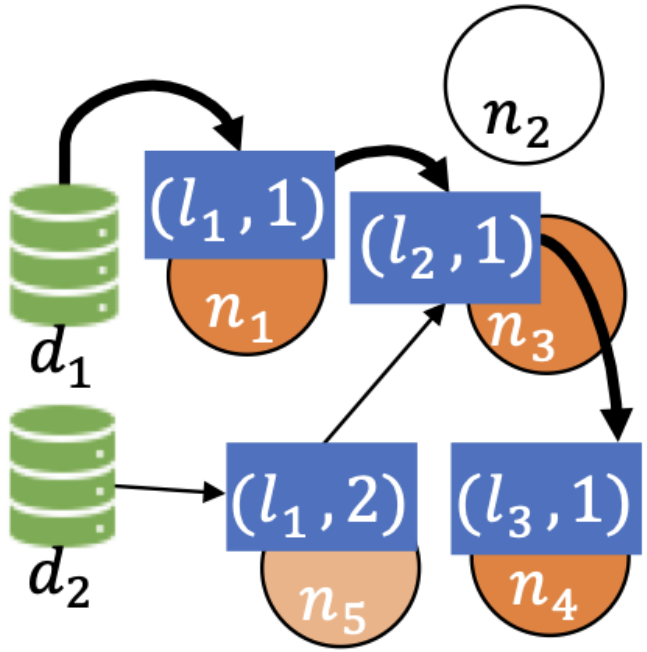


Data, models, nodes: mutual adaptation

Exploit the flexibility of edge-based processing

- Lots of learning happening in next-generation networks
- Three main ingredients
  - Data sources
  - ML models (and layers of DNNs)
  - Physical nodes (with CPUs, GPUs…)
- Flexible, mix-and-match relationship
  - E.g., “the best data for the best model that I can run with my resources”
- What is the “best” model?
- Learning is a tool!
  - Accuracy is not a KPI target *per se*
  - Minimize learning cost, subject to decision quality thresholds *and deadlines*!





WALTON Institute for Information and Communication Systems Science

SETU Ollscoil Teicneolaíochta an Oirdheiscirt South East Technological University

Joint Optimization of Data and Energy Networks for digitizing Sustainable Communities

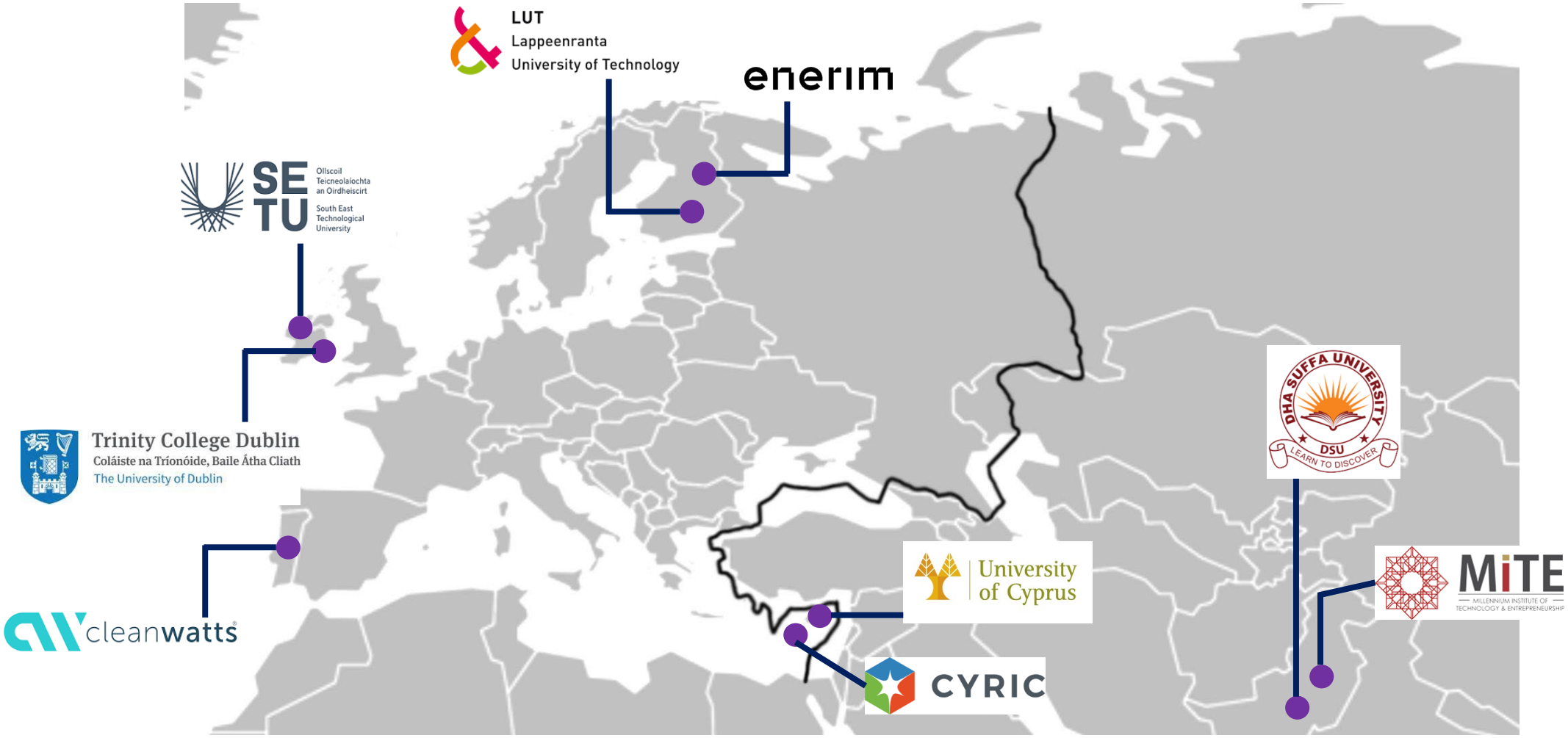
COALESCE

Dr. Indrakshi Dey (Project Coordinator)

Head-of-Division (Programmable Autonomous Systems), Walton Institute

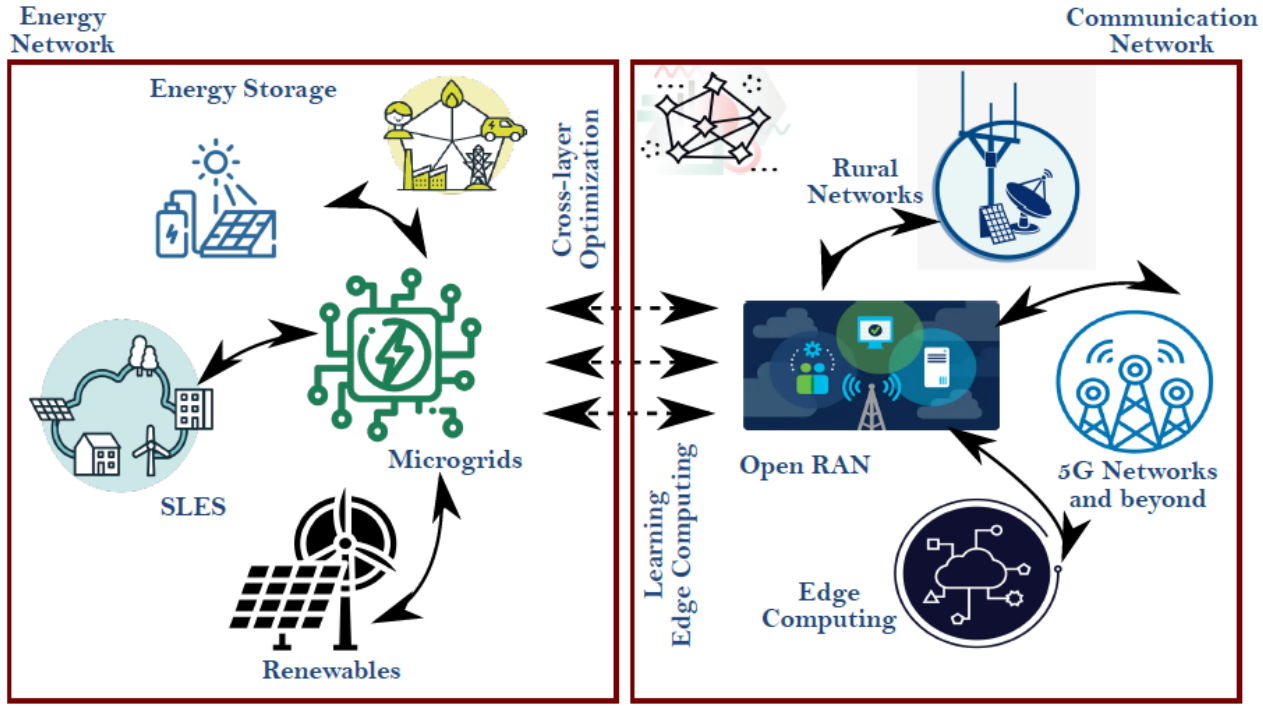
Funded by the European Union under HORIZON-MSCA-SE Project reference number: 101130739

Consortium Structure



Main Concept

The mission of COALESCE is to design and develop a cross-optimization platform that can jointly address challenges in deploying future green communication networks and microgrid infrastructures supplied by renewables through a multidisciplinary, inter-sectoral and international Staff Exchange network. In the process, researchers involved in COALESCE will be equipped with skills and expertise to address challenges related to energy requirements and energy cost of computing, processing and communications within future generations of data networks, via data-driven operation of energy systems run on renewables.



Funded by the European Union under HORIZON-MSCA-SE Project reference number: 101130739

Objectives

O1 : To develop energy-efficient ICT networks and computing architectures for microgrids and a new holistic framework considering the intrinsic relation between data and energy processes.

O2 : To foster renewable energy provisioning by managing energy assets and demand of flexible computational tasks in the data and telecom networks and to optimize connectivity, data sharing and resource access for microgrids.

O3 : To deploy, assess, and validate solutions against use cases

Funded by the European Union under HORIZON-MSCA-SE Project reference number: 101130739

COALESCE Use-cases

SWIPT in microgrids enabling WSNs

A group of metrics and optimization algorithms for energy efficiency with SWIPT and microgrid self-sustainable operation, capable of analysing the trade-off between energy consumption and energy harvesting capacity of a network.

In-building Energy Asset Management

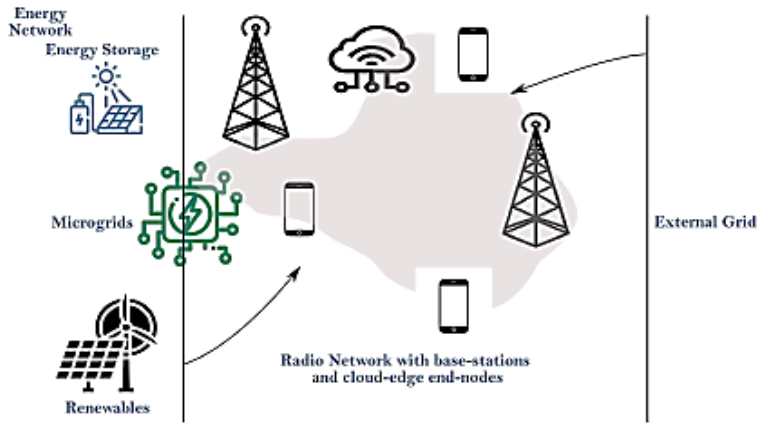
A framework that can predict optimization strategies and be robust to the integration of multiple assets and asset-class optimization engines using neural networks and federated transfer learning-based models.

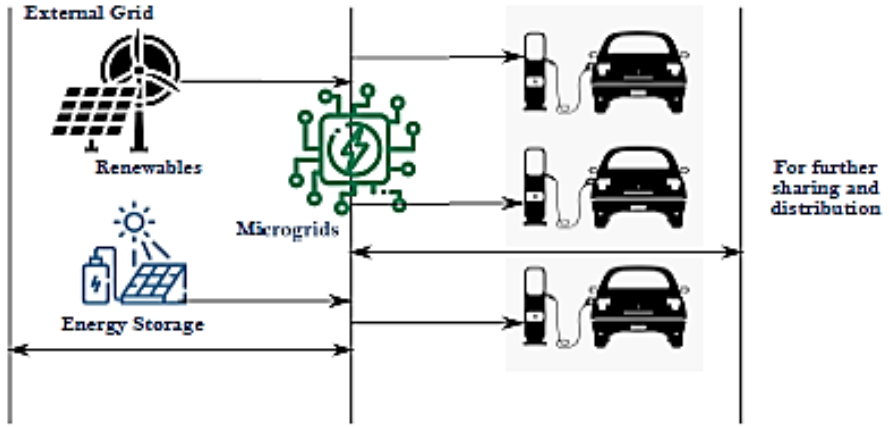
Energy-efficient 5G/6G RAN

Novel set of methodologies for the characterization of real RANs' energy consumption and open data sets for analysis, parametric models of energy consumption transfer function for uplink and downlink, and generative neural network models of the energy transfer function.

Collaborative e-transportation and SLES

Joint data-energy-transportation robust/stochastic optimization algorithms considering computational load flexibility, intermittent energy generation, energy storage mobility, and multi-agent reinforcement learning algorithms for consolidated expansion planning, operation, and scheduling of collaborative e-transportation and SLES.





WALTON Institute for Information and Communication Systems Science

Joint Optimization of Data and Energy Networks for digitizing Sustainable Communities
Funded by the European Union under HORIZON-MSCA-SE Project reference number: 101130739

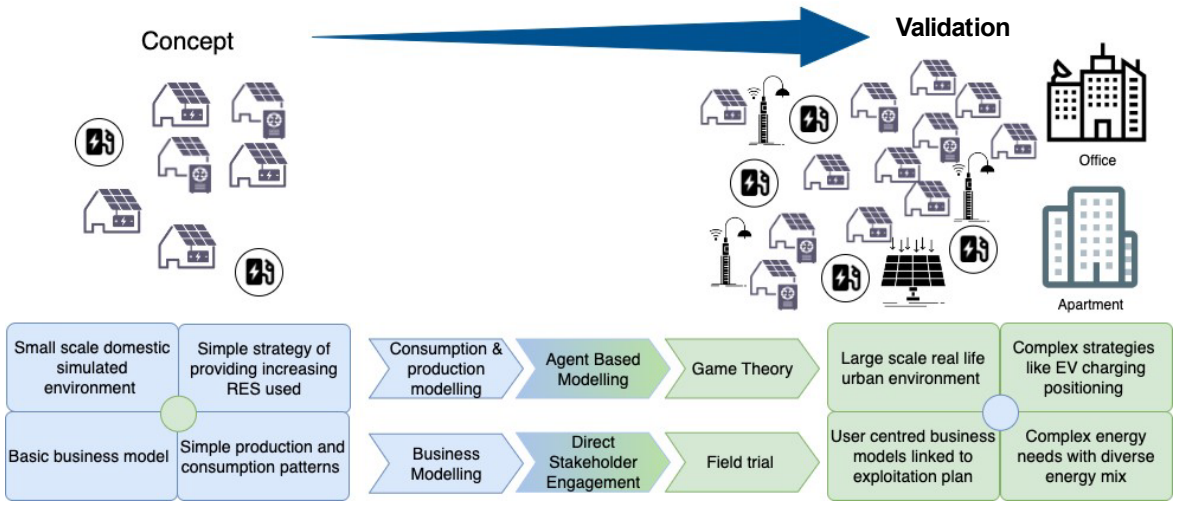
Validation Strategy

Step 1: The first step will focus on the gathering of the requirements that will be needed to realise the use cases and strategies.

Step 2. The goal of the next step is to develop demonstrations targeted at stakeholders and will be utilized in terms of providing exploitable outputs for the non-academic partners, while also providing feedback to the technical work-packages in an iterative way.

Step 3: The aim of the final step is to maximize the impact of the work on society and to maximize the future potential of the work towards generating new corporate and social impacts.

COALESCE validation strategy is built on an iterative model so that, there is ample flexibility built into the work plan to align changing environmental and social factors and shifting market trends and policies.



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https://www.youtube.com/@Coalesce-Horizon

https://twitter.com/CoalesceHorizon

https://coalesce-horizon.eu/

Thank you for your time.

Any questions?

Indrakshi Dey

Indrakshi.dey@waltoninstitute.ie

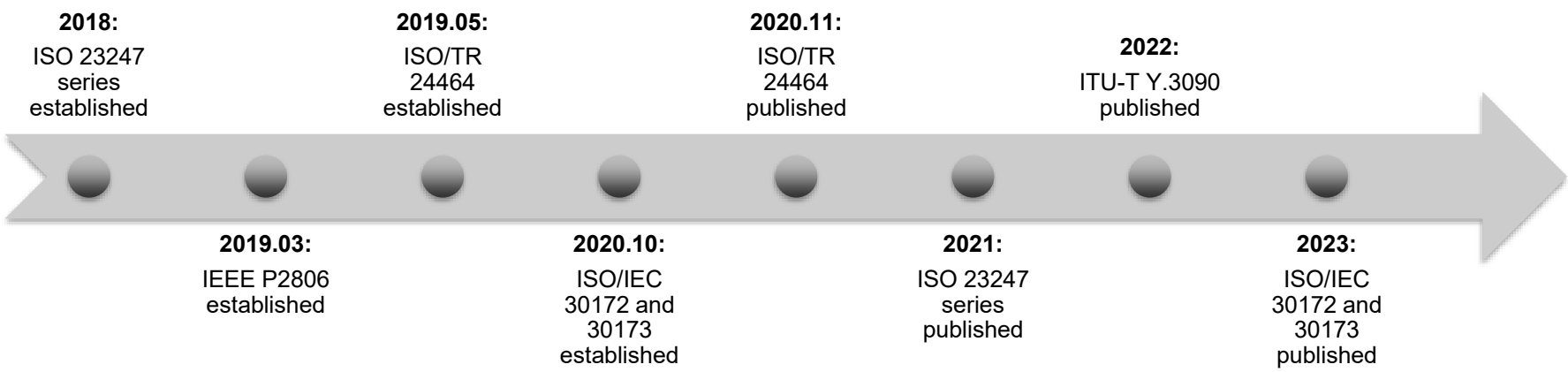
Funded by the European Union under HORIZON-MSCA-SE Project reference number: 101130739

Integrating Network Digital Twinning into Future AI-based 6G Systems

Co-funded by the European Union

6GSNS

Background on Digital Twin (DT)



- **ISO 23247:** "Digital Twin Framework for Manufacturing"
- **IEEE P2806:** "System Architecture of Digital Representation for Physical Objects in Factory Environments"
- **ISO/TR 24464:** "Automation systems and integration — Industrial data — Visualization elements of digital twins"
- **ISO/IEC 30172:** "Internet of things (IoT) – Digital twin – Use cases"
- **ISO/IEC 30173:** "Digital twin – Concepts and terminology"
- **ITU-T Y.3090:** "Digital twin network – Requirements and architecture"

Wen Sun, Wenqiang Ma, Yu Zhou, and Yan Zhang, "An Introduction to Digital Twin Standards", GetMobile: Mobile Comp. and Comm. 26, 3 (September 2022), 16–22. https://doi.org/10.1145/3568113.3568119

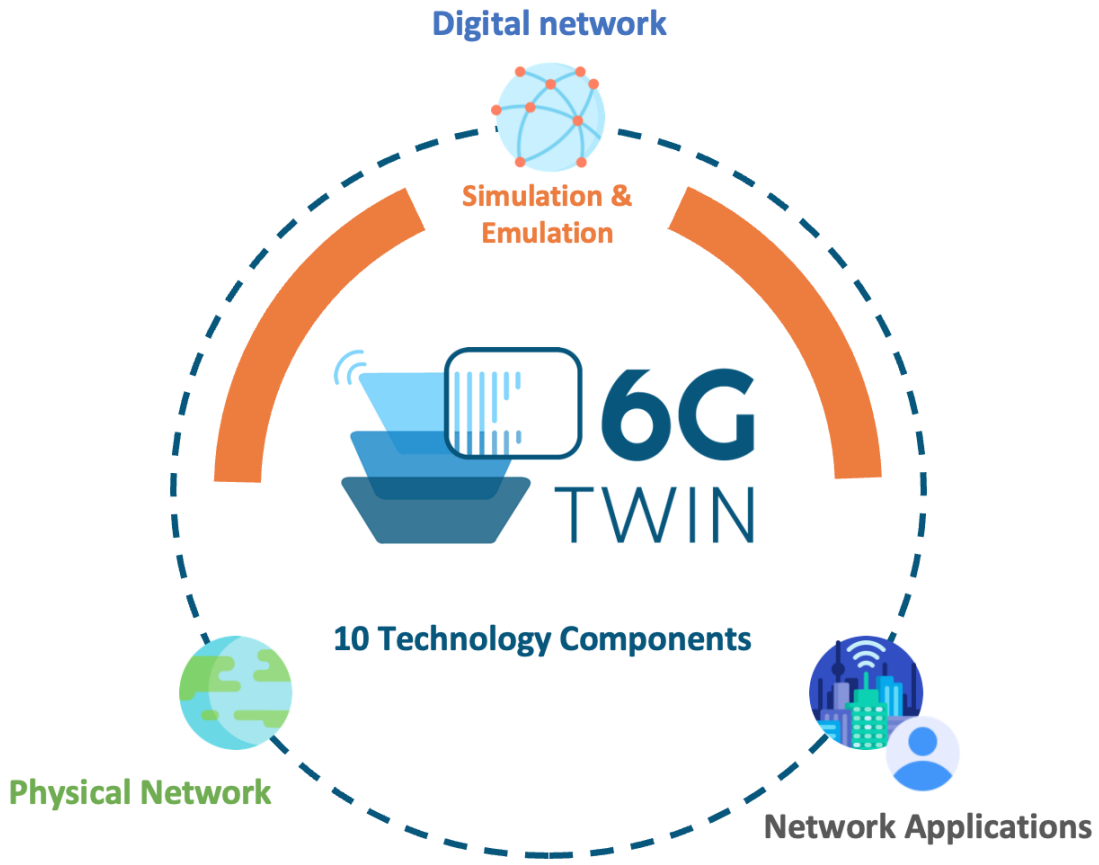
What are the needs?

- Still a long way to go to fully **realise the concept of network digital twin**:
  - Duality between research dreams and industry realities
- Need to demonstrate its application in **tangible use-cases** for future 6G systems
- Need to **integrate properly** this concept with future AI-based architectures.

6G-TWIN's overarching objective

Developing an **AI-native 6G architecture** that **incorporates Network Digital Twins** for:

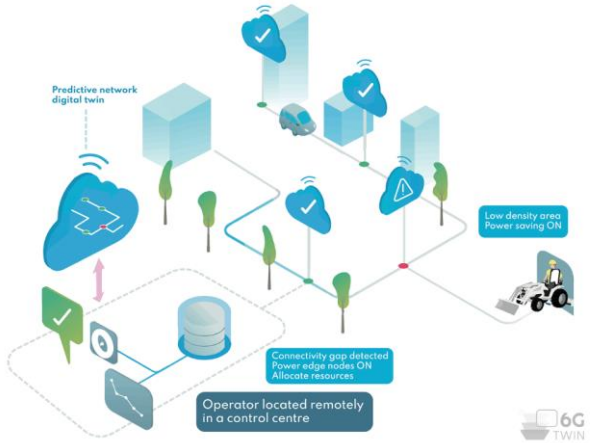
- Network simulation and planning
- Network operation and management
- Data generation by simulation
- AI training and inference
- What-If analysis



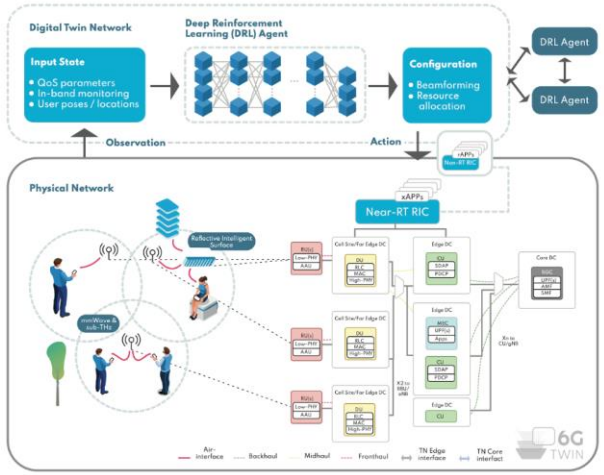
[1] X. Lin, L. Kundu, C. Dick, E. Obiodu, T. Mostak and M. Flaxman, "6G Digital Twin Networks: From Theory to Practice," in IEEE Communications Magazine, vol. 61, no. 11, pp. 72-78, November 2023, doi: 10.1109/MCOM.001.2200830.

6G-TWIN's demonstrators

- **Teleoperated driving demonstrator**: NDT solutions allow to **anticipate** (predictive DT) the network behaviour that could face a teleoperated vehicle prior to its departure, to ensure an extreme quality of service and availability of the network resources all along its journey.



- **Energy savings demonstrator**: NDT solutions are used to **adapt** its behaviour in near real time with the objective to optimise the overall, end-to-end energy efficiency of the network (reactive DT).



The consortium

11 partners from 8 Member States or associated Member States

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R2M RESEARCH TO MARKET SOLUTION

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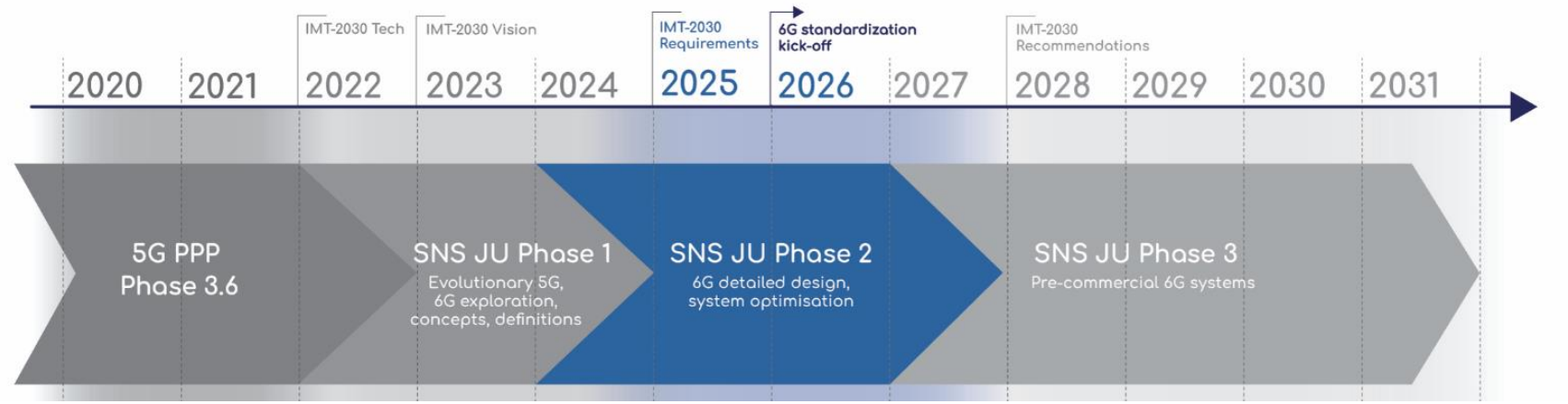
Factsheet & 6G research

- **Duration**: 1 January 2024 – 31 December 2026
- **Budget**: 4.19 millions euros
- SNS JU project portfolio, phase 2, STREAM-B-01-01: **System Architecture**



6g-twin.eu

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Enhancing Integration and Interoperability of CCAM eco-system

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Connected, Cooperative and Automated Mobility

In December 2019, the European Commission announced an ambitious strategy package for Europe to become the world's **first climate-neutral continent by 2050**.

The **Horizon Europe strategic plan 2021-2024** enlightens the research and innovation priorities to support a sustainable recovery and further **accelerating the green and digital transitions**, ultimately **leading to a climate-neutral and green Europe.**

In the mobility sector a basic importance is given to the digitalisation of transport **focusing on automated mobility**.

European Union is placing big effort for accelerating the deployment of **CCAM innovative technologies and services, generated by automation** (**increased safety** and **reduced environmental impact**).

Connected, Cooperative and Automated Mobility

Connected and autonomous vehicle technologies provides an **approach to resolve the traffic problems caused by human-driven vehicles.**

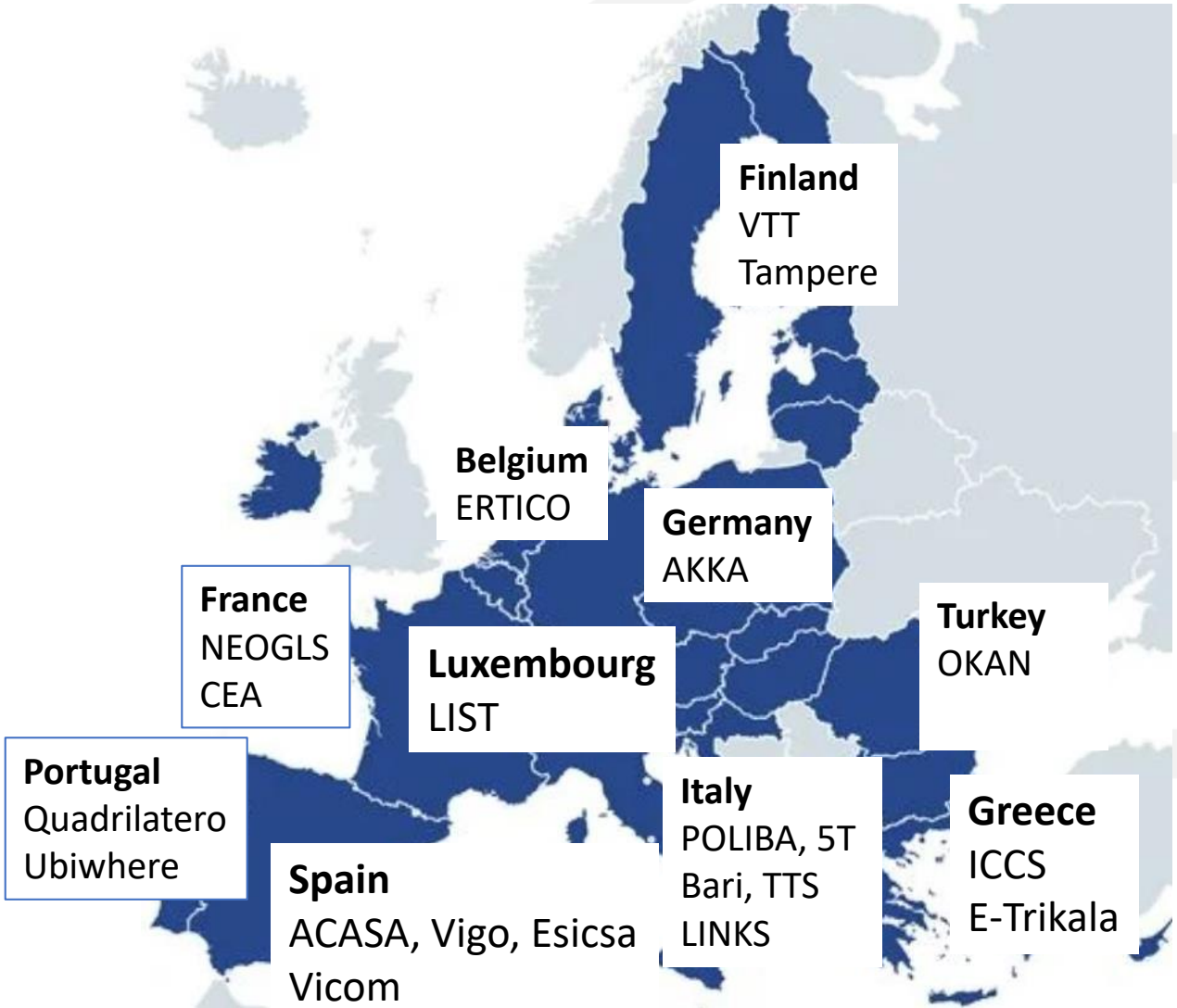
CAVs are able to **reduce crash risk, traffic delay, and energy consumption.**

100 % of vehicles being CAVs on road will not occur in the near future, it is estimated that CAV penetration rate would not **exceed 90 % before 2045**.

A transition period where HVs share the road network with CAVs is inevitable

It is essential to **develop traffic management strategies** for mixed traffic environments

IN2CCAM at a glance



Call identifier: Horizon-CL5-2022-D6-01

Topic: Horizon-CL5-2022-D6-01-04 “Integrate CCAM services in fleet and traffic management systems (CCAM Partnership)”

EC funding: 4.979.626.00 €

Duration: November 2022– October 2025

21 partners, 10 Countries

Demonstrations in **six living labs:**

4 lead living labs, 2 followers

Strategic Objectives

Objectives

- **develop, implement and demonstrate innovative services for connected and automated vehicles, infrastructures and users**
- **accelerate the implementation of innovative CCAM technologies and systems for passengers and goods**
- **providing benefits to all citizens** by implementing a full integration of CCAM services in the transport system.

Impacts for society

- i) **safety:** reducing the number of road accidents caused by human error
- ii) **environment:** reducing transport emissions and congestion by smoothening traffic flow and avoiding unnecessary trips
- iii) **inclusiveness:** ensuring inclusive mobility and good access for all

The approach is based on the **implementation and integration of enhanced Physical, Digital and Operational Infrastructures** to enrich CCAM services and increase safety and traffic efficiency.

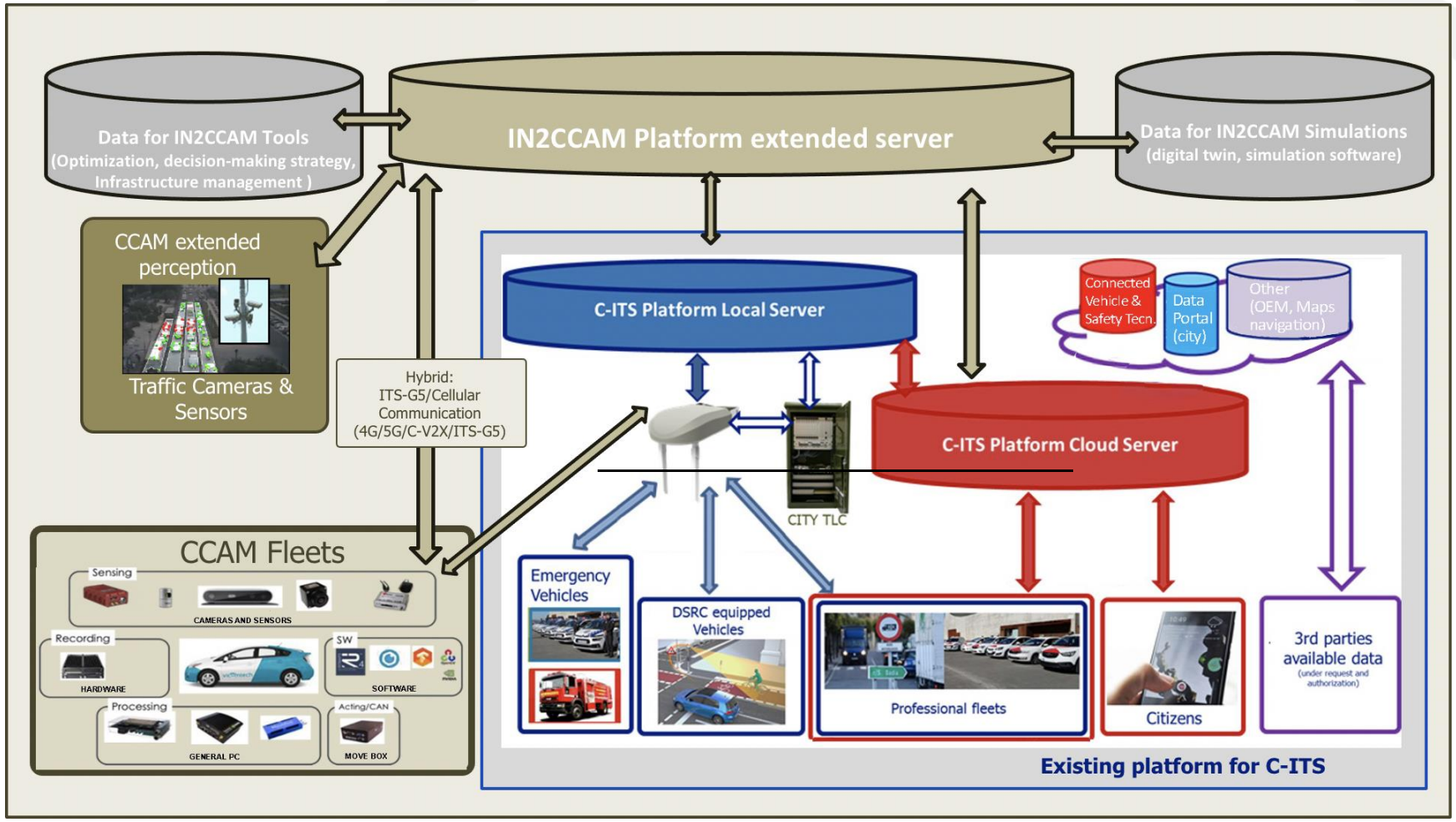
Physical Infrastructures

Physical infrastructures in each LLs will be updated so that the autonomous vehicles can travel considering the possibilities of:

- **dynamic dedicated lanes**
- **intelligent traffic lights**
- **intelligent road signs.**

Digital Infrastructure

Start from the existing traffic management systems in the LLs



New integrated services

- for traffic balancing by proposing alternative less congested roads
- Freight transport and logistics
- Vulnerable Road Users enablers.

Operational Infrastructures

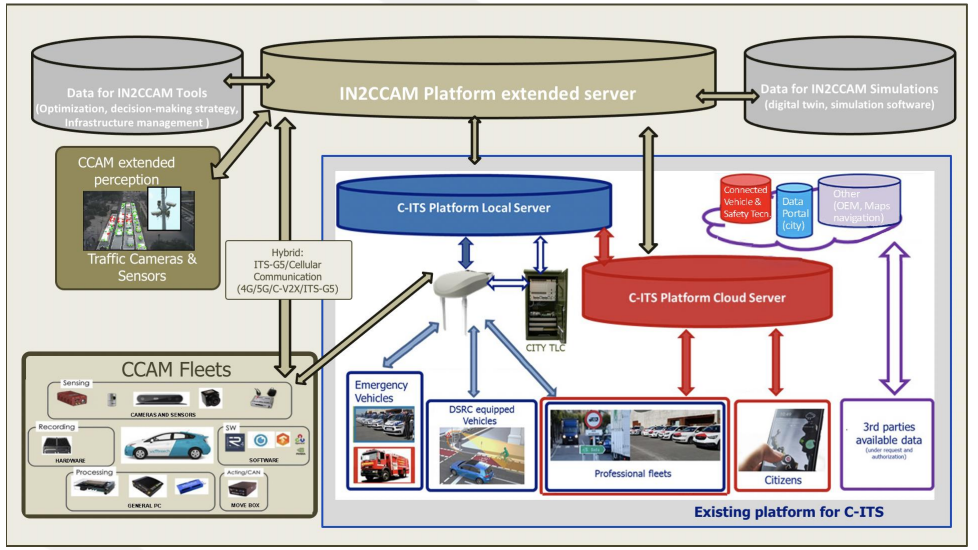
Appropriate governance models

- to integrate the services in urban planning and urban economics
- to ensure collaboration between stakeholders.

Providing Business Models

- for automated and shared vehicles
- for interoperability and integration with public transport.

The actions should develop and demonstrate concepts of traffic and fleet management **to achieve integration of CCAM vehicles in the entire mobility system**



Living labs

4 Lead LLs implement the new services and the IN2CCAM **platform extended server**, the DTN approach for maintenance and prediction, **collect data** from the field, evaluate the perception and the reactions of the involved people, provide data and information for the governance models and rules determination: **Tampere (Finland), Trikala (Greece), Turin (Italy), Vigo (Spain)**

2 Follower LLs follow the results obtained by the Lead LLs and apply their proposed services by implementing simulation campaigns: **Bari (Italy), Quadrilatero (Portugal)**

Follower LLs are implemented with reduced budget amplify the results of the Leader LL, increase the project outcome dissemination and also enrich the impact.

Sustainability Aspects

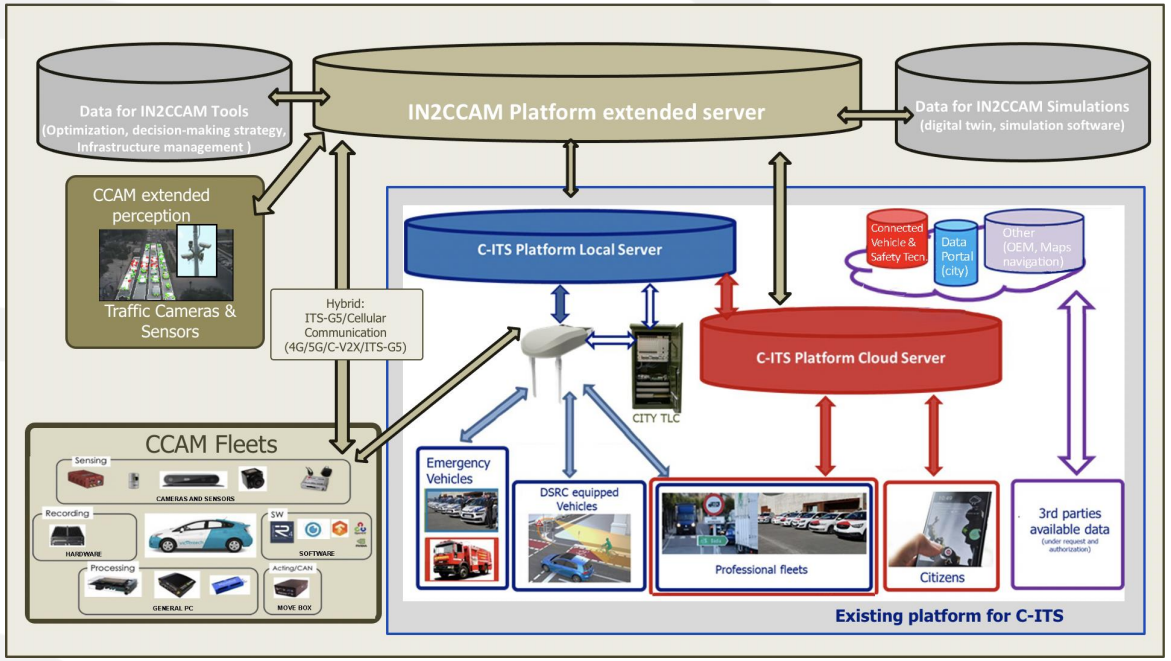
New services and applications for smart devices

- for traffic balancing by proposing alternative less congested roads, road selection to decrease traffic and congestion
- Freight transport and logistics to decrease congestion and emissions
- Vulnerable Road Users (VRU) enablers.

Innovative technologies

- Artificial Intelligence
- Machine Learning
- Deep Reinforcement Learning
- Digital Twin
- V2V and V2I algorithms for controlling intersection flow without traffic lights
- platooning

Digital Infrastructure



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