TARGET-X

WELCOME

OPEN DAY 2024

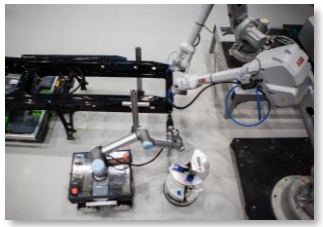
Welcome!

Niels König and Janina Gauß

Fraunhofer Institute for Production Technology IPT

You are here: TARGET-X | Testbeds

5G for energy monitoring



5G for mobile robotics

5G for cloud native production

5G for construction

5G-Industry Campus Europe (5G-ICE) in Aachen, Germany

5G for autonomous driving

IDIADA testbed in Tarragona, Spain

5G INDUSTRY CAMPUS EUROPE

WZL

FIR

Fraunhofer IPT

Construction Site

5G-Industry Campus Europe is the largest industrial 5G testbed

- 5G indoor networks on 3 different shopfloors fully equipped with machines and robots
- 5G outdoor network of 1 km² at the RWTH Aachen Campus
- 5G-NSA and 5G-SA running on industry spectrum @3.7 – 3.8 GHz
- Simultaneous 4G network running @2.3 GHz as anchor band
- 5G-URLLC Testbed @26-28 GHz
- 5G-NSA with 800 MHz mmWave spectrum @26.7-27.5 GHz

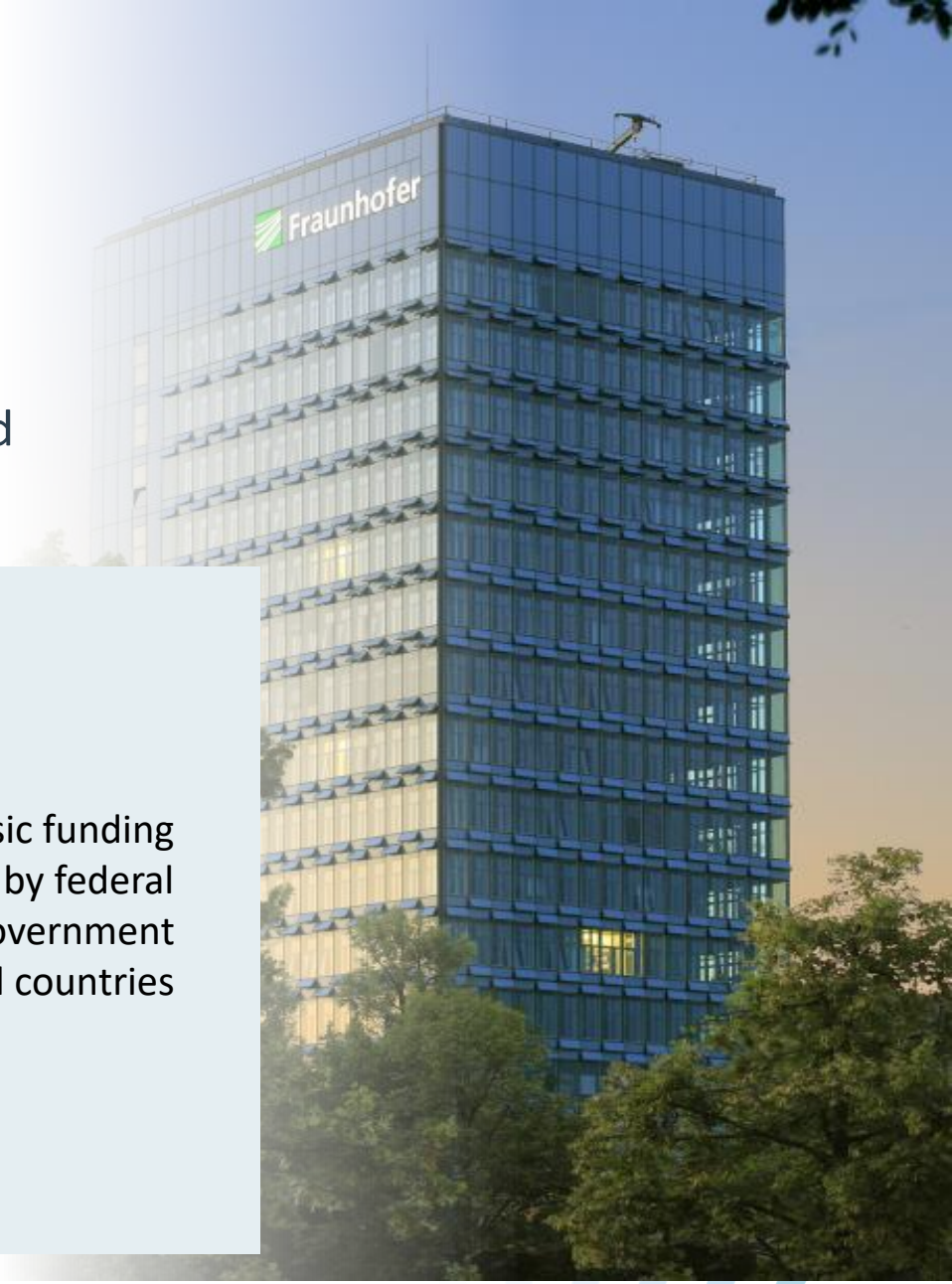
Supported by:
Federal Ministry of Transport and Digital Infrastructure
on the basic of a decision by the German Bundestag

5G network supplier: ERICSSON

IT Center | RWTH AACHEN UNIVERSITY | Fraunhofer IPT | WZL | RWTH AACHEN UNIVERSITY | fir an der RWTH Aachen

Fraunhofer-Gesellschaft

The world's leading applied research organization



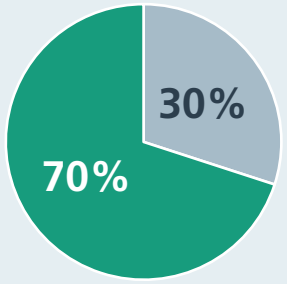
Application-oriented research with a focus on future-relevant key technologies as well as on the utilization of the results in business and industry. Pioneer and driving force for innovative developments.

30 000 employees

€2.9 billion financial volume
€2.5 billion contract research

76 institutes and research institutes

Industry-orders and public Funded research projects



Basic funding by federal government and countries

Fraunhofer Institute for Production Technology IPT

The Fraunhofer IPT was founded in **1980** and is headquartered in Aachen

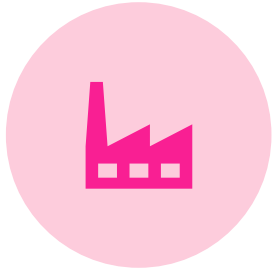
The IPT combines know-how **from all areas of production technology** on 8000 m² shopfloor and laboratories

More than **530 employees** work on over **570 research and industrial projects** with a Research budget of **32 million euros**

TARGET-X Open Day – Our goals:

NETWORKING

CONNECTING WITH FSTP PARTNERS



INDUSTRIAL FEEDBACK

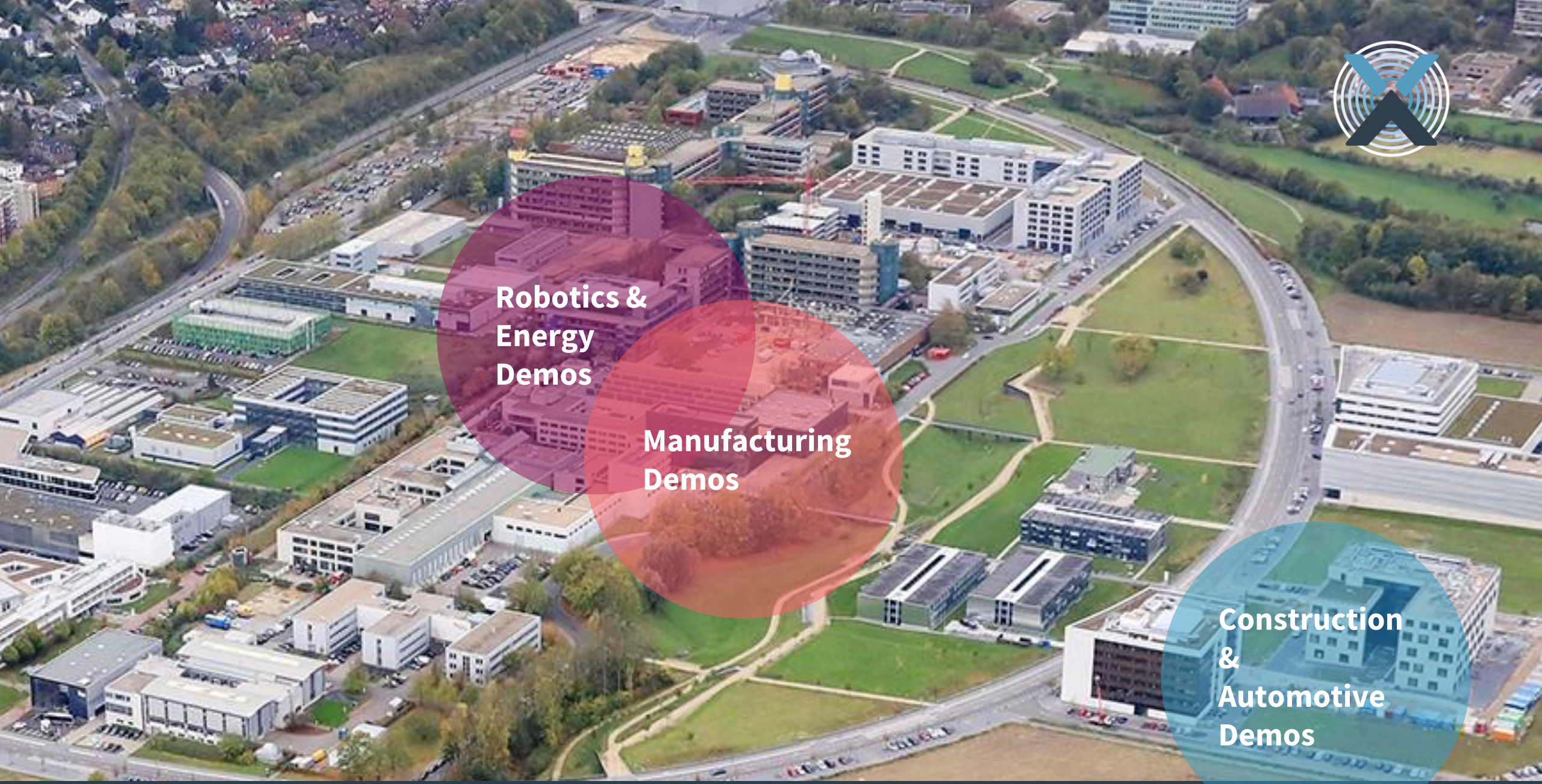
SHOWCASING

Agenda

09:00 – 09:30	Welcome!
09:30 – 10:00	Introducing TARGET-X: On goals, the project approach, results and outlook
10:30 – 11:00	Coffee break 
11:00 – 12:45	Presentation of selected FSTP projects

Agenda

12:45	Walk together to the construction site
13:00 – 14:30	Lunch on construction site | Network and roam around, „Open Campus Week“ takes place at the same time
14:30 – 14:45	Opening of the demo on the main stage, in front of the truck
14:45	Gather in groups in front of the main stage, your guide will take you on the tour
17:00	End of the event


Robotics &
Energy
Demos
Manufacturing
Demos
Construction
&
Automotive
Demos

Introducing TARGET-X

On goals, the project approach, results and outlook

Niels König

Fraunhofer Institute for Production Technology IPT

Agenda

1 Goals for Today's Meeting

2 Objectives of TARGET-X

3 Project Approach

4 Results

5 Outlook on Next Steps

Agenda

TARGET-X | Open Day | Goals for Today's Meeting

Goals for Today‘s Meeting

- Provide an overview of the overall progress of the TARGET-X project
- Give insights into the developments of the Open Call projects
- Give an impression of our industry-related demos at 5G-ICE

Learn more about our innovative solutions for the implementation of 5G and 6G in industry

Agenda

TARGET-X | Our Objective

Accelerating the digital transformation of key verticals

- energy,
- construction,
- automotive, and
- manufacturing

using large-scale trials in multiple testbeds, evaluating 5G/6G technologies such as

- real-time communication,
- localization,
- self-description,
- digital twinning, and
- sensor-network data fusion

methodologically with KPIs and KVIs.

Key facts

Call: »SNS Large Scale Trials and Pilots (LST&Ps) with Verticals« (6GSNS Stream D)

Project runtime: 1.1.2023 – 30.06.2025

Project costs: €14,509,491.25

Requested EU contribution: €13,162,555.38
FSTP funding: €6,000,000.00

Agenda

1 Goals for Today's Meeting

2 Objectives of TARGET-X

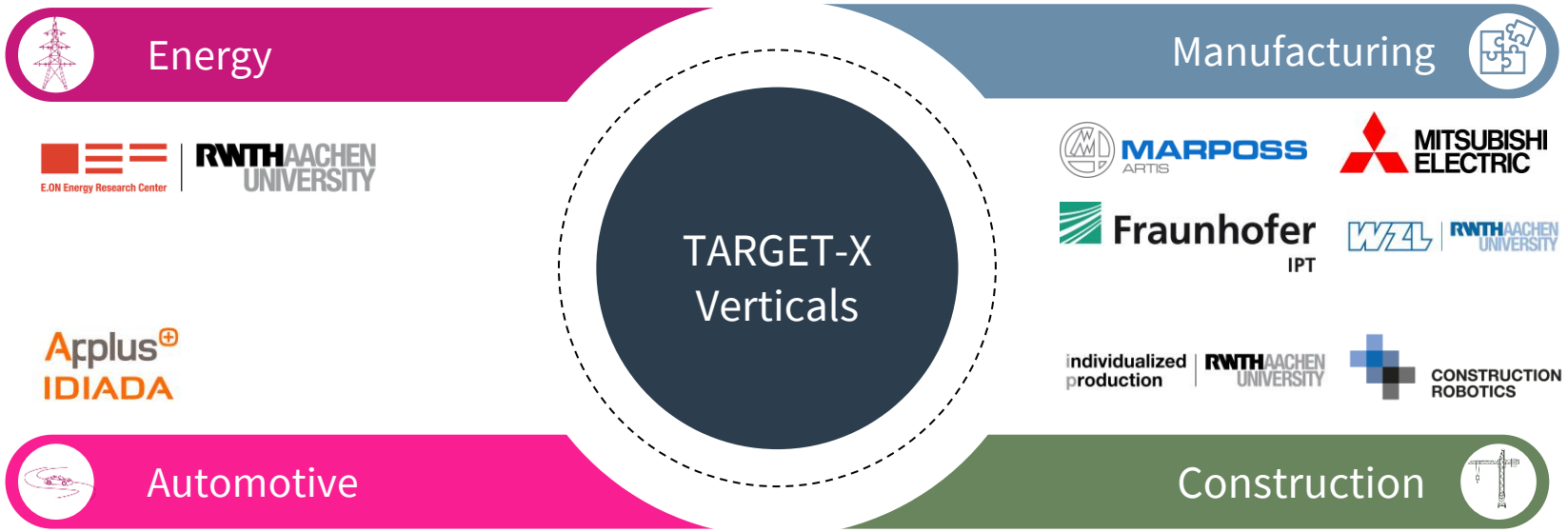
3 Project Approach

4 Results

5 Outlook on Next Steps

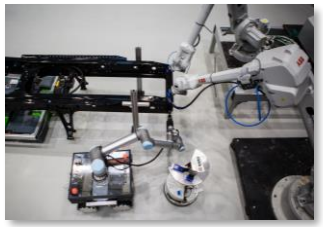
TARGET-X | Partner overview

Coordinator: Fraunhofer IPT
Technology: Ericsson Germany, Ericsson Turkey, Neutroon, Fivecomm, Qualcomm
Research: Fraunhofer IPT, RWTH-ACS, RWTH-WZL, RWTH-IP, I2CAT
Financial Support for Third Parties: FundingBox Accelerator, FundingBox Communities



TARGET-X | Testbeds

5G for energy monitoring



5G for mobile robotics

5G for cloud native production

5G for construction

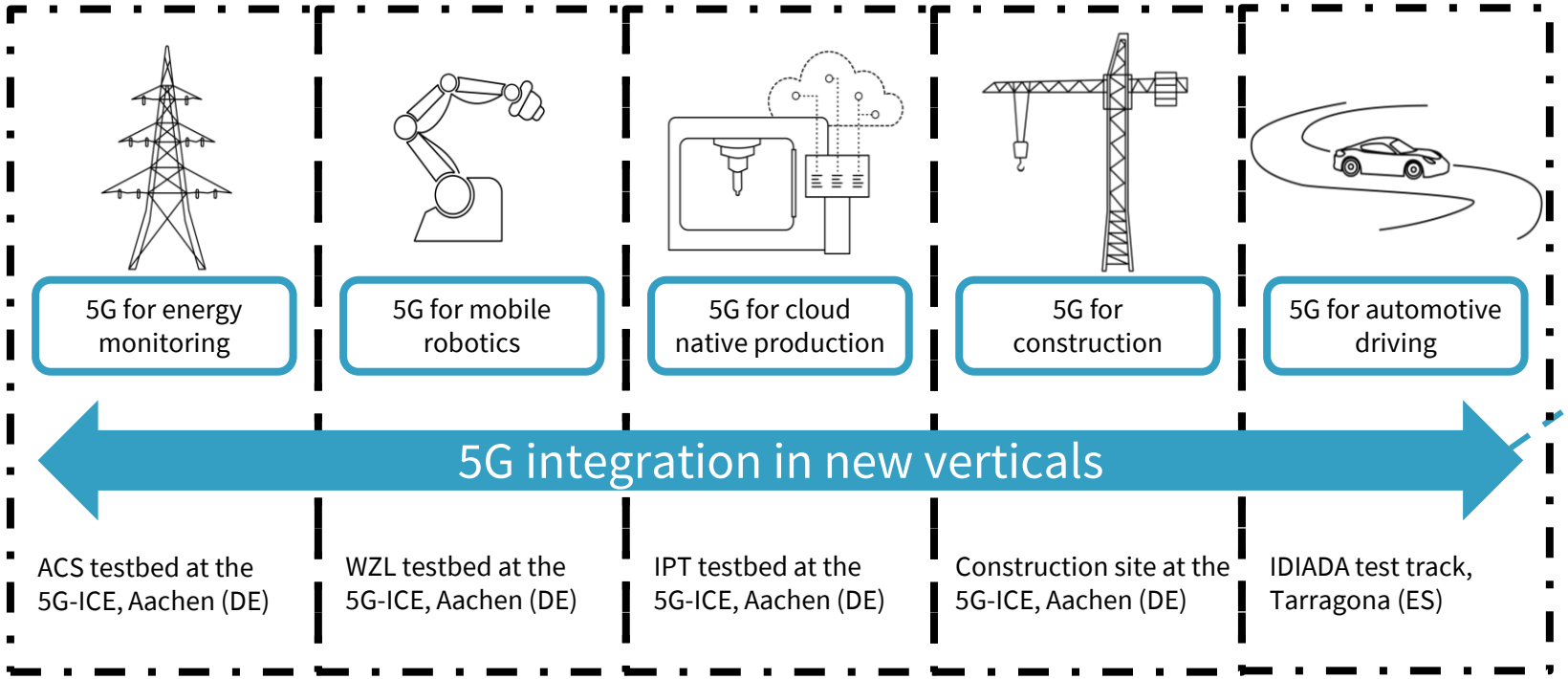
5G-Industry Campus Europe (5G-ICE) in Aachen, Germany

5G for autonomous driving

IDIADA testbed in Tarragona, Spain

TARGET-X | Overall concept

Testbeds for Energy, Manufacturing, Construction, Automotive – Work packages 2 – 5

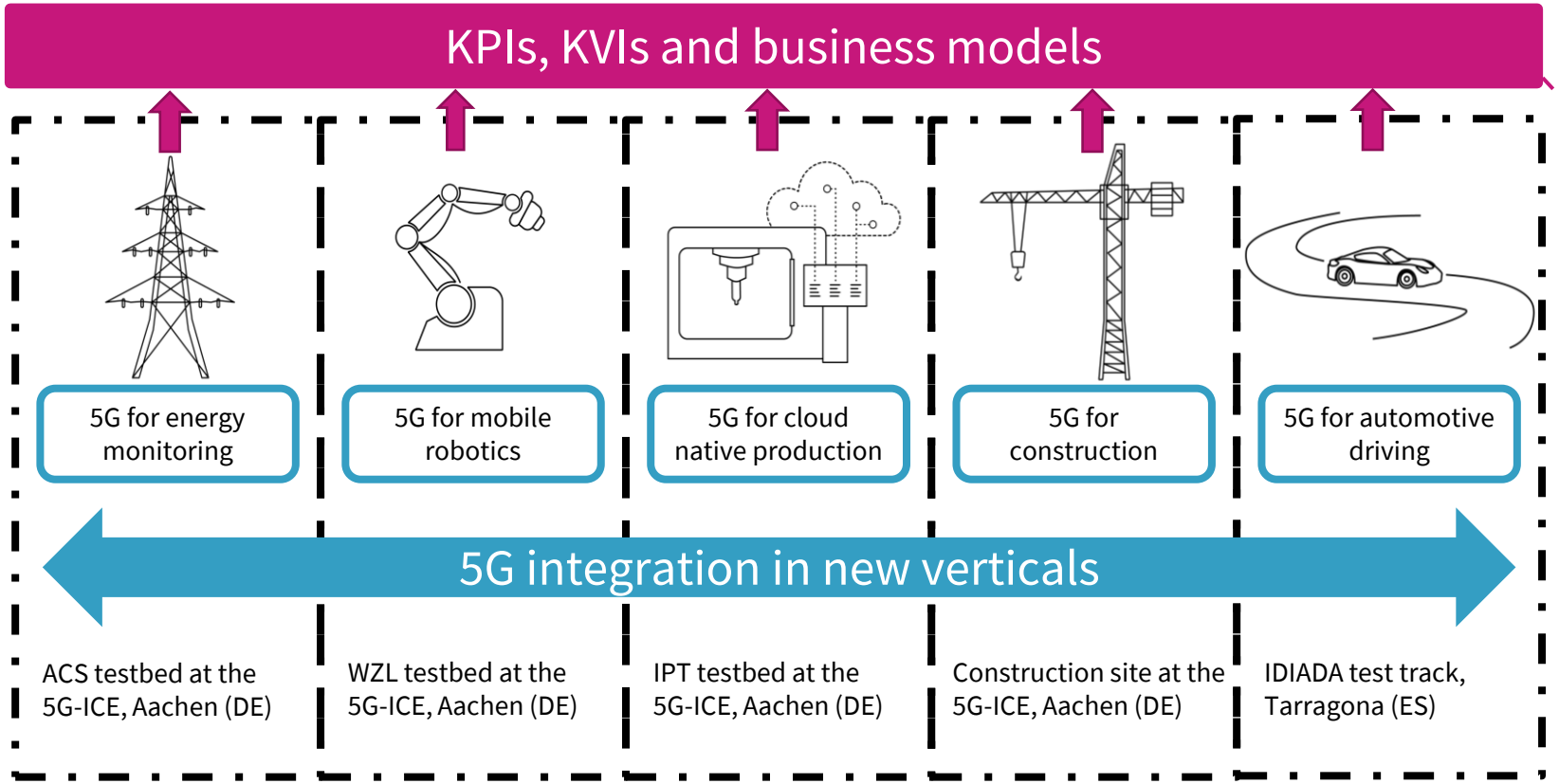


WP 2 - 5

- Broaden the exposure of 5G by onboarding new verticals
- Increase learnings on needs of new verticals
- Identify synergies

TARGET-X | Overall concept

KPIs, KVIs and business models – Work Package 1 Methodological Assessment Framework

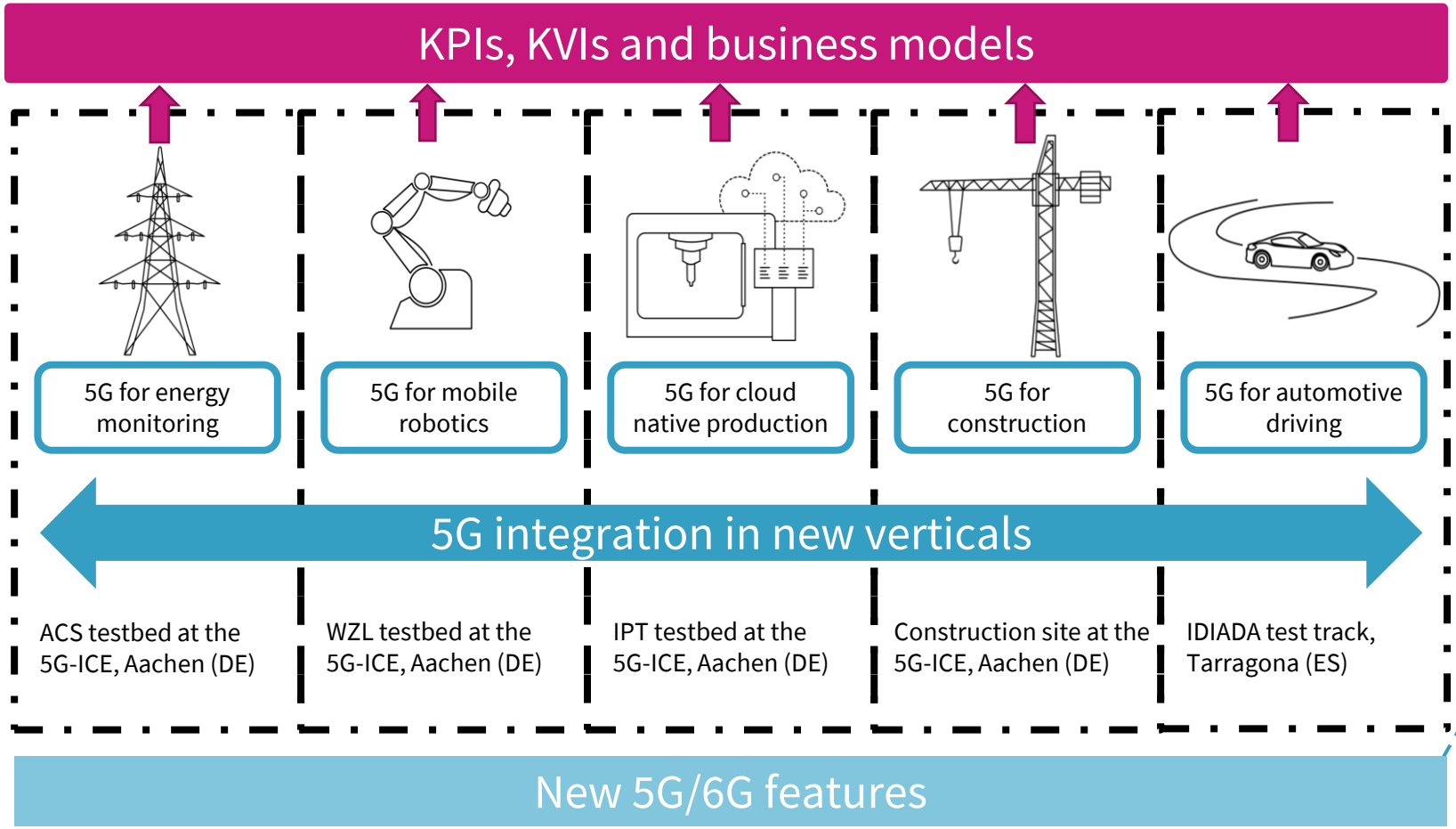


WP 1

- Derive KPIs and KVIs for 5G/6G development
- Allow for methodological assessment

TARGET-X | Overall concept

New 5G/6G features – Work Package 6 Technology evolution

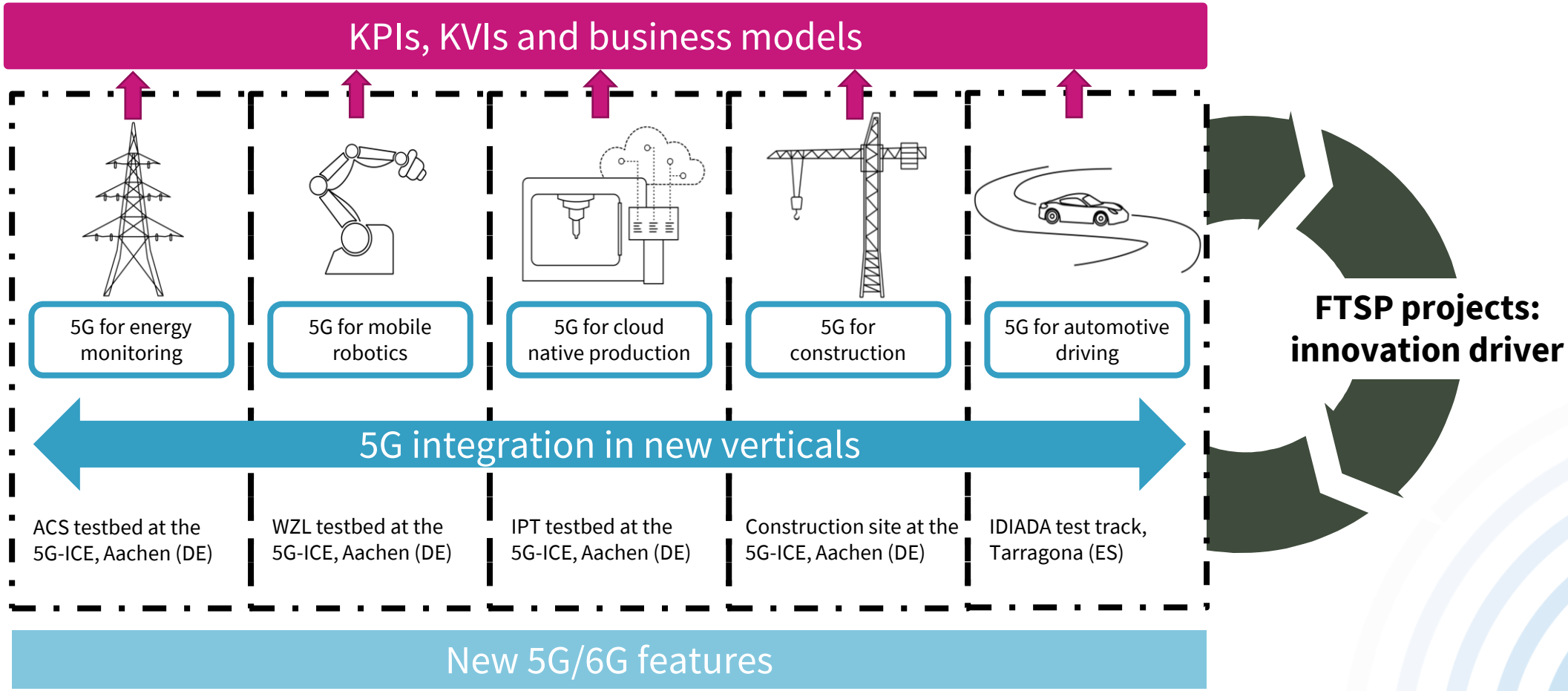


WP 6

- In-depth study and use of key beyond 5G features
- Tighten interworking between devices, NW and services

TARGET-X | Overall concept

New 5G/6G features – Work Package 6 Technology evolution



Agenda

1 Goals for Today's Meeting

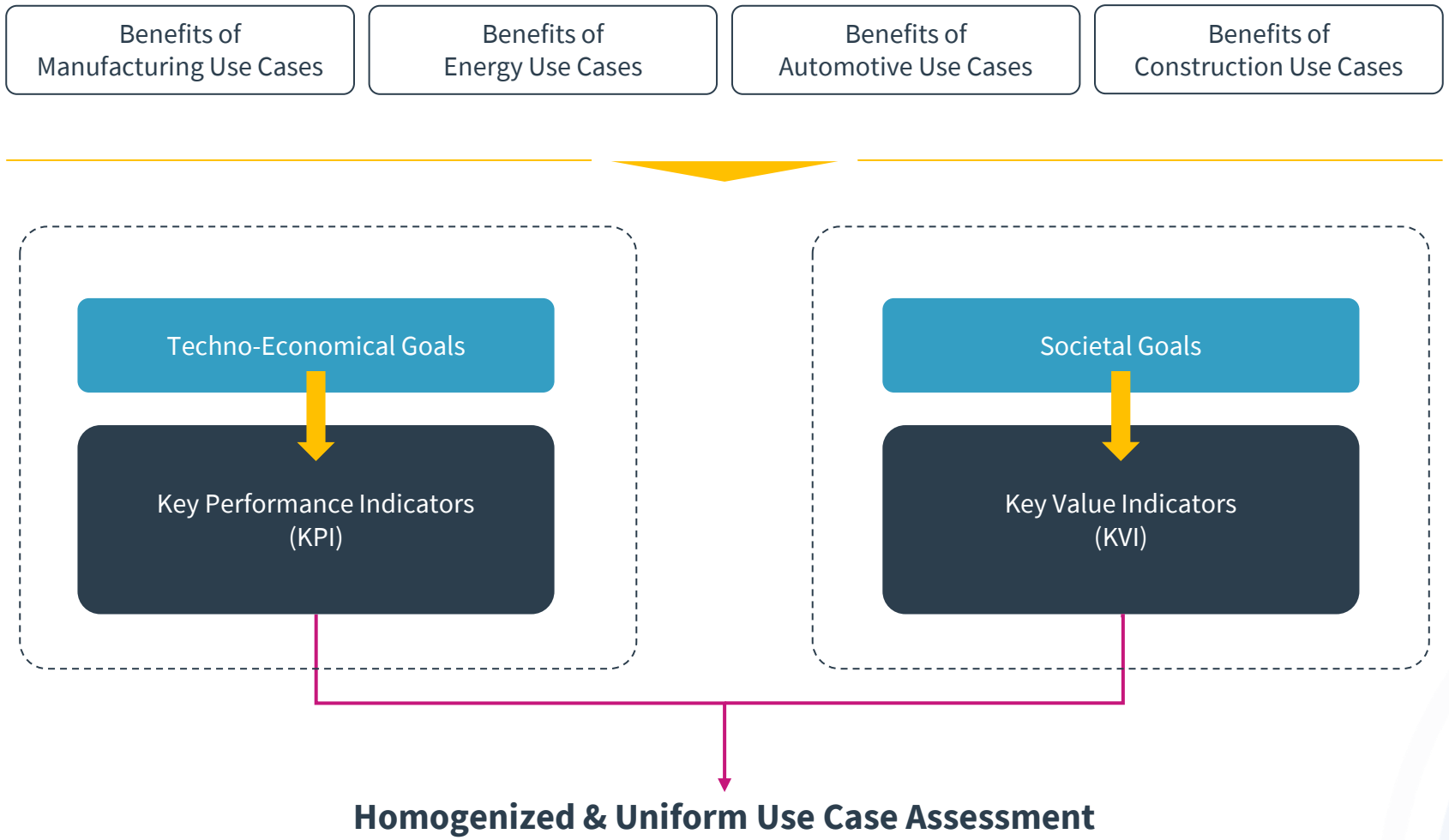
2 Objectives of TARGET-X

3 Project Approach

4 Results

5 Outlook on Next Steps

TARGET-X | Methodological Assessment Framework



TARGET-X | Methodological Assessment Framework

Use Case Characterization

Description of all 11 TARGET-X use cases and their individual benefits

Key Performance Indicators

- Definition of 17 KPI to capture the techno-economic value proposition of a use case
- KPI focusing on:
  - Expanding process insights
  - Increasing operational capability
  - Increasing process efficiency

Key Value Indicators

- Definition of 10 KVI to capture the societal value proposition of a use case
- KVI focusing on:
  - Safety-related aspects
  - Transparency on ecological impacts
  - Digital inclusion

Development of a methodology to quantify the **value proposition** of 5G/6G use cases from the **techno-economic** and the **societal perspective**

TARGET-X | Results

The preliminary project results are illustrated by the demos shown later today

Robotics & Manufacturing

- Use of Asset Administration Shell for
  - Dynamic management of a wireless sensor platform
  - Traffic steering
- Edge-Controlled Automation with Mobile Manipulation
- METER-X (Robotics & Energy):
  - Energy awareness through robot trajectory analysis

Construction

- METER-X (Construction & Energy):
  - Energy awareness through construction process analytics
- XR Assistant:
  - Extended Reality (XR) based planning of deconstruction processes
- Two additional demos from FTSP projects

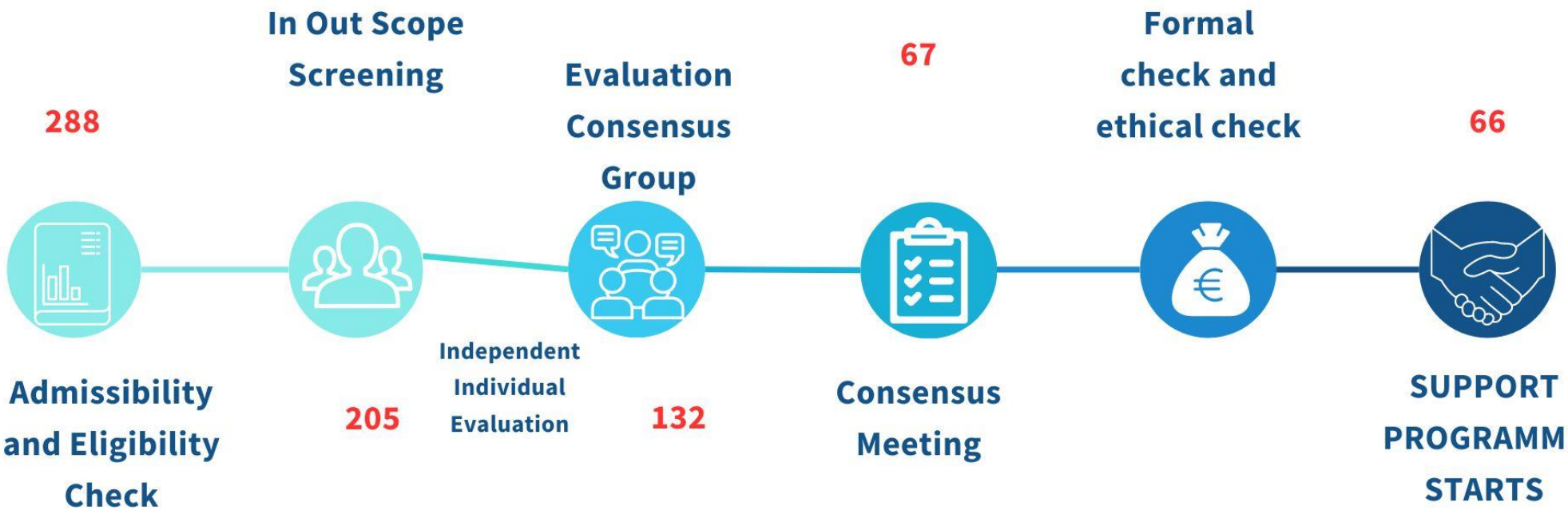
Energy

- METER-X:
  - Energy awareness through robot trajectory analysis
- METER-X (Construction & Energy):
  - Energy awareness through construction process analytics

Automotive

- Predicted Quality of Service for tele-operated vehicles
- Three additional demos from FSTP projects

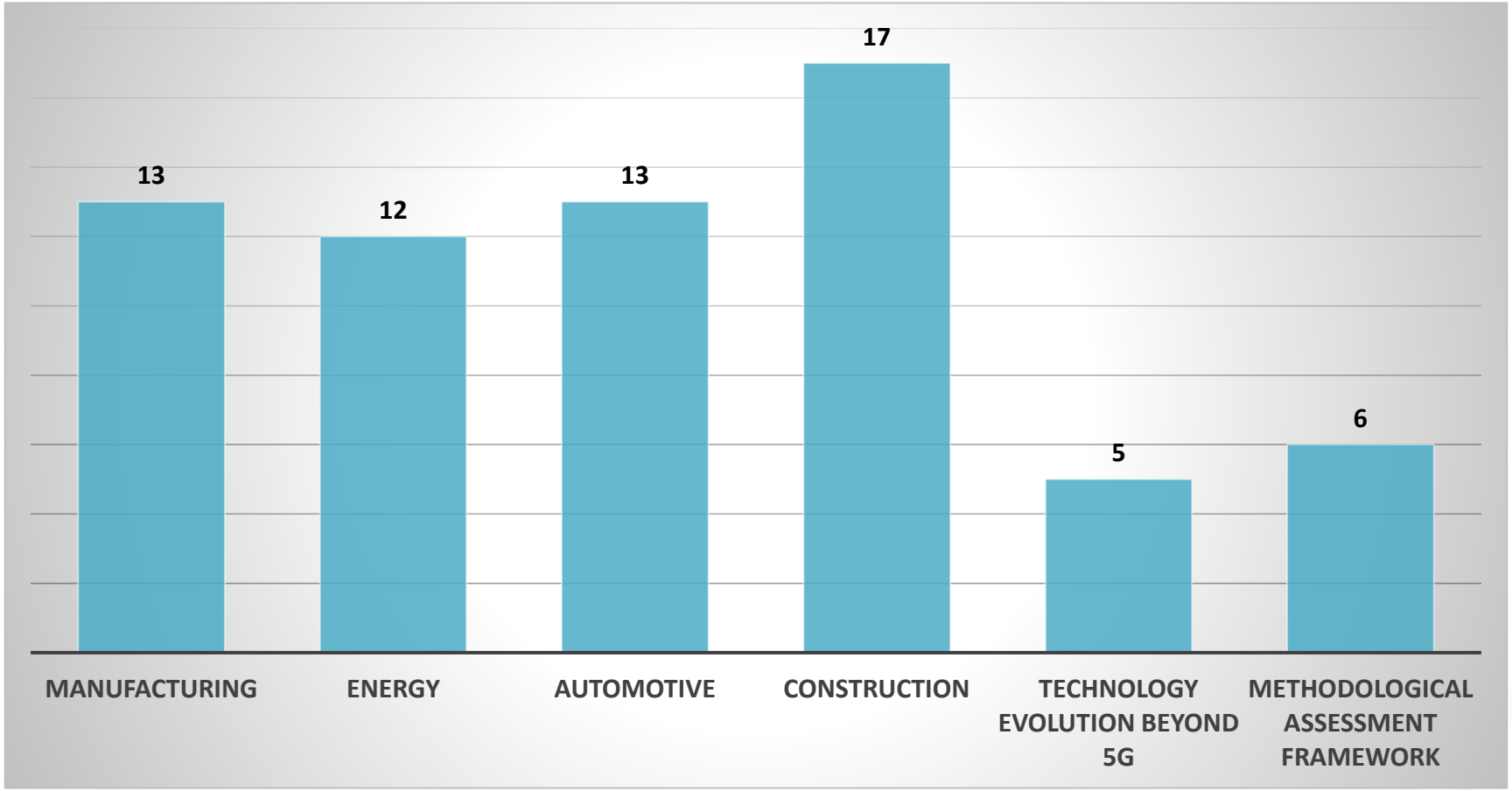
FSTP in numbers: Both Open calls



TRANSVERSAL TECHNICAL CONSIDERATIONS

TITLE	PROJECTS FUNDED IN THE 1st OPEN CALL	PROJECTS FUNDED IN THE 2nd OPEN CALL
METHODOLOGICAL ASSESSMENT FRAMEWORK- WP1	0	6
MANUFACTURING – WP2	7	6
ENERGY- WP3	6	6
AUTOMOTIVE- WP4	7	6
CONSTRUCTION- WP5	5	12
TECHNOLOGY EVOLUTION BEYOND 5G – WP6	1	4

BENEFICIARIES OF BOTH OPEN CALLS PER VERTICAL



Agenda

1 Goals for Today's Meeting

2 Objectives of TARGET-X

3 Project Approach

4 Results

5 Outlook on Next Steps

TARGET-X | Outlook & Next Steps

- 2nd round of Open Call projects to enhance transfer of innovation to industry
- Implementation and assessment of all TARGET-X use cases until June 2025

TARGET-X Use Cases

Brief overview of TARGET-X Use Cases

Technical Work Package Leaders

Manufacturing

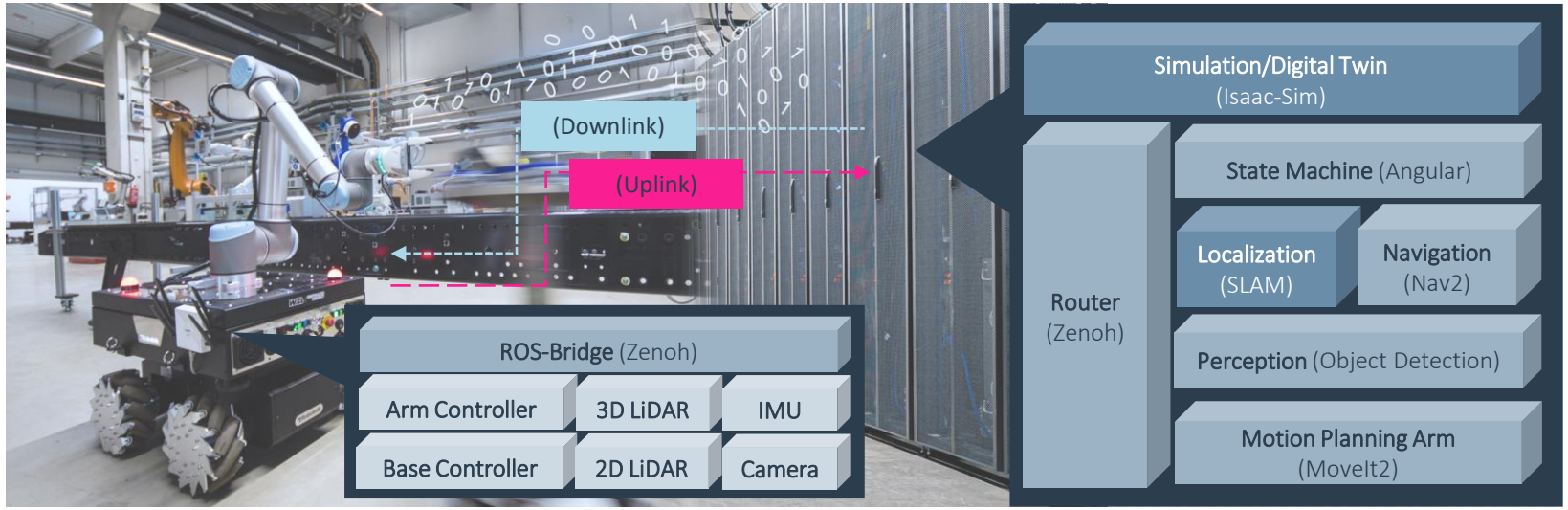
Lucas Manassés Pinheiro de Souza

Laboratory for Machine Tools and Production Engineering (WZL) of RWTH Aachen University

Edge-Controlled Automation with Mobile Manipulation

Automating bin-picking with mobile robots using 5G and edge computing for real-time control

- **Objective**
  - *To enhance efficiency and precision in industrial assembly tasks through advanced connectivity and edge computing.*

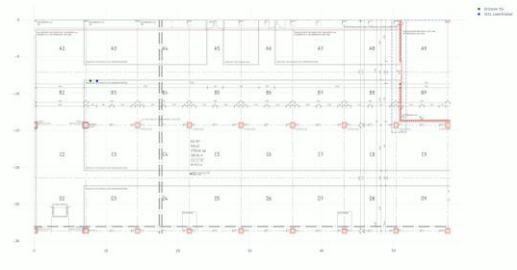


Requirements

- *Typical UL data rate: 143 Mbit/s :*
  - *3D lidar (127 Mbit/s),*
  - *Camera (13 Mbit/s),*
  - *2D lidar (2 Mbit/s)*
- *Typical DL data rate: 0,01 Mbit/s*
- *UL/DL ratio: 14300*

Addressed Beyond 5G Aspects

- *5G NR Positioning for localization of the Mobile Manipulators at the Shop-floor.*

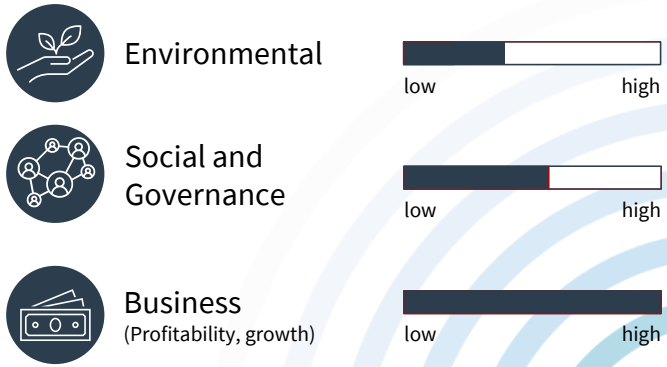


5G Localization for Mobile Robots at RWTH-WZL

Results and added Values

- *Reduced task time and costs.*
- *Improved environmental impact through energy savings and optimized resource consumption.*
- *Enhanced process efficiency, stability, and worker safe.*
- *Digital inclusion of workers.*

Benefit Evaluation



Energy

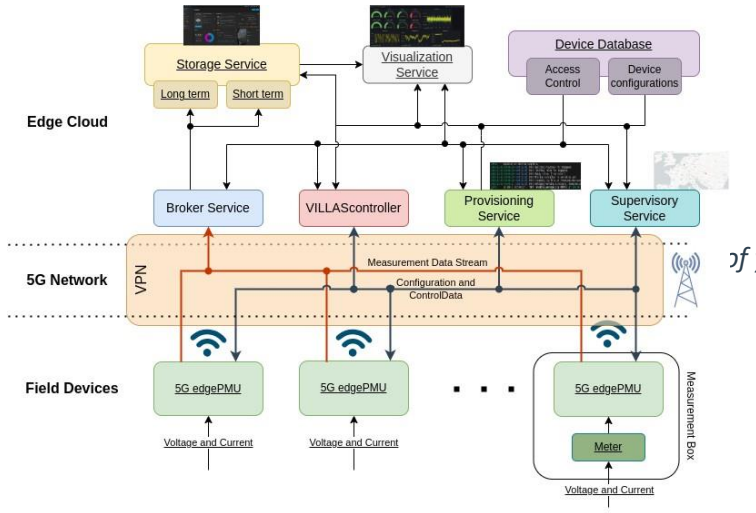
Manuel Pitz

E.ON Energy Research Center at RWTH Aachen University

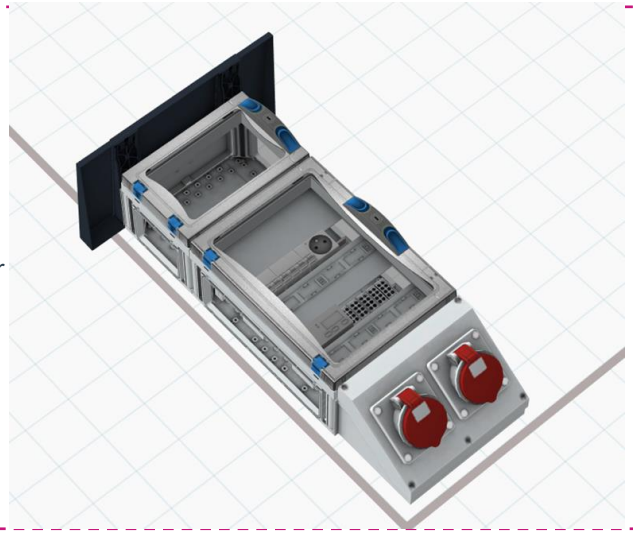
Grid Monitoring and Energy Awareness

Brief Description of the Use Case

- **Objective**
  - *Increase energy awareness and power grid observability with low-cost and 5G-enabled hardware.*



of your



Requirements

- *High sampling rate data acquisition device*
- *High global time precision within less than 100 us*
- *Fast transmission of samples for grid services controlled via the edge cloud*

Addressed Beyond 5G Aspects

- *Integration of RedCap devices for cost reduction*
- *Evaluation of possible grid protection use cases thatrequire very low latency*

Results and added Values

- Increased observability of the grid
- Increased energy awareness
- Augmented datasets with high time resolution for big data applications

Benefit Evaluation

Environmental

low high

Social and Governance

low high

Business
(Profitability, growth)

low high

Construction

Marit Zöcklein

Center Construction Robotics

XR assistant for deconstruction task planning

Brief Description of the Use Case

- **Objective**
  - *Support human worker in the planning of the process sequence during deconstruction tasks*

Requirements

- *Tablet with 5G chipset*
- *Server hosting a triple store*
- *IFC or Linked Building Data Model of the existing building*

Addressed Beyond 5G Aspects

- *Bridging the gap between the physical and digital environment*
- *Realizing digital models and information in the physical world*
- *Using extended coverage of 5G on the construction site*

Results and added Values

- *Visualization of inner structure and joints of building elements*
- *Demolition-free deconstruction*
- *Supports reclaiming building materials*
- *Increase work efficiency*

Benefit Evaluation

Environmental

low high

Social and Governance

low high

Business
(Profitability, growth)

low high

Automotive

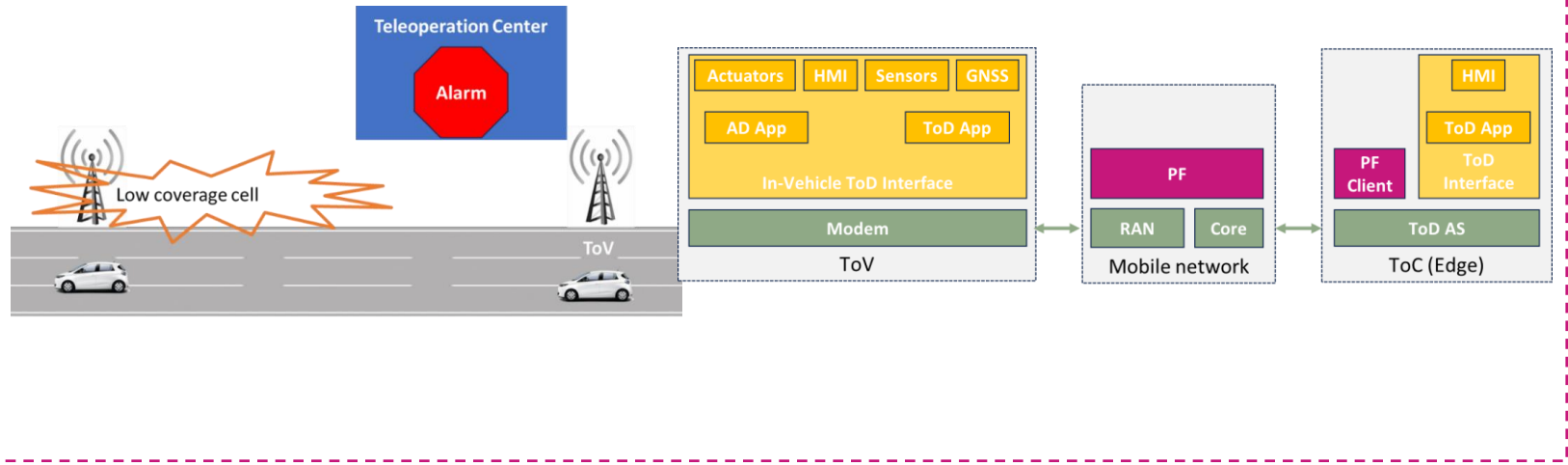
Dr. Jad Nasreddine

i2CAT Foundation

Predictive quality of service for tele-operated vehicles

Brief Description of the Use Case

- **Objective**
  - *Demonstrate the importance of accessing network performance information through 5G features to avoid sudden breaking/accidents in the case of tele-operated driving*



Results and added Values

- *By deploying such solution, remote drivers will be notified with any problem in the network ahead of time so they can take the decision efficiently*
- *Decrease the trip time and cost by reducing sudden breaking*

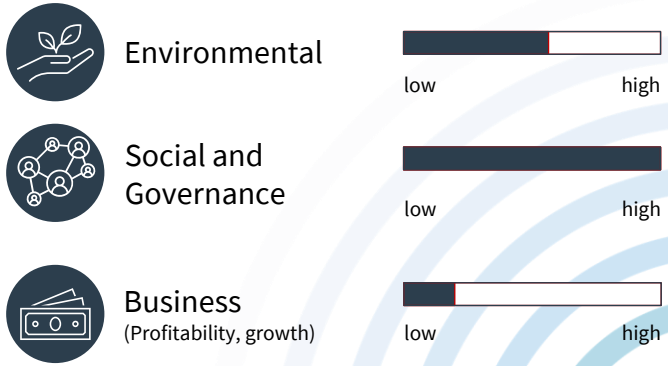
Requirements

- *Exposure API notifying the ToV of bad network performance in its path*
- *Good uplink video streaming (high throughput, and low jitter and latency)*
- *Good downlink command transmission, especially in terms of reliability and latency*

Addressed Beyond 5G Aspects

- *Network exposure API*
- *Edge computing*

Benefit Evaluation



Selected FSTP-Projects

First Open Call

5G-Bench Motiv

Prof. Konstantinos Maliatsos

Feron Technologies

5G-BenchMotiv

FERON Technologies, GR

Challenge and Motivation

- *5G verticals impose competing QoS network requirements in coexisting configurations.*
- *Performance assessment through network KPIs for users to troubleshoot 5G networks & detect capabilities for given network configurations.*
- *Attention to time critical services including 5G for industry automation.*
- *Lack of open network benchmarking and monitoring tools spanning from the radio access, through the network to the application.*
- *Existing solutions generally not portable - or application/network/hardware-specific*

Objective

5G-BenchMotiv

- *provides an open-source toolbox for "black-box" and "grey-box" network benchmarking for various 5G traffic profiles*
- *is a low cost and agile solution enabled to cope with varying levels of data availability with an extended list of KPIs*
- *incorporates on-demand applications and traffic profiles in the benchmarking measurements potentially interfacing with industry automation protocol data.*
- *offers an automated processing stream for (re-) configuring the monitored data plane of network assets.*
- *sets the base-line for network/slice performance*

A prototype measurement tool combining a portable unit (Golden Unit) and agile in-network deployed SW allowing for controlled, active/passive tests from the Golden Unit to a varying network depth, benchmarking 5G performance

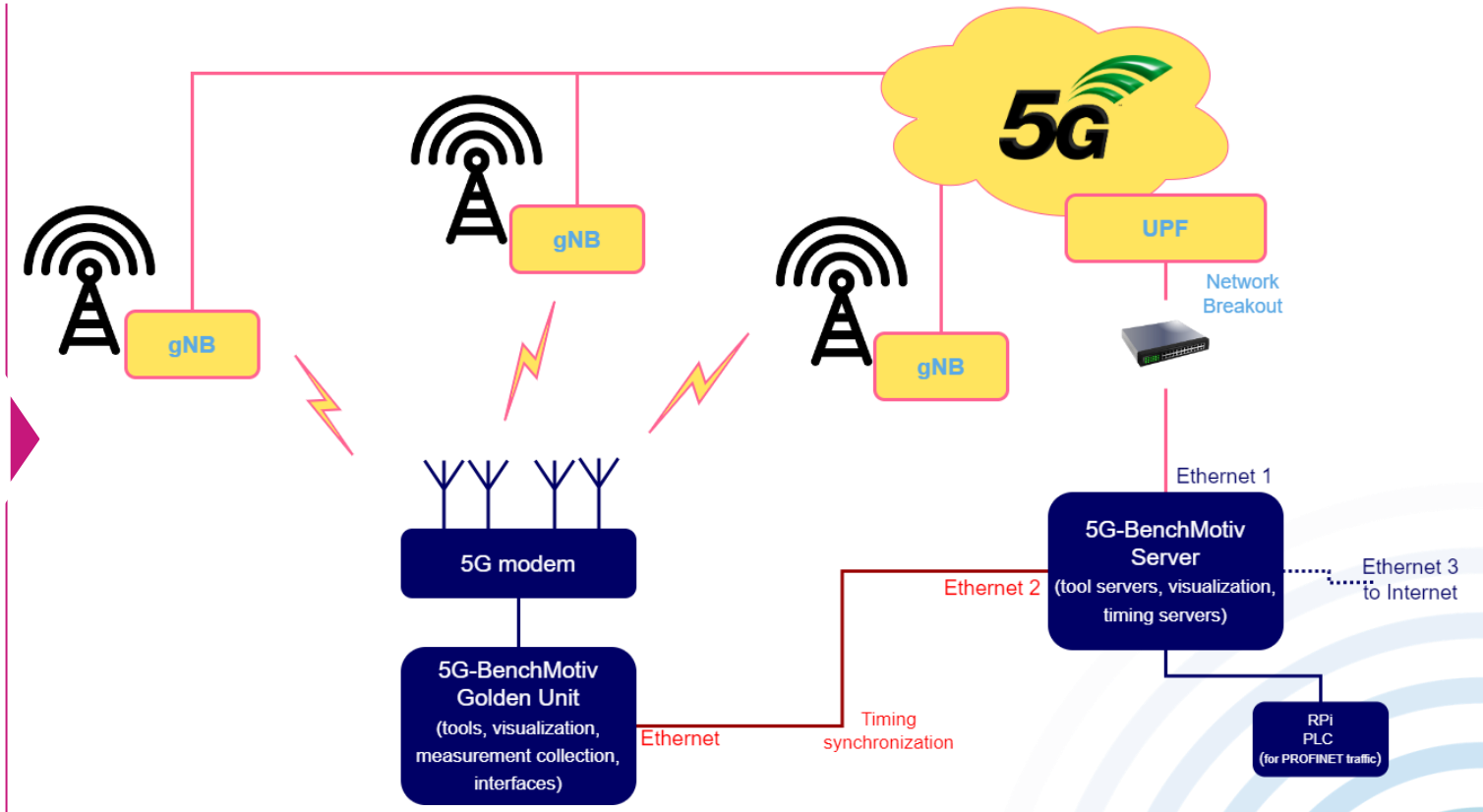
5G-BenchMotiv

FERON Technologies, GR

Solution Approach

5G-BenchMotiv.

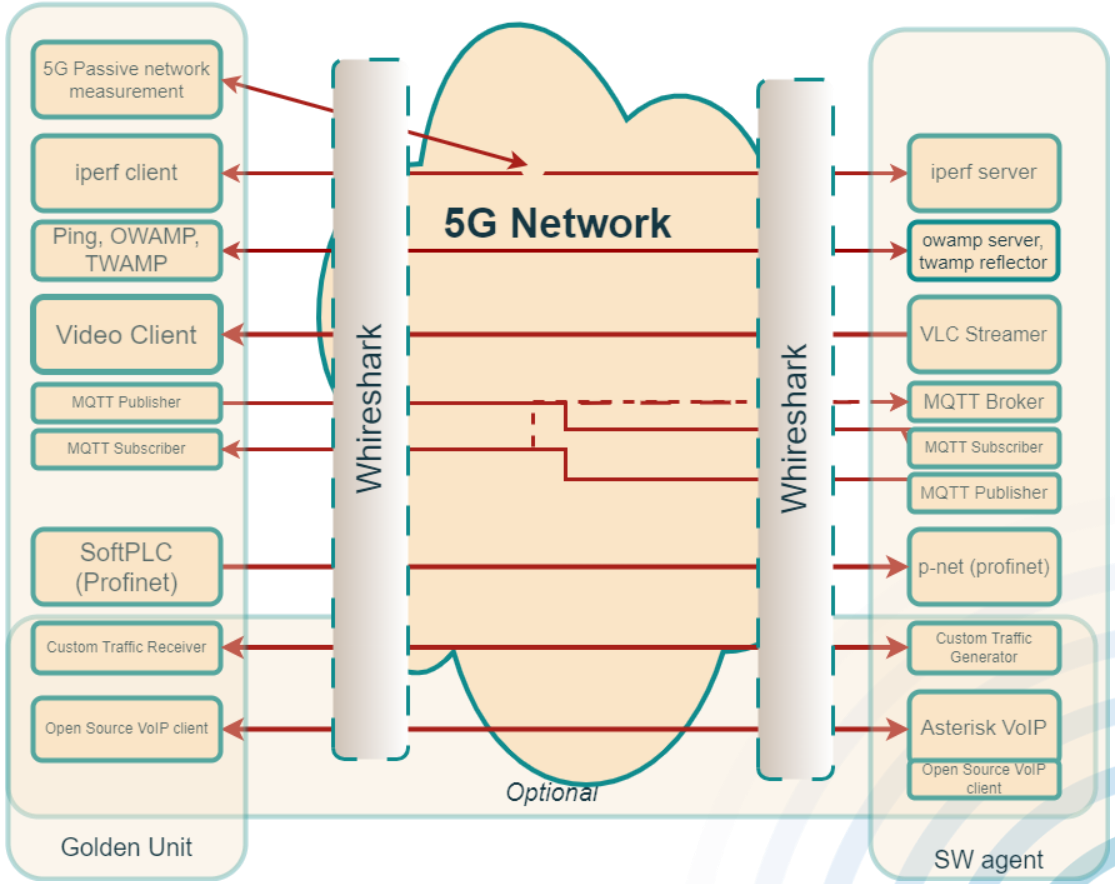
- *defines a client-server network benchmarking architecture for various paths, protocols - from the user to the edge and backend services.*
- *implements a dual-agent network measurement schema: the HW prototype (i.e., golden unit), a computing unit with radio interfaces and all required network analysis software; and the SW agent/server acting as vantage (or end) point for benchmarking, comparative analysis and bottlenecks identification.*
- *evaluates traffic profiles (TCP/UDP) and application-specific profiles e.g., HTTP, FTP, Video-on-Demand, and especially profiles miming industrial automation traffic.*
- *extracts KPIs including throughput, latency, packet losses, jitter, retransmissions, and radio-specific metrics.*
- *performs automated orchestration, collection, processing, and visualization of results with special.*
- *exposes API and GUI for measurement configuration.*



5G-BenchMotiv

FERON Technologies, GR

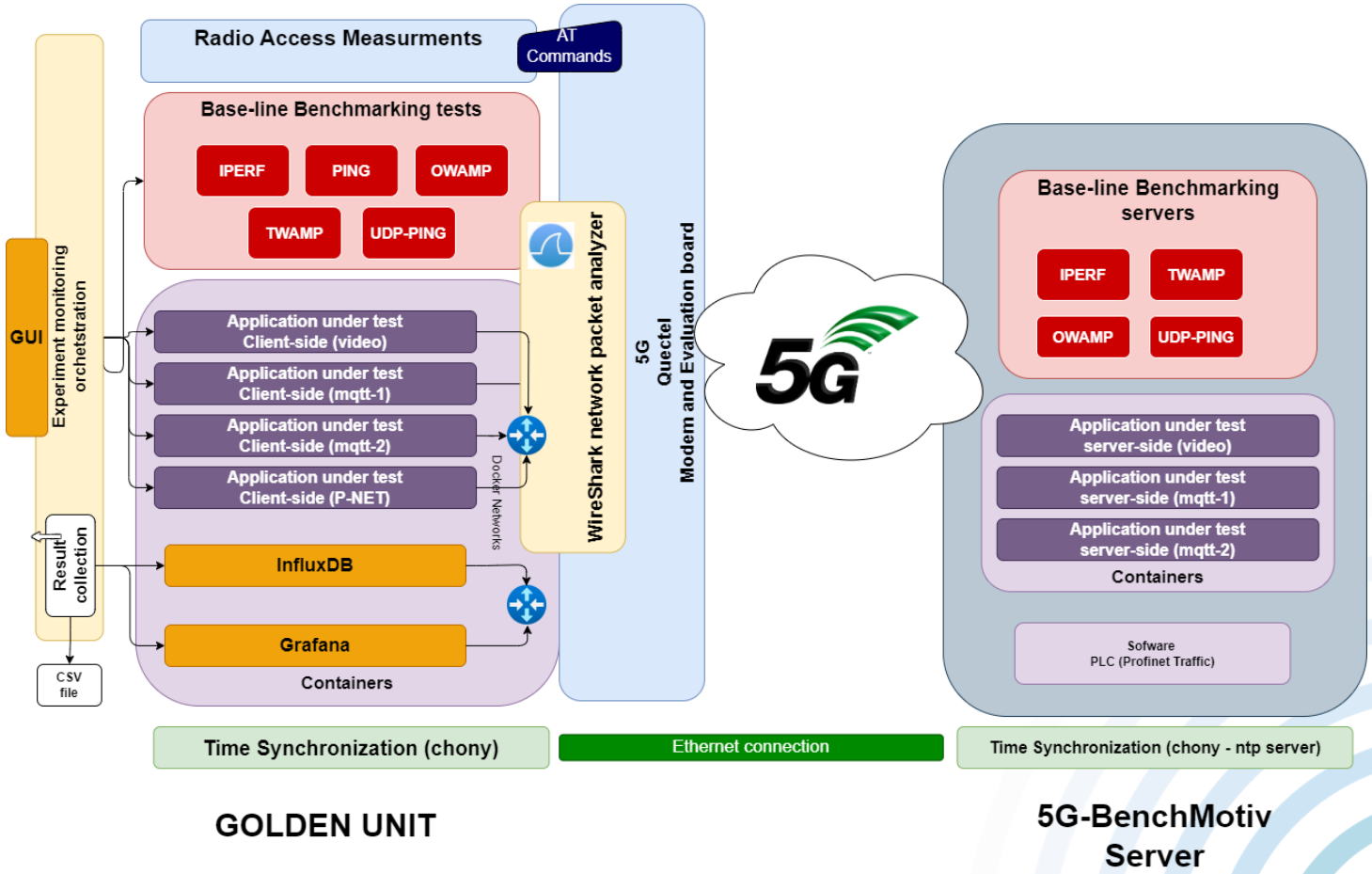
- Radio Access Measurements for the serving cell using modem AT commands.
- Base-Line (application-agnostic) measurements using popular open tools and protocols.
- Application-specific measurements where end-to-end throughput and latency is evaluated using WireShark



5G-BenchMotiv

FERON Technologies, GR

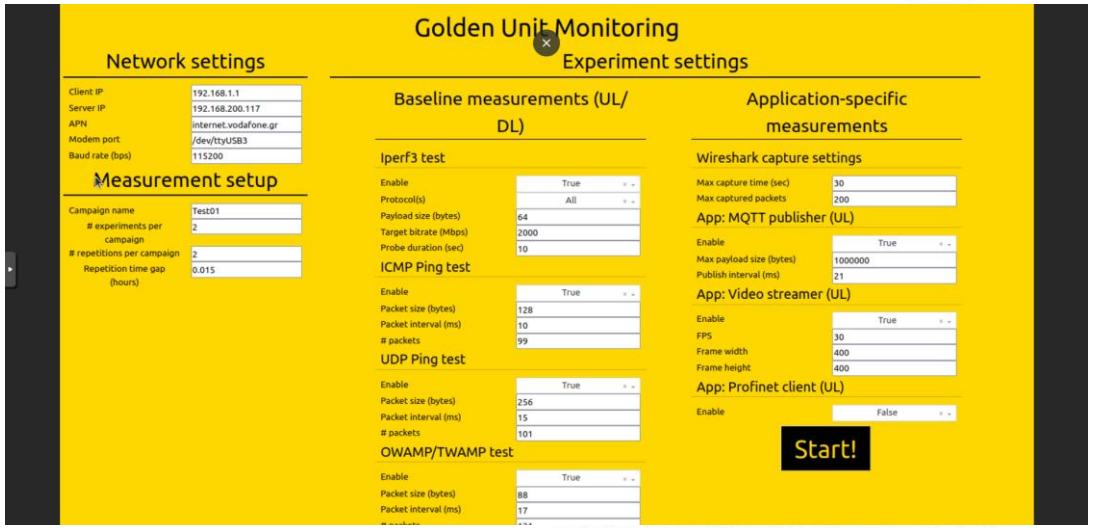
- Measurement orchestrated using a web interface or through command line.
- Results visualized either in the GUI or as time-series graphs in Grafana (embedded container).
- Results extracted in CSV file or stored in an influxDB (containerized at the golden unit).
- Time synchronization necessary between client and server. If possible back-to-back ethernet connection between golden unit and server (acting also as ntp server)



5G-BenchMotiv

FERON Technologies, GR

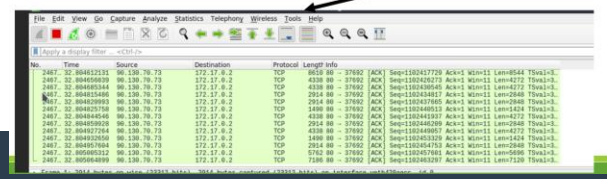
- The tool builts upon a collection of open benchmarking tools (iperf3, ping, owamp/twamp deployments, udp-ping)
- Utilizes the open interfaces of Quectel evaluation boards for 5G RAN measurements and data.
- Applications like Video streaming, MQTT IoT and Profinet are containerized, and use dedicated virtual ports in the Docker network.
- With containerization of popular applications and the use of Wireshark to monitor inbound or outbound container traffic and thus evaluate application-generated throughput and round-trip time. Without containerization we wouldn't be able to separate/classify traffic per application.
- The experiments can be orchestrated, and results visualized through the Golden Unit GUI – accessible at the IP address of the Golden Unit.

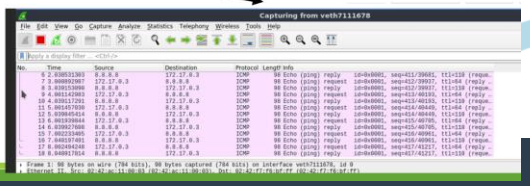


2 docker (Virtual) interfaces found in wireshark

Downloding APP

Ping APP

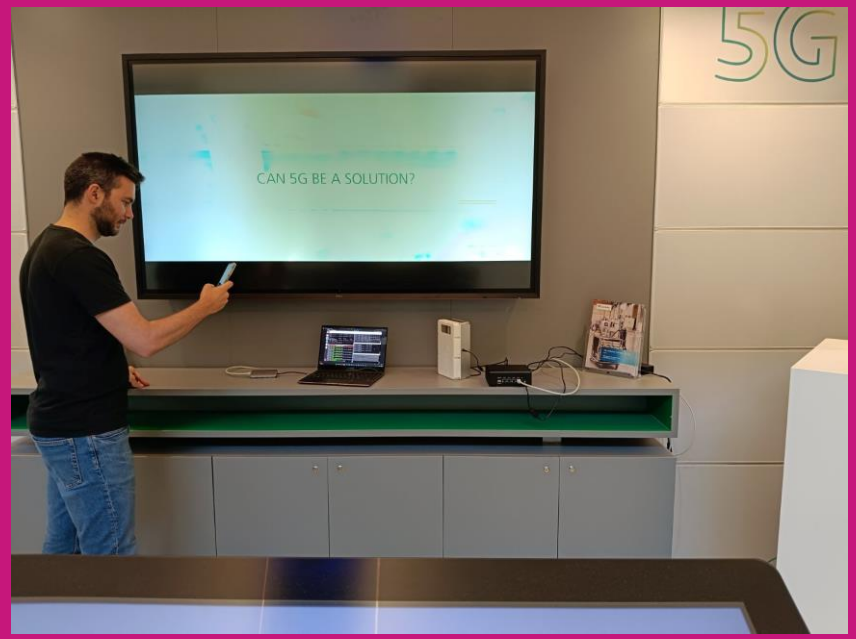




5G-BenchMotiv

FERON Technologies, GR

Execution of integration & validation measurements at Fraunhofer IPT and Ericsson facilities (SA, NSA and mmWave setups) with the support of the Ericsson mentoring team



5G-BenchMotiv

FERON Technologies, GR

5G-BenchMotiv

FERON Technologies, GR

5G-BenchMotiv

FERON Technologies, GR

Results

- *The project produced an open tool with full documentation available at https://github.com/feron-tech/5G-BenchMotiv*
- *Benchmarking is possible at radio, network and application-level, where the performance of each application or protocol can be evaluated separately and/or jointly in order to assess their performance under real-world conditions.*
- *Measurements were performed at both Fraunhofer IPT and Ericsson Aachen private research networks – supporting 5G-SA, 5G-NSA, as well as mmWave (FR2) deployments to assess network as well as validate tool operation.*
- *The tool is modular, extendible and new applications can be integrated seamlessly.*

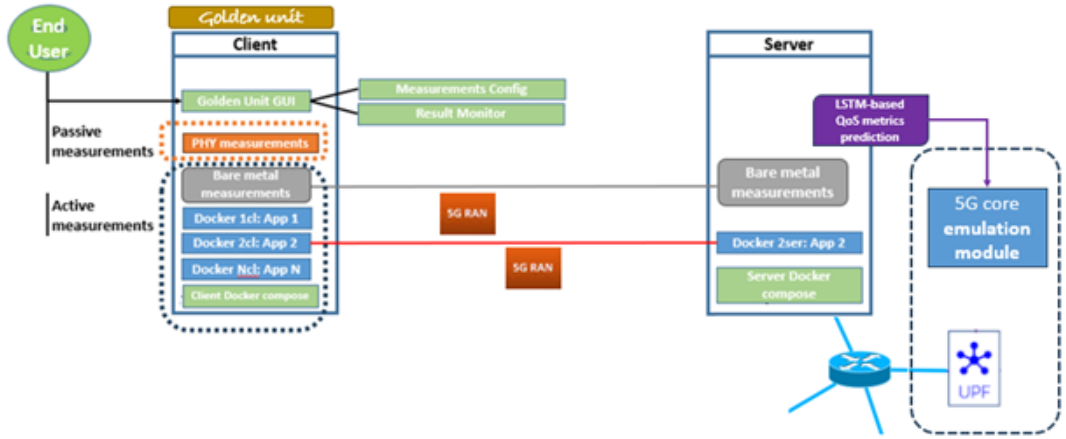
Comparison to objectives

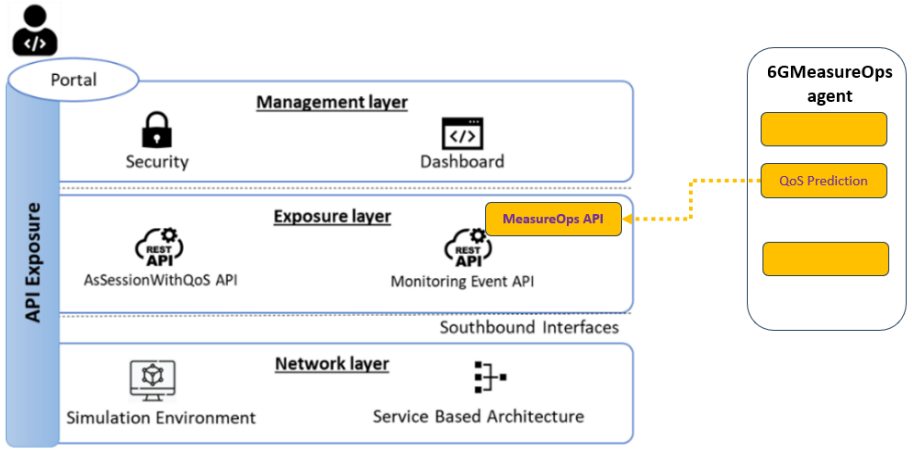
- *5G-BenchMoiv Objectives covered:*
  - *Open-source toolbox for "black-box" network benchmarking.* ✓ *Div: gray-box and energy evaluation for VNFs not feasible for test*
  - *Evaluation of various traffic profiles with the extraction of KPIs extending from radio access to application.* ✓
  - *Measurements of Radio Access Network conducted.* ✓
  - *Emulation of industrial automation traffic and PROFINET.* ✓
  - *Execution of active and passive testing cases through a configurable dashboard for NSA, SA, FR1, FR2.* ✓
  - *Means to set a reference measurement set.* ✓

A modular, upgradable, multi-tier, open, generic benchmarking tool for network performance assessment.

5G-BenchMotiv

FERON Technologies, GR





Outlook and Next Steps

- *Improvement with the integration of a single unit for both ends (extended golden unit – no need for servrer) in order to avoid synchronization issues.*
- *Multiple interfaces and/or sim cards in order to evaluate multiple networks at the same time.*
- *Development of test containers for various other types of applications extending to different verticals.*
- *Maintain, support and upgrade the solution.*
- *Offer benchmarking as a service – including drive-tests. Fully support the use of the tool from the installation to analysis and assessment*
- *Support Ericsson and TARGET-X beyond the scope of the project in order to conclude to a stable version that fits the requirement of a networking and telecommunication company.*
- *Record extended datasets for joint exploitation with the network provider-operator.*
- *Explore new possibilities for projects to further exploit the developed solution.*
  - *The tool will be used in two FERON projects (5G-IANA micro-project and SEQURED EDF project).*

ASTREO-ENERGY-5G

Jonjan Hoxha, Alberto Marri

Astreo

ASTREO-ENERGY-5G

Astreo

Challenge and Motivation

- *Our project addresses the urgent need to **reduce energy consumption** and **carbon emissions** in industries*
- *We want to offer a **scalable** and **flexible** approach that can be easily adopted by various **manufacturing environments** within the EU*

Objective

- *Revolutionizing energy monitoring with a plug&play **5G-enabled sensor***
- ***Automated intelligent insights** for industrial machines*
- *Energy sensor to be **seamlessly** integrated into various manufacturing environments*
- *The gathered data is wirelessly transmitted via **5G** in every selected frequency to a base station*

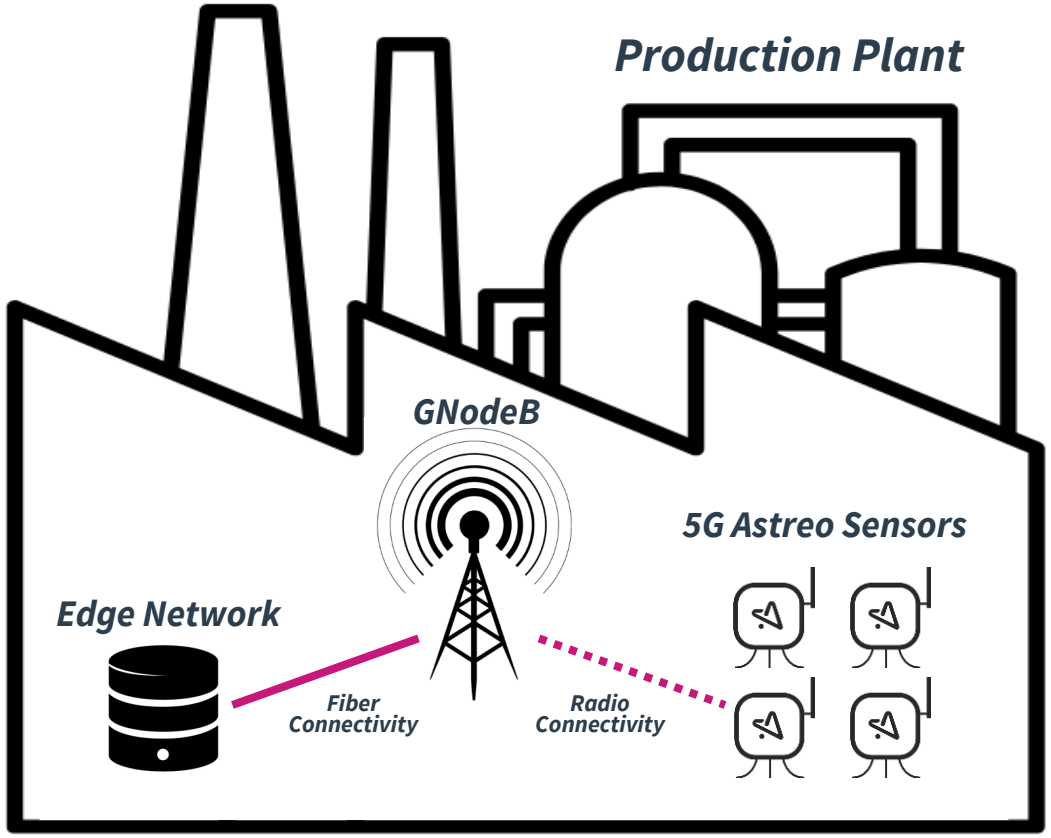
We want to save on energy consumption and reduce pollution using the latest 5G Technology and AI algorithms

ASTREO-ENERGY-5G

Astreo

Solution Approach

- *We are developing a **5G sensor** to extract power consumption data from each industrial machinery*
- *We will install one sensor per machine, and we will send data of **current** and **voltage** usage*
- *Our **Cloud Platform** analyzes data, using our intelligent algorithm, and we generate reports*
- *Both **Public** and **Private** Edge Approach*



ASTREO-ENERGY-5G

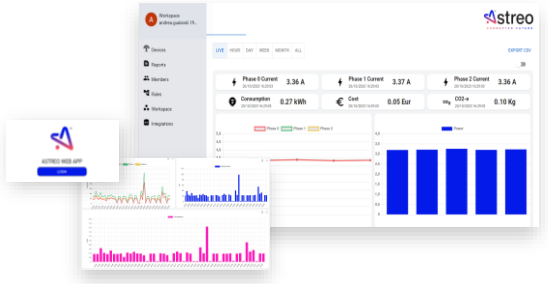
Astreo

PLUG AND PLAY HARDWARE

Astreo's Sensors are **easy** to install and communicate **wirelessly**

INTELLIGENT ALGORITHMS

Automatic and **periodical reports** about the production line



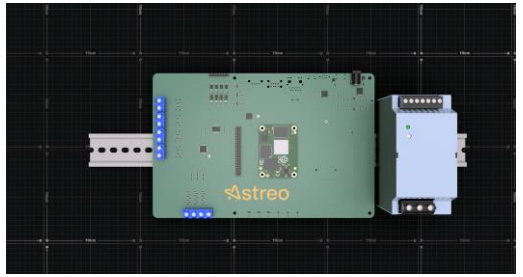
CLOUD SOFTWARE PLATFORM

Data are shown on a software platform, available **on Cloud**

ASTREO-ENERGY-5G

Astreo

Solution Compatible with any Machinery



Machine-agnostic and it works in **any industrial environment**

CAPTURING POWER

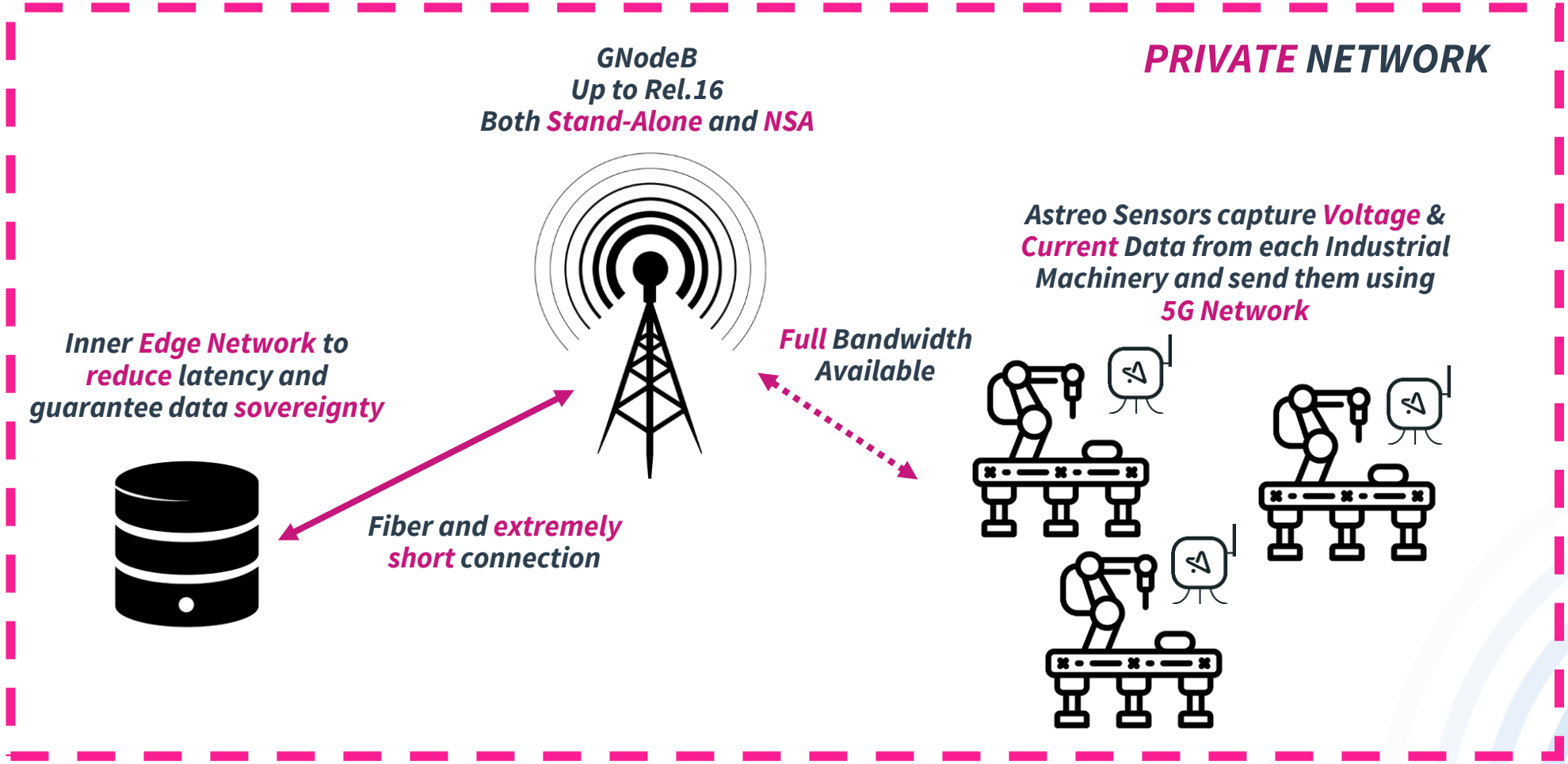
Our sensors capture data about **Current** & **Voltage**

REAL TIME MONITORING

Real-time data transmitted to the **5G edge**

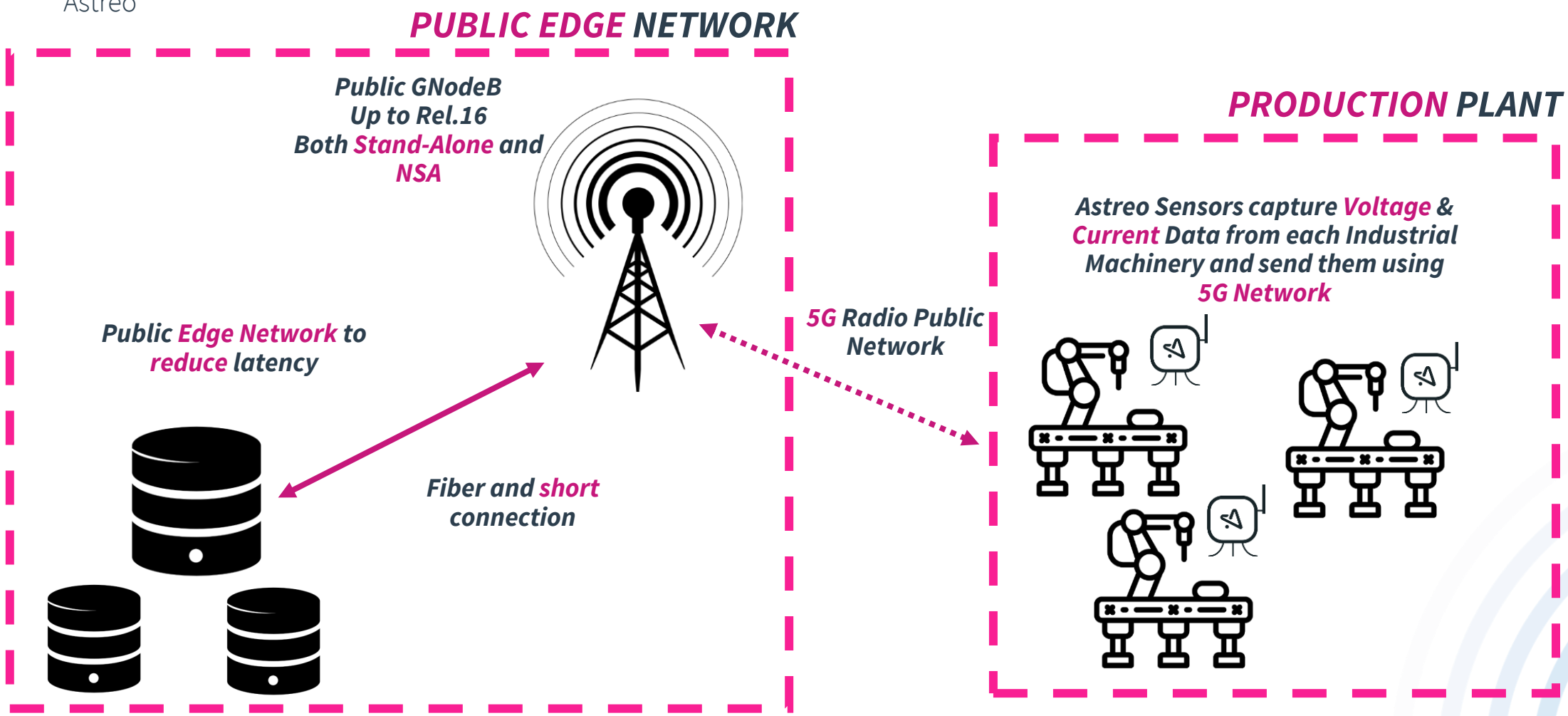
ASTREO-ENERGY-5G

Astreo



ASTREO-ENERGY-5G

Astreo



ASTREO-ENERGY-5G

Astreo

Results

- *Setup of a **private network** using our 5G sensors, achieving results in term of capacity and latency*
- *Full **Power Monitoring** of industrial machineries and data available on the Cloud Platform through **5G Connectivity***
- *10% of **Potential Energy Saving** and **CO2-e Reduction Techniques***

Comparison to objectives

- *Our sensors are **plug&play** and **easy** to install, exactly as was our objective*
- *We achieved **full time** of energy monitoring, without interruption or data loss*
- *We achieved 10% of Potential Energy Saving, which is **in target** with our goal*

We are showing using 5G technology and data-driven approach is possible to save on energy and reduce pollution

ASTREO-ENERGY-5G

Astreo

Outlook and Next Steps

- *Improving **AI** algorithms and analysis*
- *Closed-loop feedback actions*
- *Save **more** than 10% of Energy*
- *Improving **Scalability** of the Sensors and of the Cloud Platform*

Hybrid Formation-Regulation Control for CAVs

Hacı Mehmet Güzey

Ada Guzey Engineering

Hybrid Formation-Regulation Control for CAVs

Ada Guzey Engineering Software Mechatronics Ltd.

Challenge and Motivation

- ***Challenge:*** *Maintaining synchronized speeds and safe following distances in truck platooning under varying traffic conditions while minimizing energy consumption and preventing sudden braking or acceleration.*
- ***Motivation****: To develop a robust, energy-efficient, and secure control system for CAV platooning that leverages 5G communication to enable real-time data exchange and improve road safety, fuel efficiency, and overall traffic flow.*

Objective

- ***Objective:*** *To develop and validate a hybrid formation-regulation control system for CAV truck platooning, ensuring synchronized speeds, safe following distances, and improved energy efficiency through the use of real-time 5G communication.*
- ***Relevance to 5G Industrial Use:*** *Demonstrate the industrial application of 5G technology in enhancing the reliability, speed, and security of vehicle-to-vehicle (V2V) communication within truck platoons, showcasing 5G's potential to revolutionize connected and autonomous vehicle operations.*
- ***Contribution to TARGET-X Goals:*** *The HybridCAVs project contributes to TARGET-X by providing a practical use case for 5G-enabled autonomous driving, helping to accelerate the digital transformation of the automotive sector through large-scale trials and real-world validation of advanced vehicle platooning technologies.*

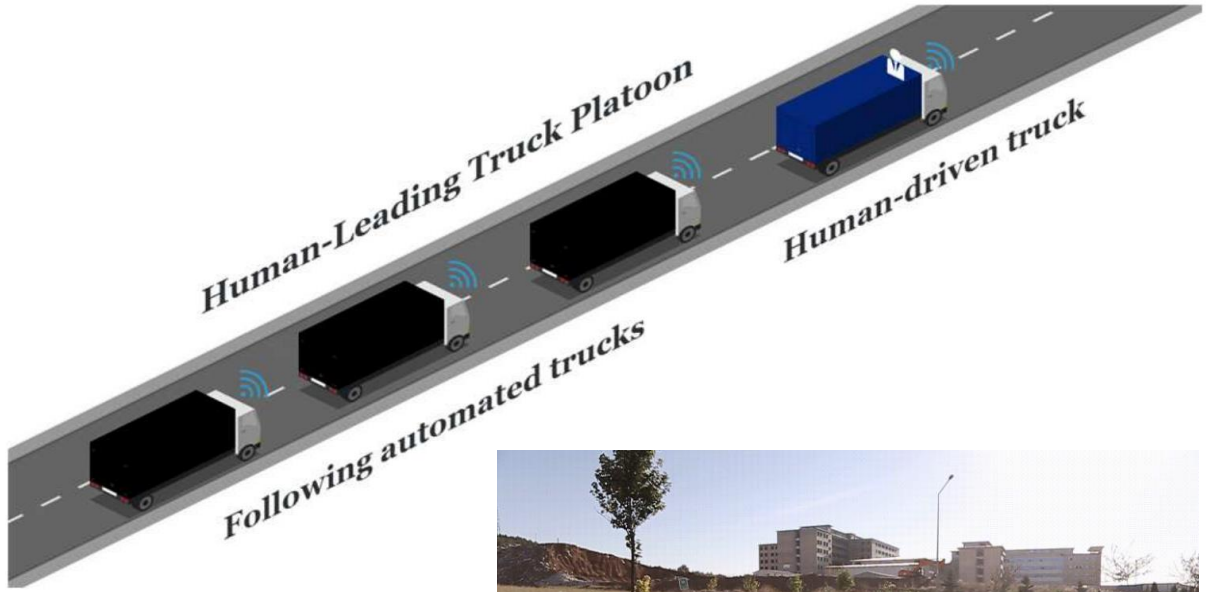
How can we create and validate a 5G-powered control system that boosts safety, energy efficiency, and synchronization in autonomous vehicle platoons?

Hybrid Formation-Regulation Control for CAVs

Ada Guzey Engineering Software Mechatronics Ltd.

Solution Approach

- ***Hybrid Control System:*** *Developed a hybrid formation-regulation control system integrating speed consensus and following distance controllers for smooth, energy-efficient platoon management.*
- ***Prototyping and Testing:*** *Designed and built prototype autonomous trucks and rigorously tested the system in both simulated environments and real-world 5G infrastructure.*
- ***5G Integration:*** *Leveraged 5G technology for real-time, low-latency communication between vehicles, ensuring precise synchronization and safe operations.*



Hybrid Formation-Regulation Control for CAVs

Ada Guzey Engineering Software Mechatronics Ltd.

Sytem Dynamics

$$\dot{x}_{1i} = x_{2i}$$
$$\dot{x}_{2i} = f_i + g_i u_i \quad \forall i = 1 \dots n$$

a. Following Distance Controller

$$u_i = \frac{1}{g_i}\left(-f_i + \left(f_{(i-1)} + g_{(i-1)}u_{(i-1)}\right) - \lambda\left(x_{2i} - x_{2(i-1)}\right) - k_{i1}s_i\right)$$

a. Speed Consensus Controller Design

$$u_{i2} = \frac{1}{ng_i}\left(-nf_i + \sum_{j=i}^{n}\left(f_j + g_j u_j\right) - k_{i2} \in_i\right)$$

a. Combined Controller Design

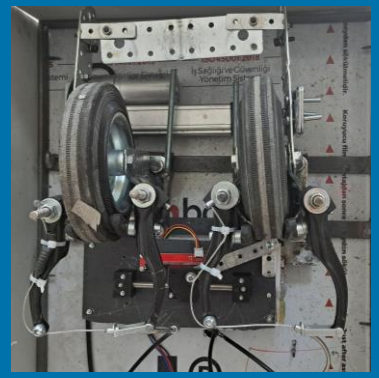
$$U_i = \begin{matrix} u_{i1}B_{inc} + u_{i2}B_{dec} & \text{in the following distance mode} \\ u_{i1}B_{dec} + u_{i2}B_{inc} & \text{in the speed consensus mode} \end{matrix}\Bigg\}$$

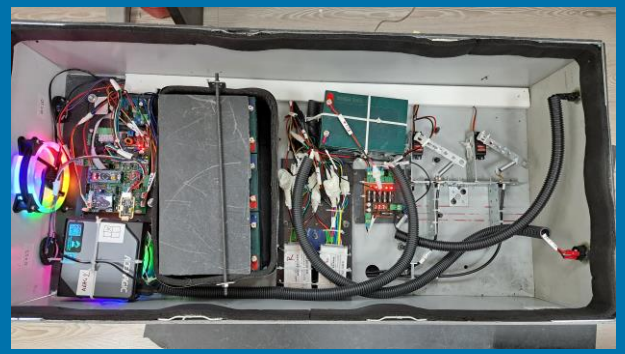
with $B_{inc} = 1 - e^{-k(t-tm_i)}$, $B_{dec} = e^{-k(t-tm_i)}$, tm_i is the last time mode is changed for the i^{th} vehicle,

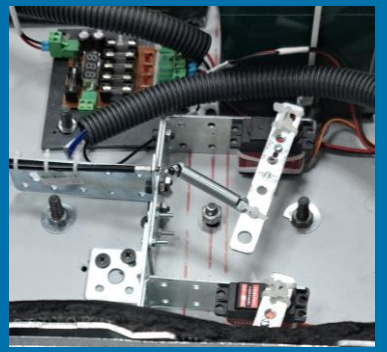
Hybrid Formation-Regulation Control for CAVs

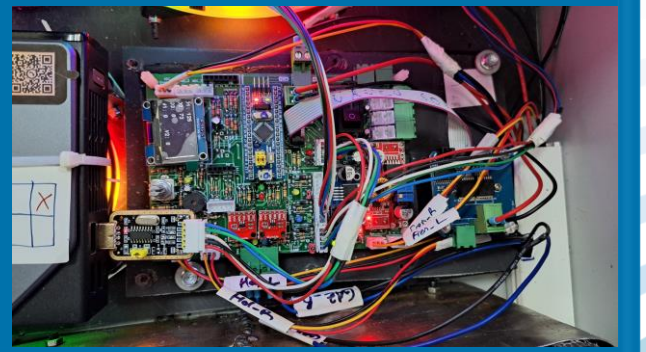
Ada Guzey Engineering Software Mechatronics Ltd.

Prototype Truck Developement for Platoon Control Tests









Hybrid Formation-Regulation Control for CAVs

Ada Guzey Engineering Software Mechatronics Ltd.

Prototype Truck Developement for Platoon Control Tests

Hybrid Formation-Regulation Control for CAVs

Ada Guzey Engineering Software Mechatronics Ltd.

Hybrid Formation-Regulation Control for CAVs

Ada Guzey Engineering Software Mechatronics Ltd.

Results

- ***Validated Control System:*** *Successfully developed and validated a hybrid control system that efficiently synchronizes vehicle speeds and maintains safe following distances in platoons.*
- ***Proven 5G Advantage:*** *Demonstrated the significant benefits of 5G technology in reducing communication latency and enhancing the safety and reliability of autonomous vehicle operations.*
- ***Prototype Development:*** *Built and tested functional autonomous truck prototypes that serve as a scalable platform for future research and development in vehicle platooning.*
- *https://iopscience.iop.org/article/10.1088/1402-4896/ad69e4*

Comparison to objectives

- ***Initial Objective:*** *The primary goal was to develop an energy-efficient and safe longitudinal control system for truck platooning.*
- ***Achieved Result:*** *While the longitudinal control was successfully developed and validated, we discovered that effective transverse control (steering and braking) was also essential for maintaining straight paths and overall stability. This required additional development time and effort.*

We successfully developed and validated a hybrid control system for truck platooning that enhances energy efficiency and safety, while overcoming unexpected challenges in steering and braking, resulting in a comprehensive solution published in a prestigious journal and backed by robust 5G communication and user interface development.

Hybrid Formation-Regulation Control for CAVs

Ada Guzey Engineering Software Mechatronics Ltd.

Outlook and Next Steps

- *Professionalize Prototypes: Upgrade the prototype trucks, with a particular focus on enhancing the brake and steering systems to ensure greater reliability and precision.*
- *Scalable Network Infrastructure: Expand and refine the network infrastructure to support more nodes, moving beyond the current limitation of 4 (3 vehicles and a main computer), enabling broader and more complex platooning scenarios.*
- *Commercialization: Develop a commercialization strategy to market and sell the upgraded system to universities, research centers, and truck companies engaged in truck platooning research.*
- *Partnership Development: Establish strategic partnerships with academic institutions and industry stakeholders to foster collaborative research and further innovation in platooning technologies.*
- *Field Testing and Validation: Conduct extensive field testing with the upgraded system to validate its performance in real-world conditions, ensuring it meets the needs of potential customers and aligns with industry standards.*

SBPATH-5G

Dimitri Kaparis

MetrologyLab

5G-Enhanced Robotic Welding Guidance – SBPATH-5G

Metrology – LAB LTD (Bulgaria)

Challenge and Motivation

- *Challenge: Address the complexity and inefficiency in current robotic welding processes by integrating advanced technologies like AR, VR, and 5G for real-time data visualization and precise control.*
- *Motivation: Enhance the accuracy and efficiency of automated welding operations by enabling real-time feedback and adjustments, reducing material waste, and improving overall production quality.*
- *Goal: Leverage 5G connectivity and cutting-edge simulation tools to create a robust system that supports flexible, high-precision welding in dynamic industrial environments.*

Objective

- *Objective: Develop a highly accurate, real-time robotic welding system using advanced AR, VR, and 5G technologies to streamline the welding process, reduce errors, and improve efficiency.*
- *Relevance to 5G: By leveraging 5G's low latency and high bandwidth, the project enables seamless communication between edge devices and centralized servers, ensuring rapid processing and real-time adjustments critical for industrial applications.*
- *Contribution to TARGET-X: This project aligns with TARGET-X's goals by advancing the integration of 5G in manufacturing, fostering innovation in industrial automation, and setting a precedent for next-generation robotic systems that enhance productivity and precision in complex industrial environments.*

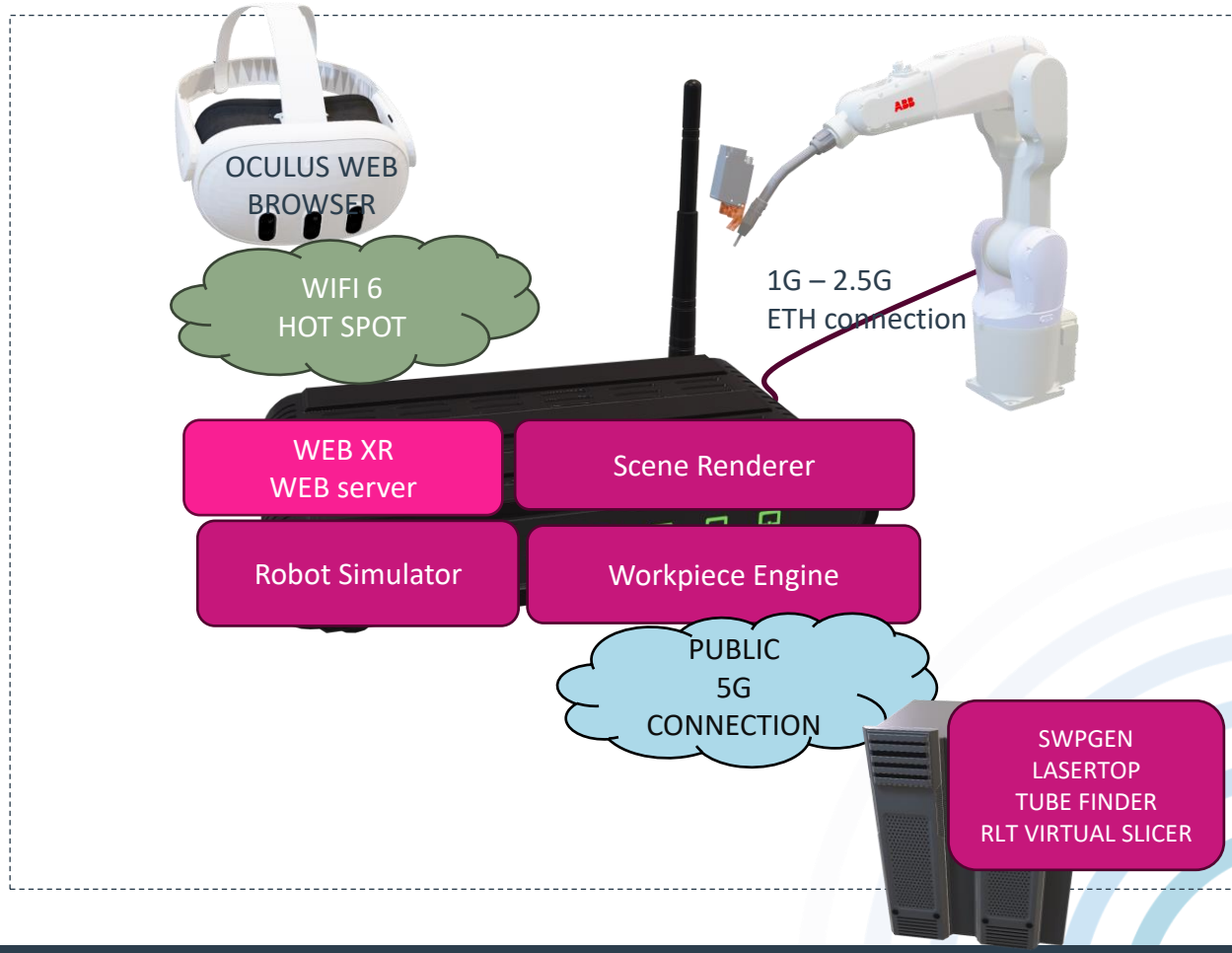
How can the integration of 5G technology with AR and VR enhance the precision, efficiency, and real-time adaptability of robotic welding processes in complex industrial environments?

5G-Enhanced Robotic Welding Guidance – SBPATH-5G

Metrology – LAB LTD (Bulgaria)

- Develop a comprehensive VR and AR platform that allows users to interact with and modify robot programs in a virtual environment. This will include creating intuitive interfaces for users to navigate through different programming stages and simulate robot actions.
- Implement advanced visualization techniques that accurately represent the robot's operating environment and its interaction with objects. This includes simulating the physical properties of materials and the robot's movements to predict potential issues in the program.
- Integrate the platform with existing robot programming and control systems, ensuring compatibility and seamless data exchange. This involves developing APIs and data exchange protocols that support a wide range of robot models and manufacturers.

Solution Approach

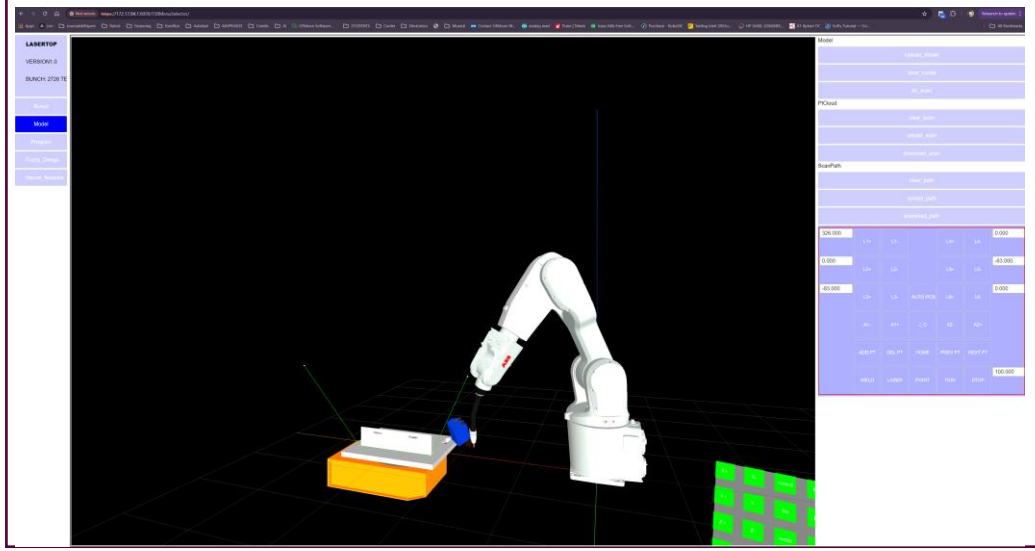


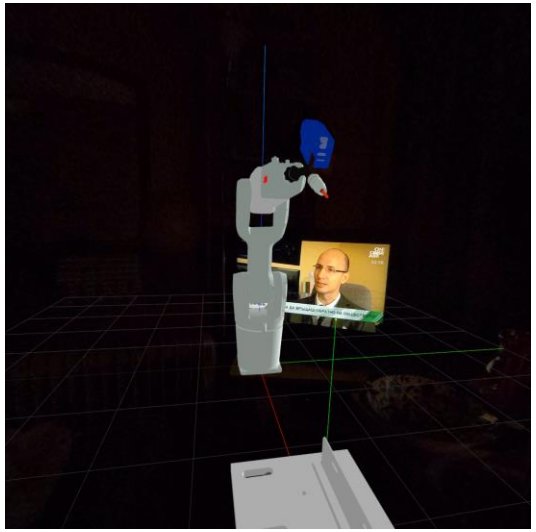
5G-Enhanced Robotic Welding Guidance – SBPATH-5G

Metrology – LAB LTD (Bulgaria)

WEB XR Technology

Web XR is a technology which allow minimal additional code over the default web Browser to provide VR and XR experience.





5G-Enhanced Robotic Welding Guidance – SBPATH-5G

Metrology – LAB LTD (Bulgaria)

USE CASES

- **SWPGEN:** A system that generates and optimizes welding paths by processing point cloud data from real or virtual scans, enabling real-time adjustments and simulations.
- **LASER TOP:** An application that proposes and optimizes welding parameters based on defined paths, ensuring precision and efficiency in automated welding operations.
- **Point cloud Slicer:** A tool that generates detailed point clouds from CAD drawings through virtual scanning, facilitating accurate welding path planning and simulation.
- **Tube Center Finder:** An application that detects tube centers from point cloud data of scanned metal sheets and adjusts welding programs accordingly for heat exchanger assembly.

Project Name

Metrology – LAB LTD (Bulgaria)

Objective	Result
Improve Precision in Robotic Welding	Achieved significant precision improvements in welding paths
Increase Efficiency of Welding Process	Reduced material waste and process time
Integrate 5G for Real-Time Communication	Established low-latency, reliable 5G communication
Enable Real-Time Feedback and Simulation	Implemented effective real-time feedback and path adjustments

5G-Enhanced Robotic Welding Guidance – SBPATH-5G

Add you company logo here

Metrology – LAB LTD (Bulgaria)

Results

- *Enhanced Precision: Successfully developed a system that significantly improves the accuracy of robotic welding through real-time adjustments enabled by 5G and AR/VR integration.*
- *Increased Efficiency: Demonstrated reduced material waste and faster welding processes by enabling instant feedback and simulation of welding paths.*
- *Seamless 5G Integration: Validated the effective use of 5G technology in industrial environments, ensuring reliable, low-latency communication between edge devices and centralized servers for complex manufacturing tasks.*

Comparison to objectives

- *Objective: Improve the precision and efficiency of robotic welding using 5G, AR, and VR.*
- *Result: Successfully enhanced precision and reduced material waste, meeting the objective of creating a more accurate and efficient welding process.*
- *Objective: Seamlessly integrate 5G technology for real-time communication in industrial environments.*
- *Result: Achieved reliable, low-latency communication between edge devices and servers, validating the effective integration of 5G in the system.*
- *Objective: Enable real-time feedback and simulation in robotic welding.*
- *Result: Implemented real-time feedback and simulation, allowing for immediate adjustments and ensuring that the system operates as envisioned.*

The project successfully met its objectives by improving the precision and efficiency of robotic welding processes through the effective integration of 5G technology, enabling real-time adjustments and reliable communication in an industrial setting.

5G-Enhanced Robotic Welding Guidance – SBPATH-5G

Metrology – LAB LTD (Bulgaria)

Outlook and Next Steps

- *Please provide an overview of the next steps (4-5 bullet points)*

SPARTA

Soumya Kanti Datta

Digiotouch

Secure, Open APIs for Automotive Applications (SPARTA)

Digiotouch

Challenge and Motivation

- *The automotive sector is challenged by the need to securely and efficiently integrate diverse connectivity technologies through APIs for sensor data acquisition, network infrastructure management, and data analysis systems into vehicular processes.*
- *The automotive sector requires a comprehensive assessment of these APIs' performance, focusing on response times, data throughput, and resource efficiency. This assessment needs to be conducted under realistic conditions to identify bottlenecks and areas for optimization, ensuring that the APIs can meet the rigorous demands of real-world automotive applications.*

Objective

- *To explore secure and efficient methods for integrating connectivity technologies (e.g., 5G, 4G) for vehicular data acquisition*
- *To develop and deploy APIs that abstract the complexities of the underlying automotive infrastructure connectivity technologies and demonstrate selecting/switching a connectivity technology (e.g., 5G) for data exchange.*
- *To assess the performance and efficiency of the APIs using metrics, such as, response time and data throughput.*

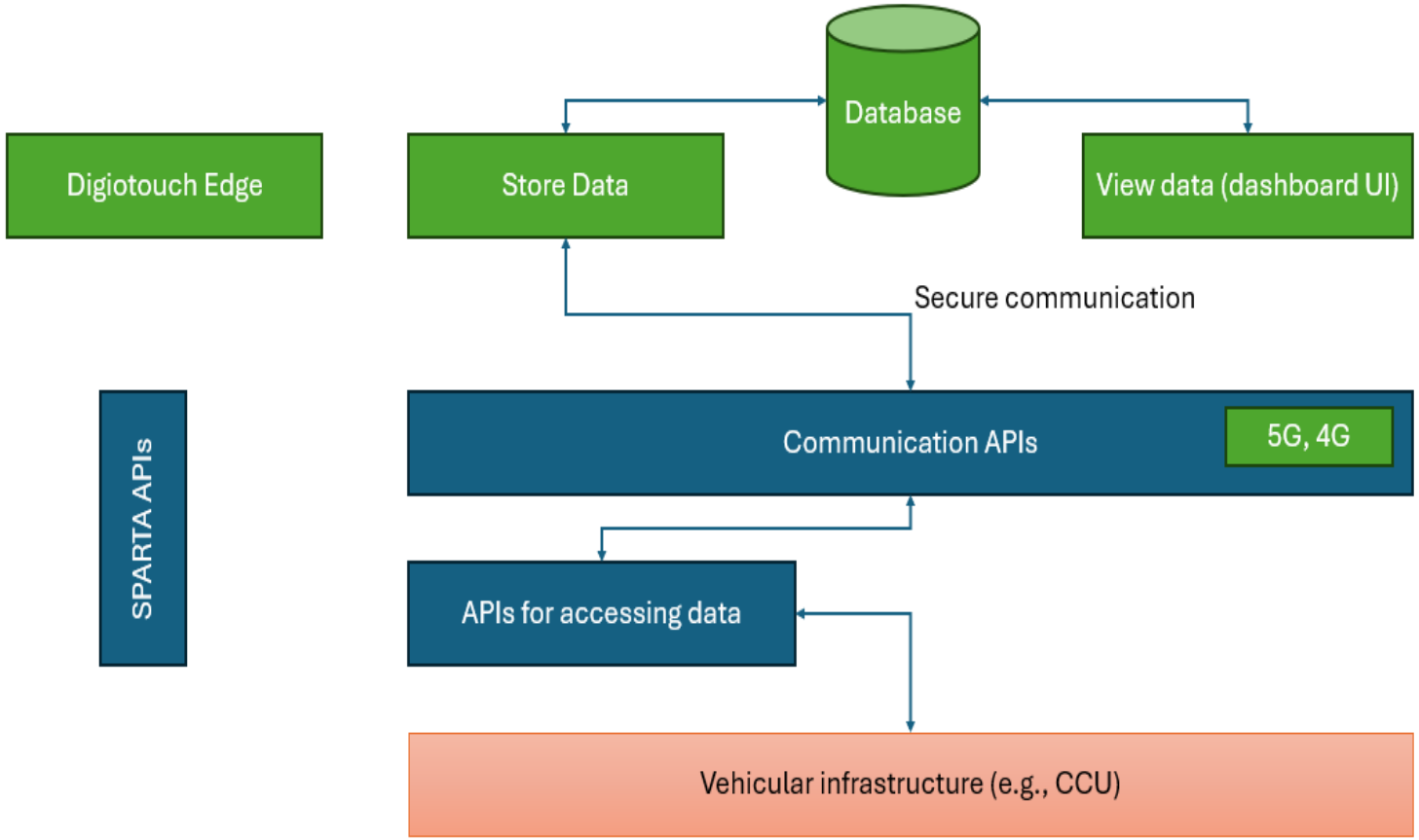
Research question – APIs for connectivity technology switching for automotive data exchange and their performance assessment

Secure, Open APIs for Automotive Applications (SPARTA)

Digiotouch

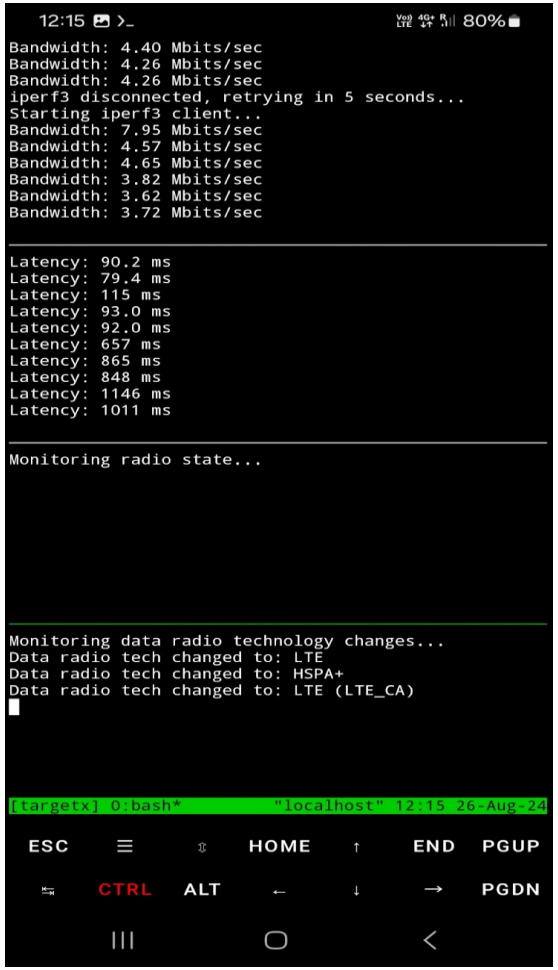
Solution Approach

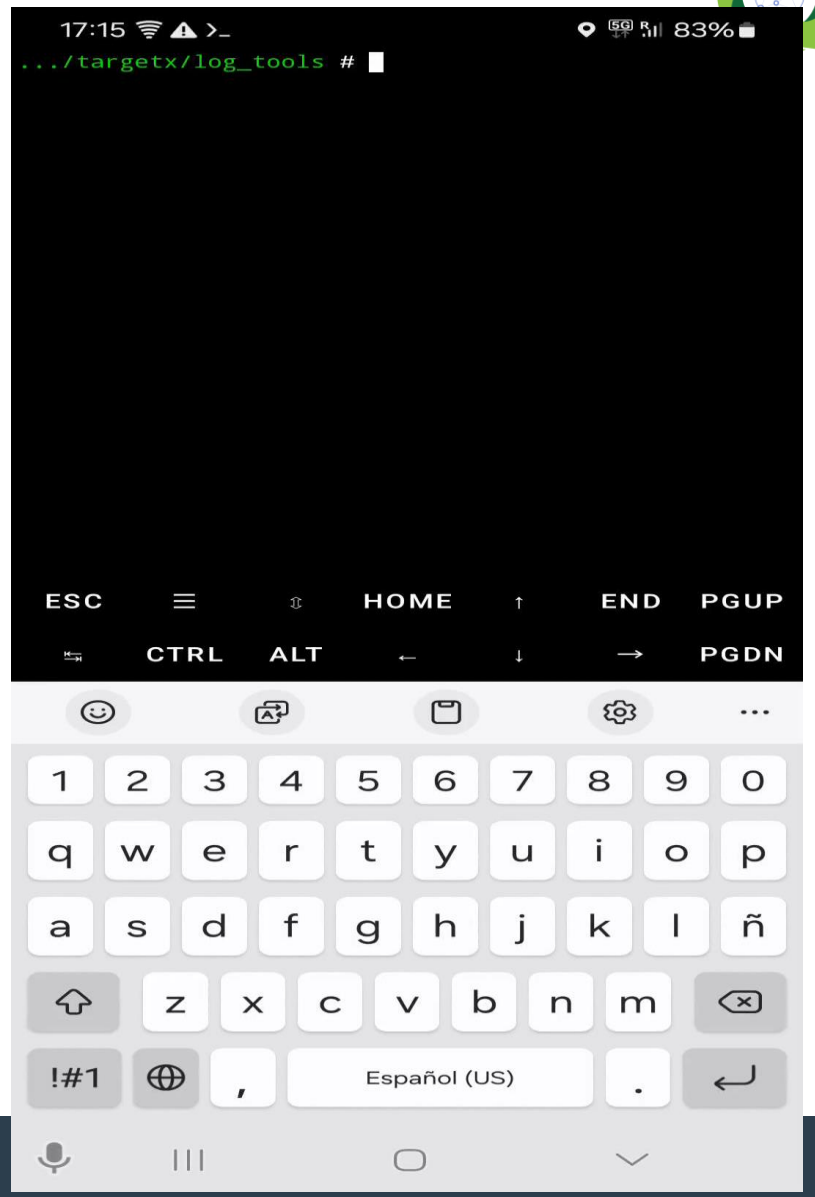
- *Developing APIs that expose and enable selecting connectivity with communication technologies, for example, 5G and 4G for data exchange.*
- *An Edge Computing Server hosting a database and a user interface (dashboard) showing measurements (for example latency, throughput, signal strength) transmitted using developed APIs.*



Secure, Open APIs for Automotive Applications (SPARTA)

Digiotouch



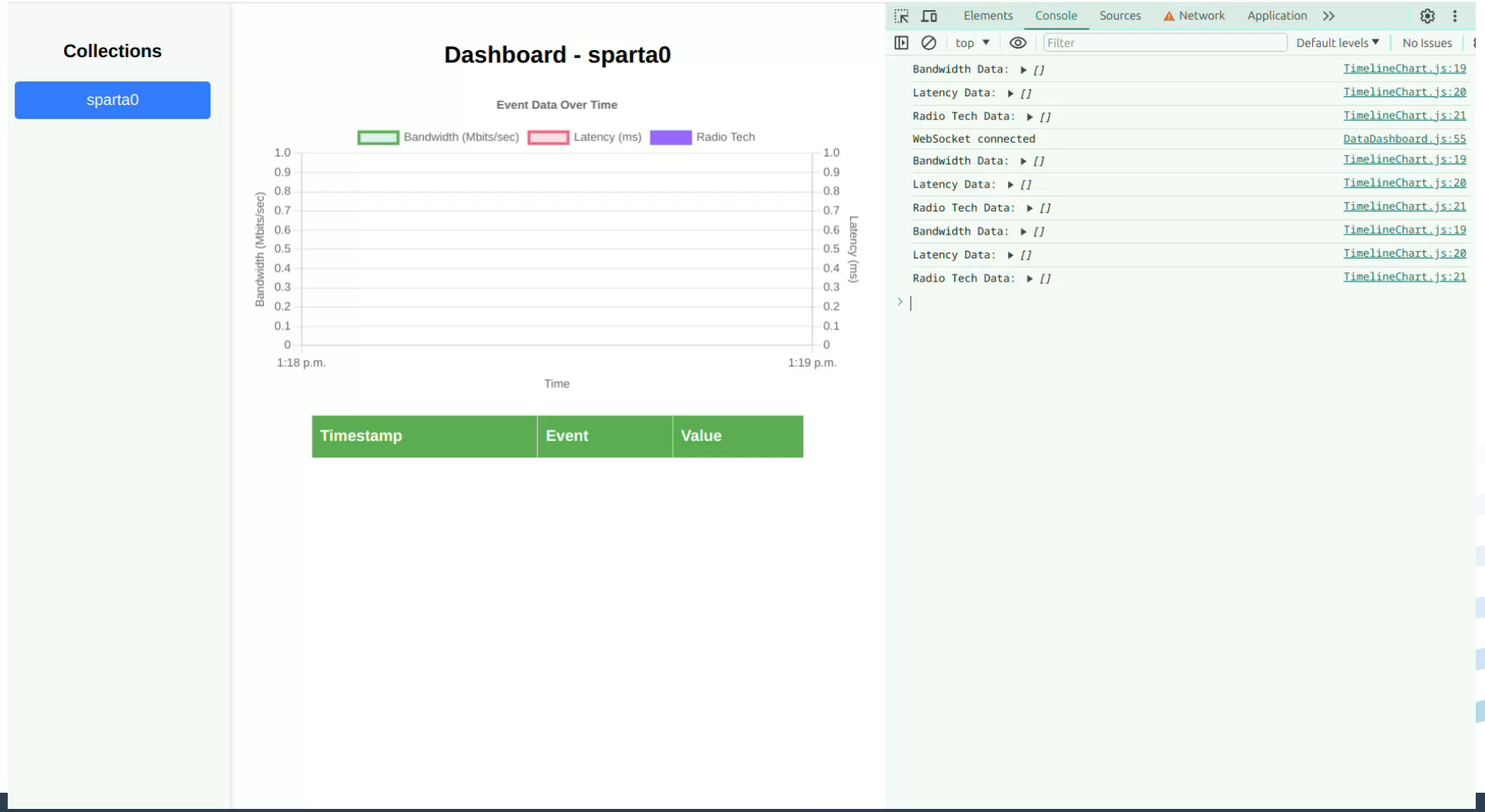


Connectivity technology switching (e.g., 5G → 4G → 3G) and establishing a reliable connection with the selected network

Secure, Open APIs for Automotive Applications (SPARTA)

Digiotouch

Dashboard with real time measurement data visualisation



Secure, Open APIs for Automotive Applications (SPARTA)

Digiotouch

Results

- *APIs that enable switching connectivity technology, establishing a reliable connection with the selected network, measurement data access and exchange.*
- *Performance assessment of the APIs with IDIADA and commercial networks.*
- *Open source APIs available at https://github.com/lporto/target.*

Comparison to objectives

- *All objectives are achieved*

Summary of results in one/two sentences

Secure, Open APIs for Automotive Applications (SPARTA)

Digiotouch

Outlook and Next Steps

- *SPARTA business development ongoing, focusing on Tier 1 and new entrants to the automotive market.*
- *Roadmap on premium software features are being prepared.*
- *A publication with the approach and test results is on the works.*

Demeter

Kayode Alao

Volvero

Demeter

MinervaS and Volvero

Results

- Improving shared mobility by creating a green and safe driving experience by exploiting context-aware information
- Use real-time data of the vehicle and the road to enhance driving skills of shared mobility services

Comparison to objectives

- Demonstrated and validated the potential of 5G technology in enhancing shared mobility.
- Developed and tested solutions that leverage 5G to improve efficiency, connectivity, and automation during the driving experience.
- Improved real-time telematics with advanced digital twins of the vehicle of MinervaS in Volvero use case.
- Tested a reward system to entice green and safe driving behaviour

Summary of results in one/two sentences

Demeter

Relevance of the Project in the Context of Industrial Use of 5G

Demeter is pivotal in the **mobility transition** towards more connected and cooperative automotive systems. By leveraging 5G technology, Demeter aims to optimize processes, enhance real-time data exchange, and improve the overall operational efficiency of in-vehicle applications.

The integration of 5G enables **faster and more reliable communicatio**n, supports the deployment of advanced IoT systems, and facilitates the automation of critical processes. This makes Demeter's project highly relevant for the transition towards next-generation mobility.

Demeter

Contribution to the Overall Goals of TARGET-X

Demeter contributes to the overall goals of TARGET-X by showcasing a practical and scalable application of 5G in the industrial sector, specifically in a shared mobility context.

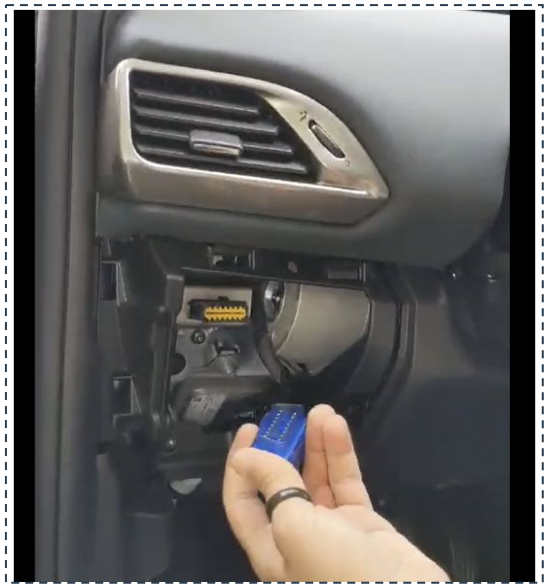
- *aligns with TARGET-X's mission to push the boundaries of 5G technology by offering a concrete example of how 5G can be used to achieve greater efficiency and innovation in industrial environments;*
- *sets the stage for broader adoption and integration of 5G solutions across various industries.*

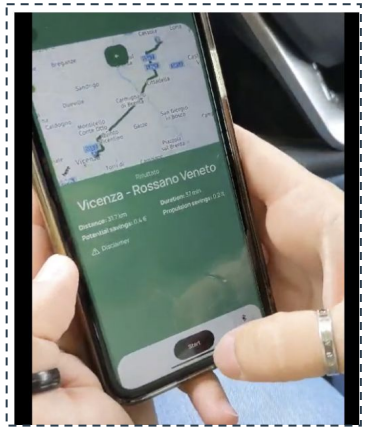
Would shared mobility market share grow if we propose a more controlled user experience?

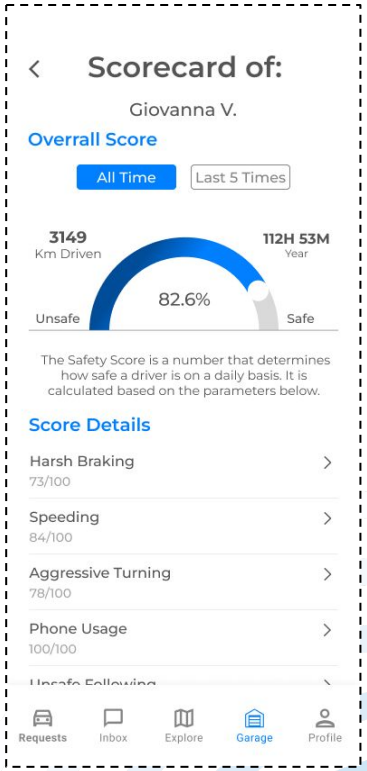
Demeter

Solution Approach

- *Integrate advanced telematics function in a shared mobility service*
- *Provide drivers with a scorecard based on a context-aware approach*
- *Trigger a gamification system to reduce hazardous driving behaviours and risks*







Demeter

Tech Development 1/2

MinervaS combines **real time CAN-bus data** with road information (road morphology, traffic conditions, weather forecast) and provides **optimal speed indications** to the driver via an HMI customized for driver's behaviour. Advanced algorithms and AI are used to predict and analyze driver behavior, evaluating adherence to speed limits, smoothness of driving (acceleration and braking), lane-keeping, and other safety and sustainability KPIs, leveraging model based approach (e.g., longitudinal dynamics)

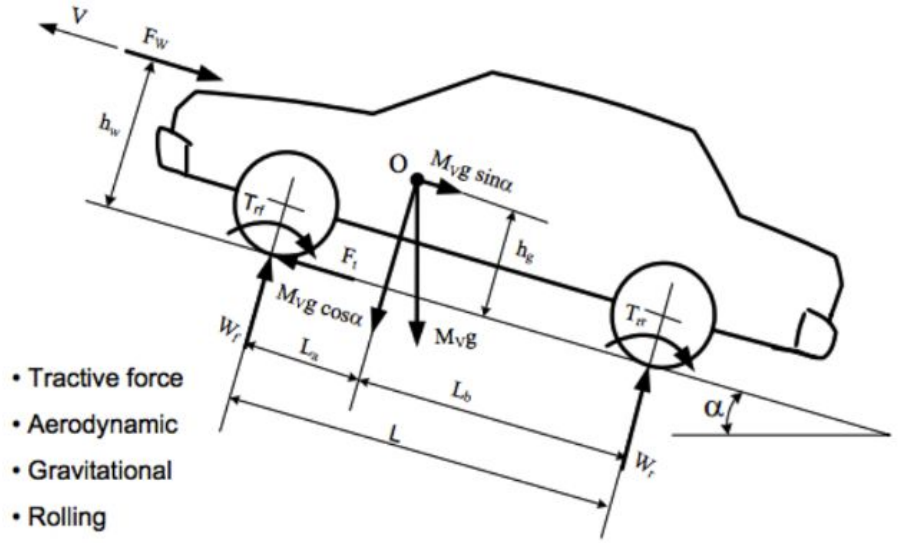
Instantaneous optimization
To adapt the reference velocity to the road slope

Full Horizon optimization

To ensure the time constraints of the expected time travel

Reciding Horizon

Adaptivity to unforseen disturbances

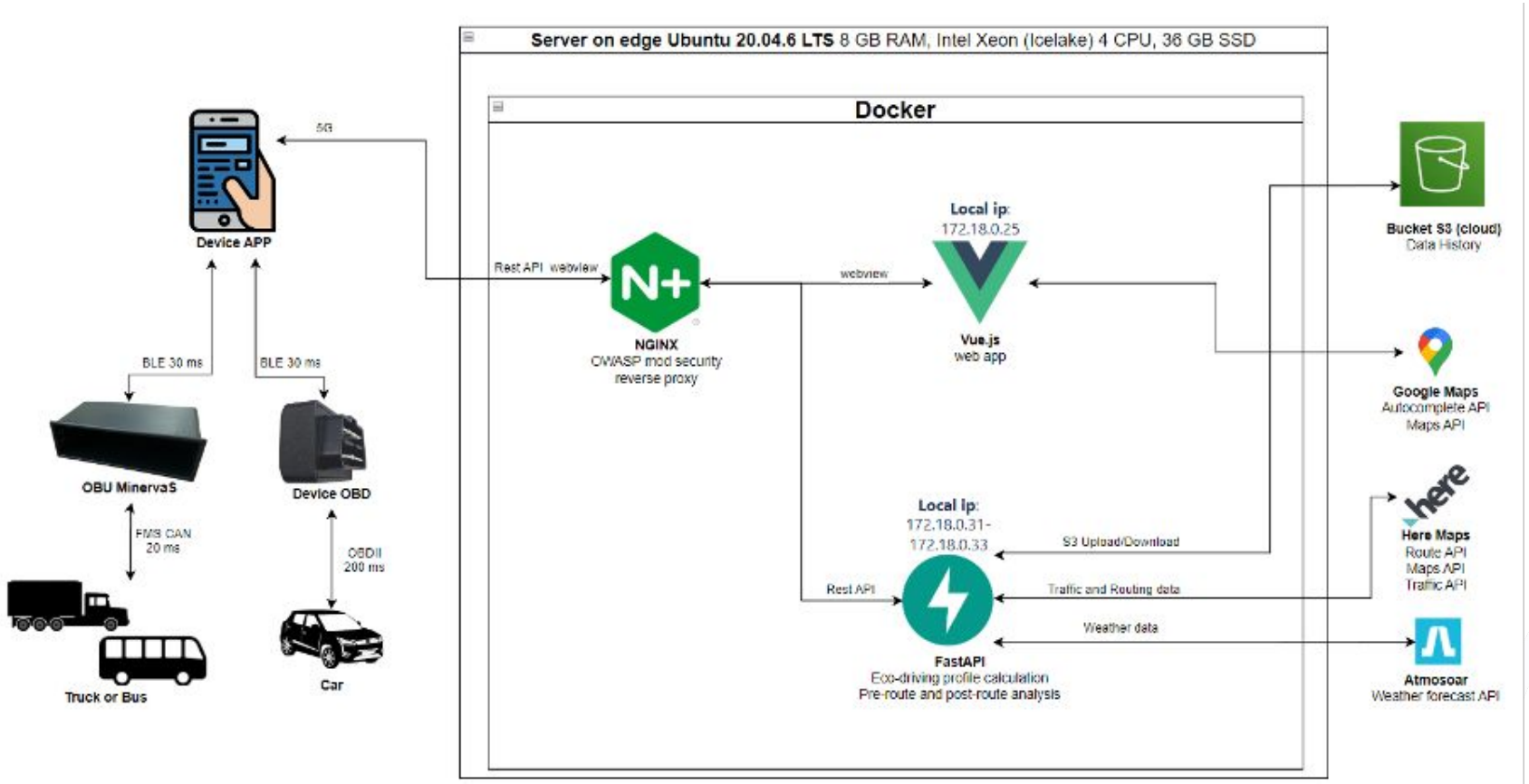


Longitudinal Dynamics Model

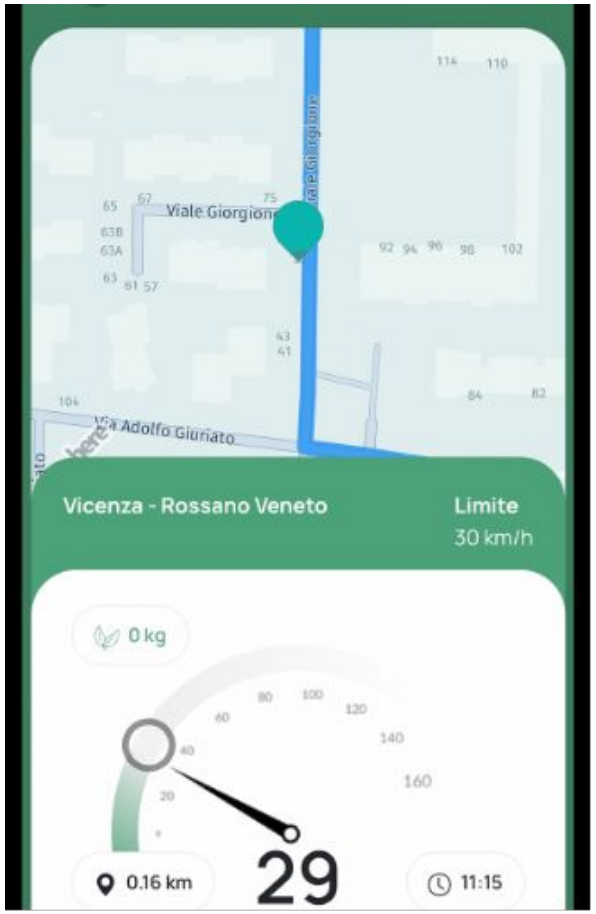
Demeter

Tech Development 2/2

Set-up of MinervaS Tech in the Volvero app under IDIADA 5G testbed



Demeter



Next Steps

- Improve the solution for EV
- Connect the solution to urban data (e.g. traffic lights and charging systems) in real-time.
- Improved the digital twins for any light-duty vehicles
- Test the solution in dedicated urban area

DynoSafe

Victor Varquero

IVEX

DynoSafe: Dynamic ODD for Safer CAVs

IVEX

Challenge and Motivation

- *Connected Automated Vehicles (CAVs) rely on the quality of the signal, which may drop affecting the proper functioning of the vehicle.*
- *Certain ADAS features can extend their Operational Design Domain if certain information is received from other vehicles or infrastructure.*
- *We aim at developing new technologies facilitating the analysis of vehicle communications.*

Objective

- *To collect at least 1500 kms of driving data, including LiDAR, video, localization, connectivity and network quality.*
- *To ingest, process and analyse collected network data in IVEX tools and automatically tag relevant events about signal quality.*
- *To develop the concept runtime monitoring systems to automatically tag relevant signal events to enable Dynamic ODDs.*

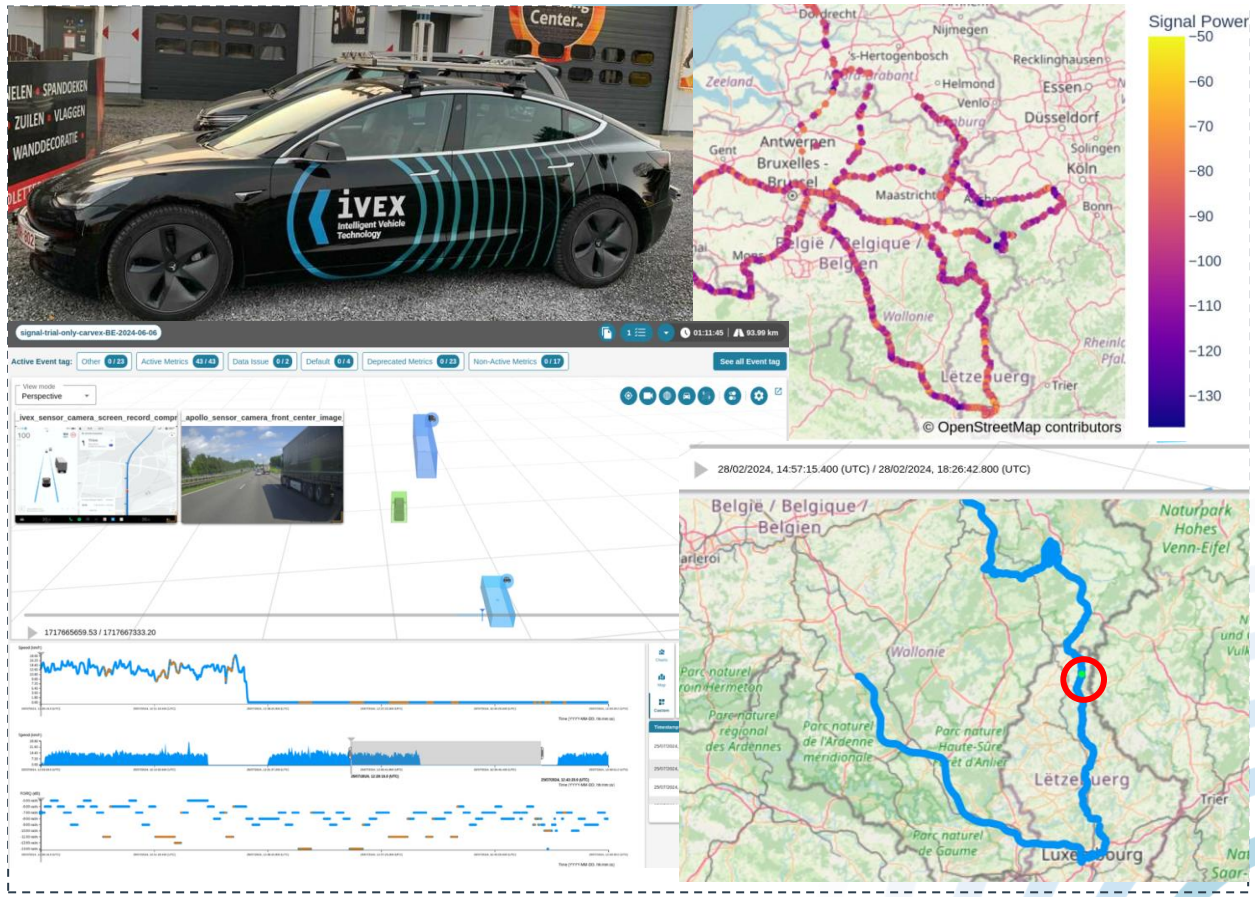
How to ensure that the communication is reliable, stable and continuous?

DynoSafe: Dynamic ODD for Safer CAVs

IVEX

Solution Approach

- *More than 2000 kms of driving data were collected, including LiDAR, Cameras, HMI and Connectivity Signal*
  - *Data collection Campaigns through 5 EU countries*
  - *GT signal collected in Aachen Automotive Campus*
- *Creation of new processing pipelines, front-end and workflows for IVEX tools*
  - *Including ODD extraction related to connectivity*
- *Performing correlation analysis*
  - *Signal Strength at different frequencies*
  - *Downlink and Uplink Speeds*



DynoSafe: Dynamic ODD for Safer CAVs

IVEX

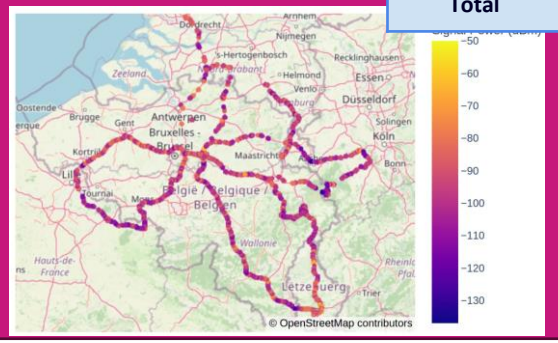
Data collection:

Collect at least 1500 kms of driving data, including LiDAR, video, localization and network quality.

- Objective exceeded with over 2000 kms.
- IVEX data collection platform (CARVEX)
  - Tesla Model 3 equipped with additional
  - New Sensor:
    - Motorola Moto G54 (5G)
    - Ericsson Device Analytics (EDA) Record the network signal quality

CARVEX Sensors:

- LiDAR
- GNSS/RTK
- 5x Cameras
- Tesla HMI



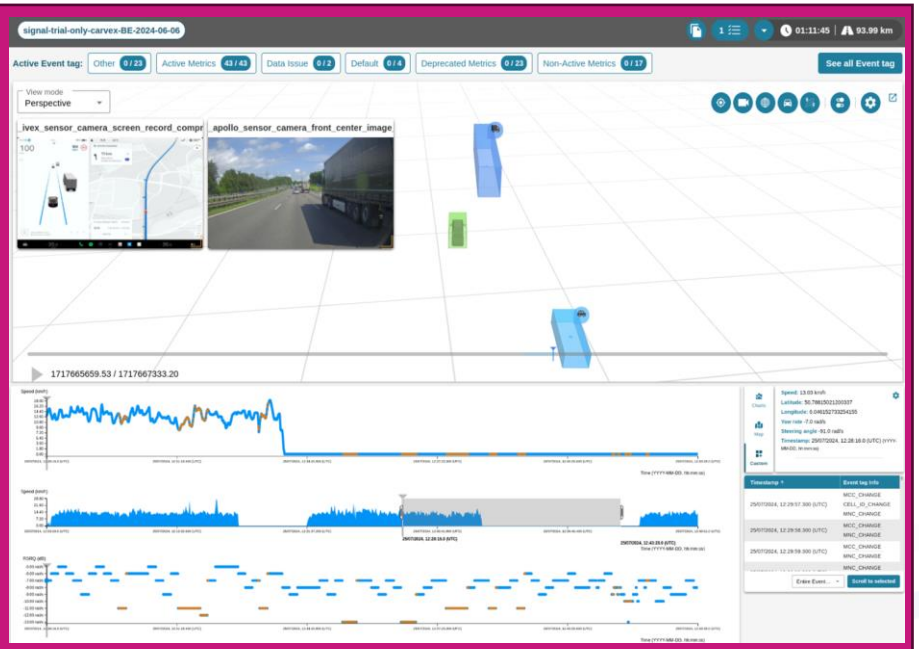
Date	Duration (hh::mm)	Distance (km)
2024-02-26	05:01	208
2024-02-27	07:12	329
2024-02-28	08:41	389
2024-02-29	07:38	390
2024-03-01	08:55	334
2026-06-03	03:09	257
2026-06-06	01:11	94
2026-07-25*	01:25	33
Total	**43h 12m**	**2034 km**

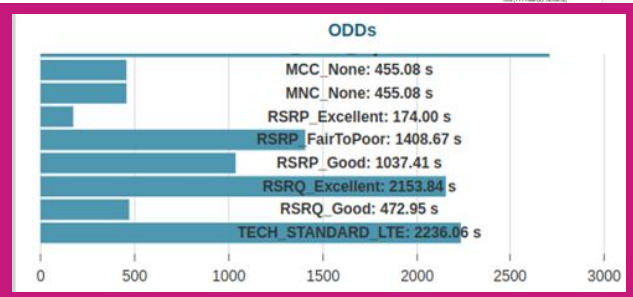
DynoSafe: Dynamic ODD for Safer CAVs

IVEX

Data processing & analysis

- New data processing pipelines were developed to process communication signals.
- New metrics (algorithm that tag timestamp relevant events in the data) were created
  - **Ping_Pong_detected:**
    tags when a cell id changes more than once in 3 s.
  - **Switch_to_RSRP_NoSignal:**
    flags every time the RSRP signal change its value and falls below -100 dB
  - **Switch_to_RSRQ_NoSignal:**
    flags every time the RSRQ signal change its value and falls below -20 dB
  - **MCC_Change:**
    an event flagging every time the MCC value changes.
  - **MNC_Change:**
    an event flagging every time the MNC value changes.
  - **CELL_ID_Change:**
    tags every time the cell id value changes
- Created new IVEX tags and ingested them as ODD.
  - showing the amount of time that during the recording the vehicle faced that specific event



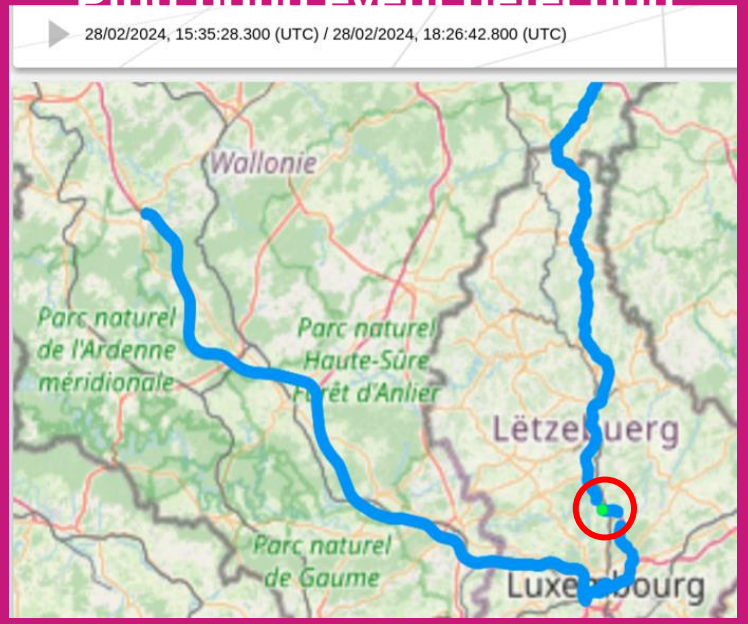


DynoSafe: Dynamic ODD for Safer CAVs

IVEX

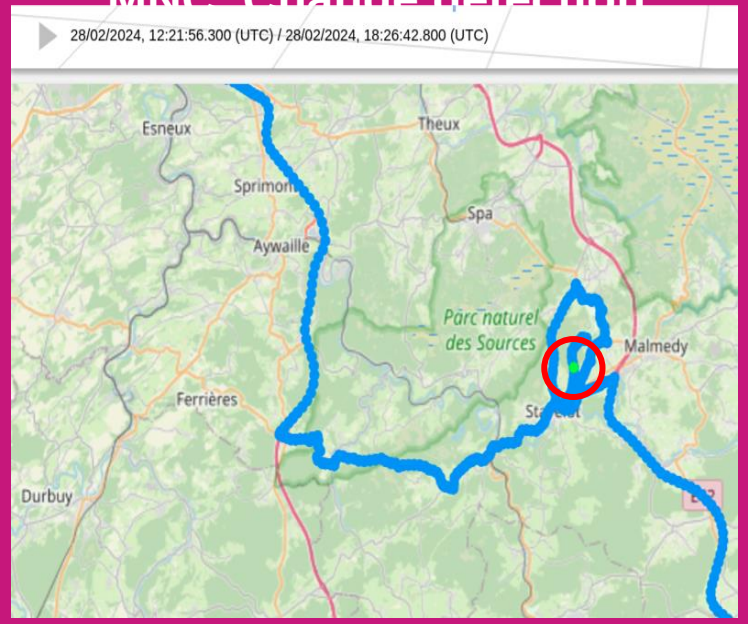
Data processing & analysis - Metric Examples

Ping pong event detection



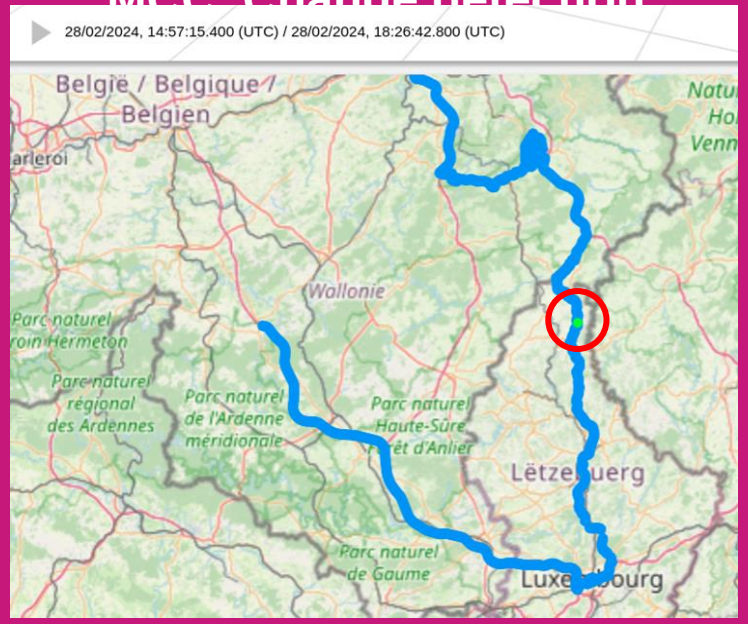
An unstable connection was detected close to Luxembourg. In a few seconds, the cell id changed many times

MNC Change detection



In this rural zone in Belgium, the network code changed, while the country code stayed the same.

MCC Change detection



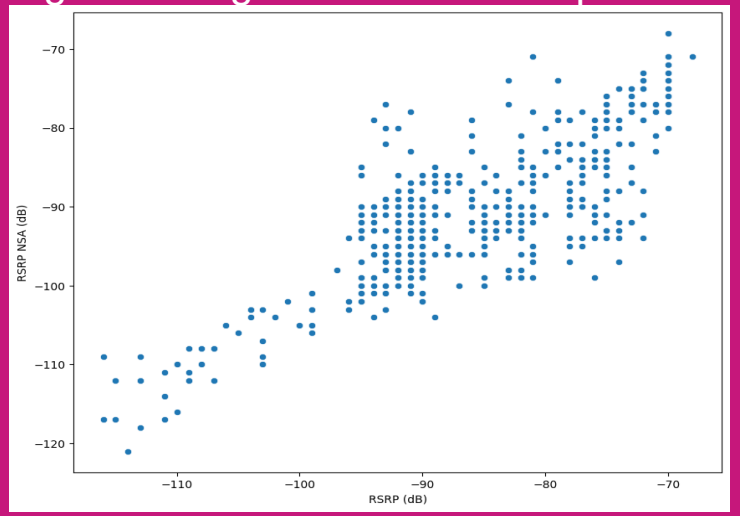
This detected event occurs when Luxembourg, Germany and Belgium borders are all close together.

DynoSafe: Dynamic ODD for Safer CAVs

IVEX

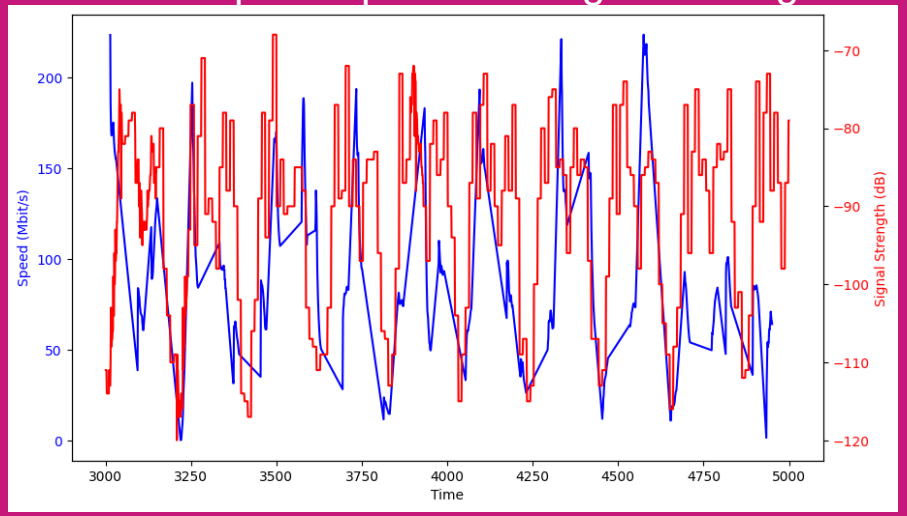
Correlation analysis

Signal strength in different frequencies



RSRP signal vs the RSRP NSA signal strength (Non-Standalone 5G). Shows a direct relationship. Most European 5G networks are NSA in which 5G is supported by existing 4G infrastructure

Downlink/Uplink Speeds vs Signal Strength



Consistent direct correlation between the Signal Strength and the Download/Upload. The higher the strength, the fastest the connection.

DynoSafe: Dynamic ODD for Safer CAVs

IVEX

Results

- *Network and communication data successfully integrated in IVEX software.*
- *New processing pipelines and metrics created, enabling simple signal strength analysis and event navigation*
- *Proof of concept for new products on monitoring signal and connectivity*

Comparison to objectives

- *The initial objectives were met and expectations have been exceeded.*

More than 2000 kms of signal data in EU roads was collected, processed and analysed opening new doors to future runtime signal monitoring components

DynoSafe: Dynamic ODD for Safer CAVs

IVEX

Outlook and Next Steps

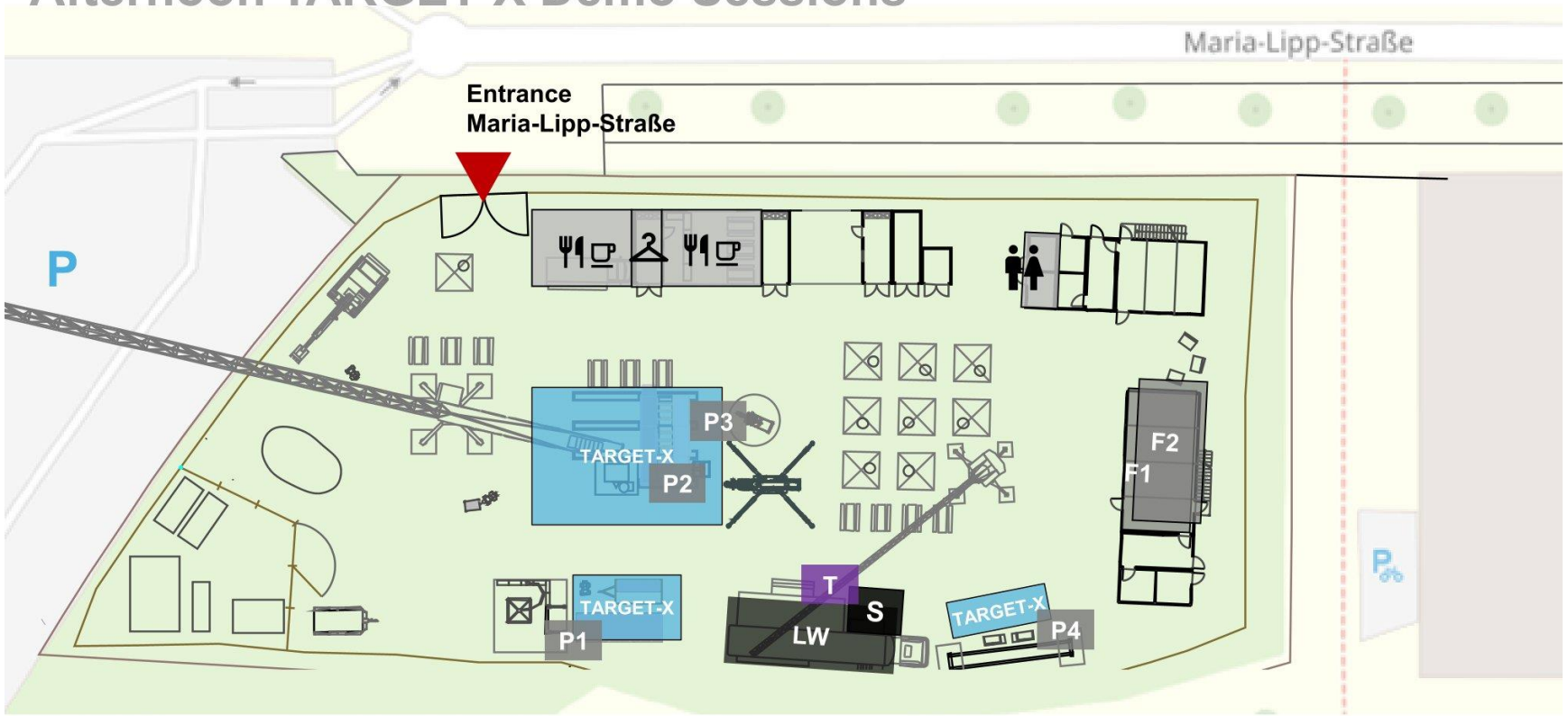
- *With the success of this project, IVEX developed tested new technologies to analyse communications signals.*
- *Next we will perform a market research analysis, and test market fit for similar solutions, following new coming regulations and needs.*

Open Minds meet Open Campus

Afternoon TARGET-X Demo Sessions

CONSTRUCTION ROBOTICS

September 17, 2024



Introduction
14:30

S Mainstage

TARGET-X Guided Tours*
Demo Sessions

T Starting Point

Times	14:45	15:35	16:20
	1	2	3

Permanent Demos

- **P1** Solar Trailer
- **P2** Steel Robotics
- **P3** Token Me
- **P4** IVEX

F1 **F2** CR Masters Programme Project Exhibition

LW Speed Dating in LW Truck

P Parking | Wardrobe | Food and Drinks | Toilets

*Please check the colour code on the name tags for the times of the tours

TARGET-X Tour

TARGET-X

Thank you for your attending the Open Day!

Contact

contact.target-x@ipt.fraunhofer.de

www.target-x.eu

Visit us on LinkedIn

Co-funded by the European Union

6GSNS