5G-IANA: 5G Intelligent Automotive Network Applications

5G-IANA overview presentation

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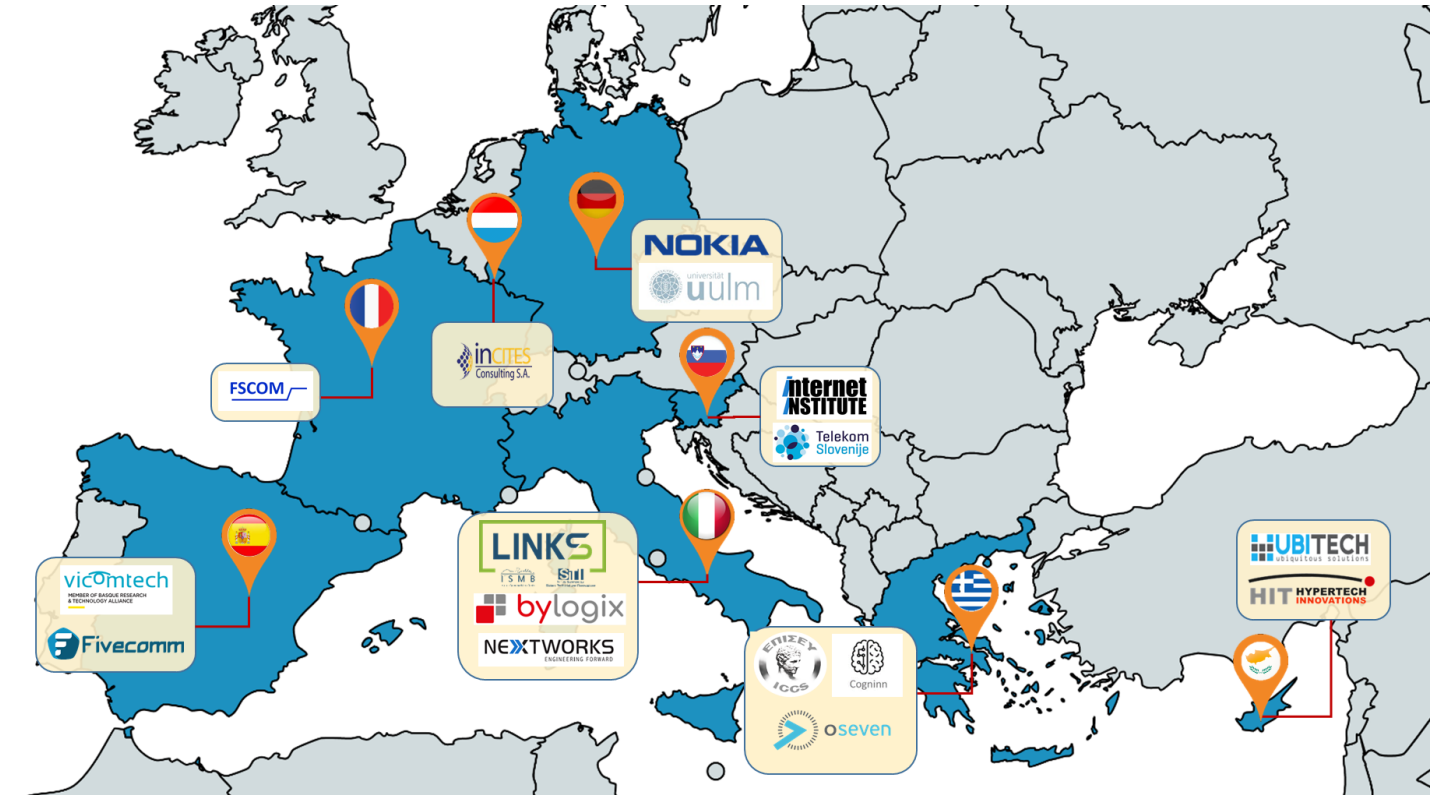# General Facts

Facts and Figures

Call Identifier: ICT-41-2020

16 Partners (10 SMEs)

8 EU Countries

Total Budget in €: 7,65M

36M Duration: 2021-2024

Scope

Provide an open and enhanced experimentation platform that will provide access to 5G network resources, on top of which third party experimenters (i.e., SMEs) in the Automotive-related 5G-PPP vertical will develop, deploy and test their services.

❖ **Different virtualization technologies** integrating **different MANO frameworks** for enabling the deployment of the end-to-end network services across different domains (vehicles, road infrastructure, MEC nodes and cloud resources).

❖ A new **Automotive VNFs Repository** that will form a repository for SMEs to use and develop new applications.

❖ A **distributed AI/ML (DML) framework**, that will provide functionalities for simplified management and orchestration of collections of AI/ML service components.

❖ Demonstration of **7 Automotive-related use cases in 2 5G SA testbeds**.

❖ **Multi-stakeholder cost-benefit analysis** to identify and validate market conditions for innovative, yet sustainable business models supporting a long-term roadmap towards the pan-European deployment of 5G as key advanced Automotive services enabler.

Objectives & Methodology

Specific Objectives

❖ Specify and provide an **Automotive Open Experimental Platform (AOEP)**.

❖ Specify and implement a **repository environment for NetApps and VNFs** to ease the design and chaining of new Automotive-related services – to be **integrated with 5G-PPP open repositories**.

❖ **Ensure co-existence with DSRC and LTE/5G and enhance network platform performances** for the Automotive vertical.

❖ **Provide accurate localization and low latency mission-critical applications.**

❖ Define, implement and trial **Connected and Automated Driving relevant Use Cases** to validate and assess the AOEP suitability and functional improvements.

❖ **Improve service creation time (5G-PPP KPI).**

❖ Create **new business opportunities and boost market for start-ups and SMEs** with Automotive NetApps.

❖ **Increase road safety and reduce automobile carbon footprint** by leveraging Connected and Automated Mobility using enhanced network performances.

❖ Ensure **cross-domain and cross-platform interoperability** and boost standardisation committees on NFV and Network orchestration.

Proposed Solution – Main Items

## Automotive Open Experimental Platform (AOEP)

❖ NetApp Orchestration and Development framework (NOD);

❖ Slice Manager (SM);

❖ Multi-domain Service Orchestrator (MSO);

❖ Virtualized infrastructure domains: OBU, RSU, MEC nodes, Cloud resources;

❖ 5G-IANA NetApps toolkit linked with a new Automotive VNFs Repository;

❖ A Distributed AI/ML (DML) framework, as part of the VNFs Repository.

5G-IANA AOEP
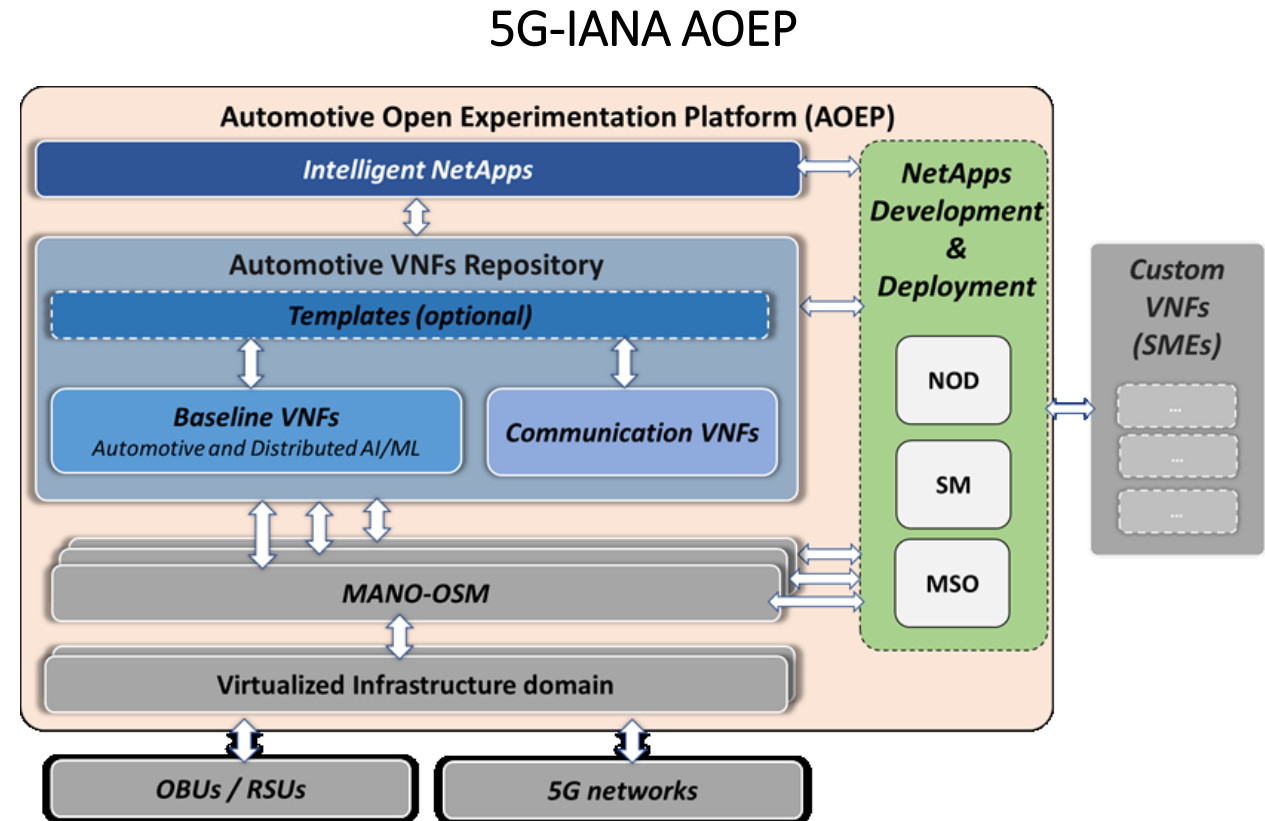
5G-IANA NetApp Orchestration and Development framework (NOD), Slice Manager (SM) and Multi-domain Service Orchestrator (MSO)

5G-IANA NOD, SM and MSO

❖ **NOD** is in charge of handling the lifecycle management of the NetApp from the application point of view, processing a request from a Vertical/Service Provider (highest level of abstraction with respect to the underlying network).

❖ **SM** is in charge of defining and provisioning the end-to-end Network Slice (NS) across the underlying domain and technology-specific platforms (e.g., NFV Orchestrators, MEC platforms, serverless orchestrators, etc.).

❖ **MSO** role is the correlation and coordination of the different nested NS running an entire NetApp composing the end-to-end NS from an upper layer perspective (coordination and composition of NS, LCM, etc.).
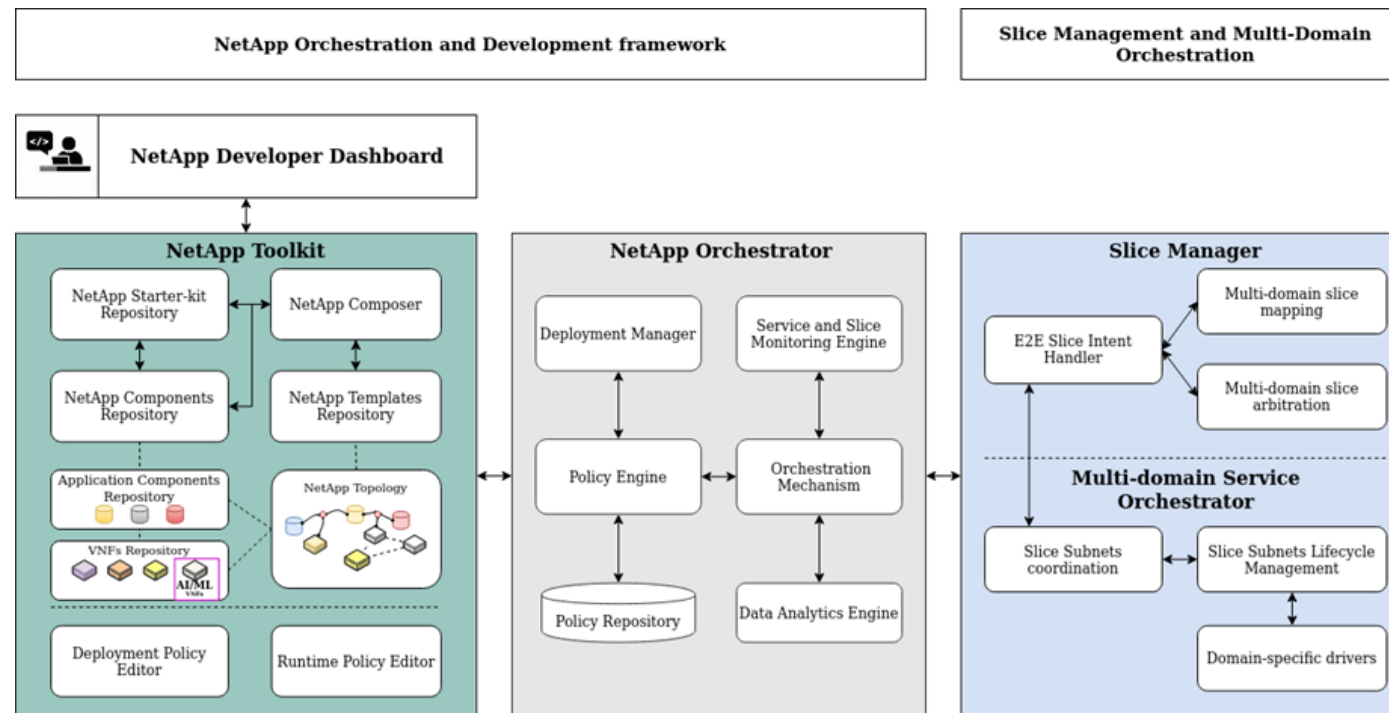
5G-IANA NetApps Toolkit and Automotive VNFs Repository

5G-IANA Toolkit and Repository

Provide functionalities for easing the design and chaining of new Automotive services:

❖ **Novel data-model** for offering to Verticals a simplified high-level representation of the different service components, in order to **hide the network complexity** from the point of view of the service deployment and inter/intra-domain components connectivity.

❖ **Interoperability with existing VNF repositories** (aggregation and integration point to offer a heterogeneous set of already existing virtualized management, communication and optimization functions for the Automotive industry and correlated business areas).

❖ Development of **6 Automotive-related Communication VNFs.**

❖ Development of **31 Automotive-related Baseline VNFs.**

❖ Development of **7 Intelligent NetApps** and demonstration through selected 5G-IANA Use Cases.

❖ All developed VNFs will be made available individually,, but also grouped into NetApp templates and "**starter-kits**" to facilitate 5G-PPP Verticals, and in particular SMEs, in the development and integration of newly developed NetApps.

Automotive VNFs Repository

Intelligent NetApps

Automotive NetApps and VNFs Toolkit

Templates (optional)

Baseline VNFs

Communication VNFs

Custom VNFs

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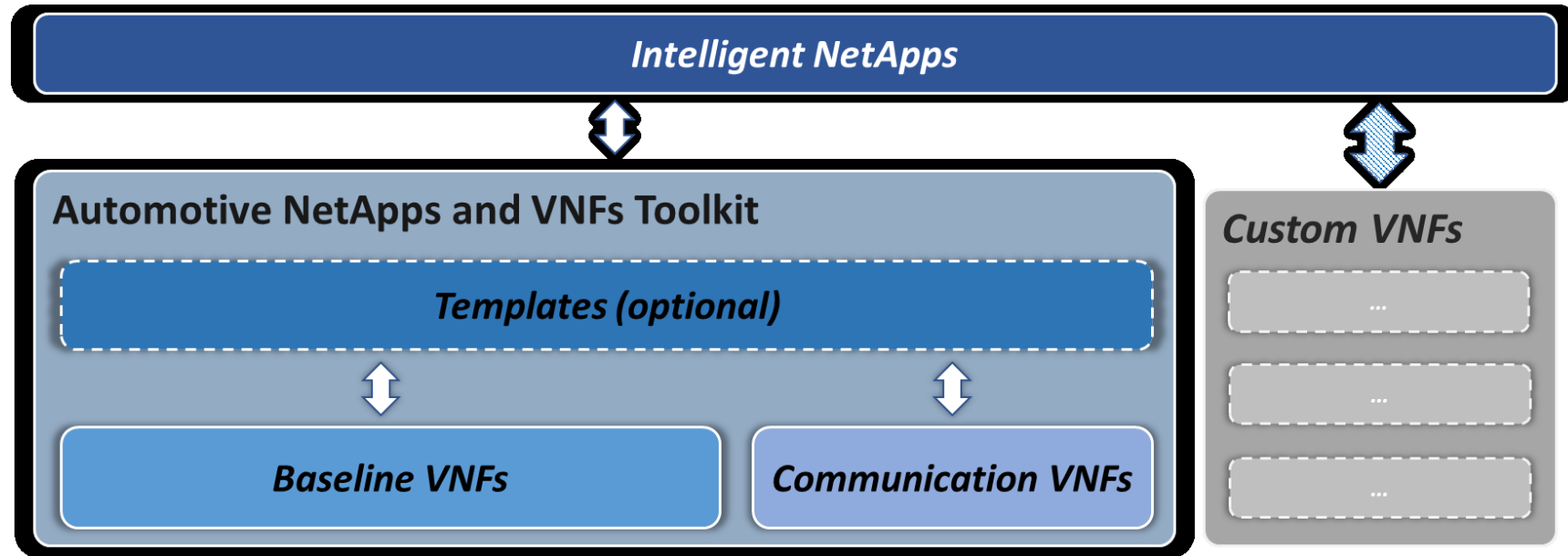
Communication VNFs

❖ C-ITS messages short-distance communication (OBU,RSU)

❖ C-ITS messages long-distance communication (OBU,RSU,MEC)

❖ Long-distance data communication (OBU, RSU, MEC, DC)

❖ Autonomous driving module interface (OBU)

❖ Sensors' data interface (OBU, RSU, MEC, DC)

❖ In-vehicle end-user communication interface (OBU)

Baseline VNFs (1/2)

❖ ETSI Decentralized Environmental Notification Service (OBU,RSU, MEC)

❖ ETSI Cooperative Awareness Basic Service (OBU, RSU, MEC)

❖ ETSI Collective Perception Service (OBU, RSU, MEC)

❖ ETSI Manoeuvre Coordination Service (OBU, RSU)

❖ ETSI Traffic Light Manoeuvre Service (RSU, MEC)

❖ ETSI Road and Lane Topology Service (RSU, MEC)

❖ ETSI Infrastructure to Vehicle Information Service (RSU, MEC)

❖ Position and Time Service (OBU, RSU, MEC)

❖ Enhanced Local Dynamic Map Service (OBU, RSU, MEC)

❖ Events Relevance Service (OBU)

❖ Log Reporting Service (OBU, DC)

❖ Actuators Interface (OBU, DC)

❖ Video Decoding (OBU)

❖ Video Encoding (OBU)

❖ Object Detection with Deep Learning (MEC)

Baseline VNFs

- ❖ Vehicle Condition Warnings Service (MEC)
- ❖ Remote Driving Central Control (MEC)
- ❖ Virtualized Cache – vCache (OBU, MEC)
- ❖ UHD Origin Streaming Server (DC)
- ❖ Load Balancer (MEC)
- ❖ vDNS (MEC, DC)
- ❖ Elasticsearch (incl. Kibana and Logtash) (MEC, DC)
- ❖ Telegraf (DC)
- ❖ 360º video slicer (MEC)
- ❖ Network (NW) monitoring (OBU, RSU)
- ❖ QoS prediction (OBU, RSU)
- ❖ Simulator of ETSI Cooperative Awareness Basic Service (MEC)
- ❖ Distributed ML Orchestrator (DMLO) (MEC, DC)
- ❖ DML Parameter Server (PS) (RSU, MEC)
- ❖ DML Aggregation Node (AggN) (RSU, MEC)
- ❖ ML node -Training Agent (MLN) (OBU, RSU, MEC,)

5G-IANA distributed AI/ML (DML) framework

5G-IANA DML framework

Provide functionalities for simplified management and orchestration of collections of AI/ML service components that support existing or newly chained services:

❖ **A novel DML representation** that provides functionalities such as ML topology selection and various performance and privacy configurations along the spectrums of ML model/parameter consistency and data distribution.

❖ Functionalities are mapped into chained VNFs that provide different ML capabilities to other VNFs:
  ❖ **Model Nodes**, **Aggregation Nodes**, **Parameter Server Nodes** and **Orchestrator Nodes**.

❖ **Distributed network monitoring service ML model** with a goal to:
  ❖ learn data traffic patterns for traffic prediction,
  ❖ learn network condition models such that Quality of Service predictions can be provided,
  ❖ learn to distinguish between normal and abnormal network behaviors to detect and predict faults.

5G-IANA Use Cases

Intelligent NetApps and 5G-IANA Use Cases

- ❖ Hazard Notification
- ❖ Vehicle Movement
- ❖ Smart Traffic planning
- ❖ Infotainment

5G-IANA Use Case

- ❖ Remote Driving
- ❖ Manoeuvre Coordination for Autonomous Driving
- ❖ Virtual Bus Tour
- ❖ Content Delivery for Vehicular Networks
- ❖ Parking Circulation & High Risk Driving Hotspot Detection
- ❖ Network Status Monitoring
- ❖ Situational Awareness in Cross-Border Road Tunnel Accidents

Use Case 1: REMOTE DRIVING (UC1-RMD)

❖ **NetApp category:** Vehicle Movement

❖ **Description:** A vehicle that is controlled remotely via a 5G network.

❖ **Partners involved:** 5COMM, NOKIA, FSCOM

❖ **Communication modes:** V2N **|Network slice types:** URLLC**|MEC use:** YES

❖ **TRL: Current:** 4 **Target:** 6

❖ **KPIs:**
  ❖ **Service Creation time**: Current value: 30 minutes Target Value: < 5 minutes;
  ❖ **Latency**: 20 ms;
  ❖ **User experience data rate**: 35 Mbps everywhere (UL/DL);
  ❖ **E2E reliability:** 99,999%.

❖ **Impact:** Provide greater comfort to people when performing certain types of activities that do not require human presence, such as taking the car from one place to another, picking up another person or delivering objects, transport material to sites in dangerous areas, transport dangerous substances, transport goods to places that are far away.

Use Case 2: MANOEUVRES COORDINATION FOR AUTONOMOUS DRIVING (UC2-MCAD)

❖ **NetApp category:** Vehicle Movement

❖ **Description:** Maneuver coordination service that aims to identify conforming trajectories between autonomous vehicles.

❖ **Partners involved:** BYL, LINKS, NOKIA, 5COMM

❖ **Communication modes:** V2V, V2I |**Network slice types:** URLLC|**MEC use:** YES

❖ **TRL: Current:** 2 **Target:** 6

❖ **KPIs:**
  ❖ **Service Creation time**: < 5 minutes;
  ❖ **Latency**: < 20 ms;
  ❖ **User experience data rate**: 35 Mbps everywhere (UL/DL);
  ❖ **E2E reliability:** 99,999%.

❖ **Impact:** Co-existence of autonomous vehicles that can potentially have different procedures for the definition of trajectories. Being able to have autonomous vehicles that agree on the trajectories and consequently on the maneuvers to perform can increase the safety of autonomous driving.

Use Case 3: VIRTUAL BUS TOUR (UC3-VBT)

❖ **NetApp category:** Infotainment

❖ **Description:** A virtual tour bus, where virtual reality users will be joining a tour guide in a static bus and will be represented in the VR space with their avatars.

❖ **Partners involved:** HIT, NOKIA, 5COMM

❖ **Communication modes:** V2N |**Network slice types:** eMBB & URLLC|**MEC use:** YES

❖ **TRL: Current:** 3 **Target:** 5

❖ **KPIs:**
  ❖ **Service Creation time**: < 3 minutes;
  ❖ **Latency**:
    • eMBB: a) E2E Latency < 20 ms round trip, b) User Plane Latency < 20 ms,
    • URLLC: a) E2E Latency < 20 ms round trip, b) User Plane Latency < 20 ms,
  ❖ **User experience data rate**: 50-100 Mbps in eMBB slice;
  ❖ **E2E reliability:** 99,999%.

❖ **Impact:** Provide a standalone service that allows the user to participate in an immersive experience of a guided tour in a place of touristic interest, enabled by the capabilities provided by 5G.

Use Case 4: AR CONTENT DELIVERY FOR VEHICULAR NETWORKS (UC4-ACOV)

❖ **NetApp category:** Infotainment, Smart Traffic Planning

❖ **Description:** Utilize V2X communication interfaces to deliver AR content to the UEs which are located in a moving vehicle. Deliver the content with ultra-low latency and also to manage the infrastructure resources to achieve optimal utilization rates.

❖ **Partners involved:** COGN, NOKIA

❖ **Communication modes:** V2I, V2N|**Network slice types:** URLLC |**MEC use:** YES

❖ **TRL: Current:** 2 **Target:** 6

❖ **KPIs:**
  ❖ **Service Creation time**: Current value: 40 minutes, Target Value: <5 minutes;
  ❖ **Latency**: Current value: 200 ms, Target Value: < 20 ms;
  ❖ **User experience data rate**: > 100 Mbps;
  ❖ **E2E reliability:** 99,9% with 85% caching efficiency.

❖ **Impact:** Provide enhanced QoE to new location-based infotainment services for future autonomous connected cars.

Use Case 5: PARKING CIRCULATION & HIGH RISK DRIVING HOTSPOT DETECTION (UC5-PCDD)

❖ **NetApp category:** Hazard Notification, Smart Traffic Planning.

❖ **Description:** Live feedback to drivers about road segments with high frequency of risk related events (e.g., speeding, harsh accelerations), as well as the estimated parking circulation time in specific areas.

❖ **Partners involved:** O7, ICCS, NOKIA, 5COMM

❖ **Communic. modes:** V2I, V2N **|Network slice types:** URLLC & eMBB **|MEC use:** YES

❖ **TRL: Current:** 2 **Target:** 6

❖ **KPIs:**
- ❖ **Service Creation time**: < 3 minutes;
- ❖ **Latency**: < 20 ms;
- ❖ **User experience data rate**: 50-100 Mbps;
- ❖ **E2E reliability:** 99,9%.

❖ **Impact:** Create driver awareness related to road segments with high accident risk, it is expected that the number of road accidents will decrease, thus providing increased road safety, improvement of driving behavior, decrease of parking circulation time.

Use Case 6: NETWORK STATUS MONITORING (UC6-NSTAT)

❖ **NetApp category:** Infotainment, Smart Traffic Planning.

❖ **Description:** Provide an overview of the status of network components or virtual network functions using ML techniques and draws conclusions and predictions with respect to the performance of the monitored components.

❖ **Partners involved:** UULM, NOKIA, FSCOM, ICCS

❖ **Communic. modes:** V2N, V2I **|Network slice types:** URLLC & eMBB **|MEC use:** YES

❖ **TRL: Current:** 2 **Target:** 5

❖ **KPIs:**
  - ❖ **Service Creation time**: < 5 minutes;
  - ❖ **Latency**: <20 ms; **Latency prediction error** < 10%;
  - ❖ **User experience data rate**: 20 Mbps everywhere (UL/DL);
  - ❖ **E2E reliability:** 99,999%, 10^{-4} packet error rate.

❖ **Impact:** Demonstrate the potentials of Distributed ML schemes in 5G-PPP verticals, where the network is volatile and privacy concerns is of outmost importance. Distributed and predictive Network Monitoring to support 5G based applications and make efficient use of their data and resources.

Use Case 7: SITUATIONAL AWARENESS IN CROSS BORDER ROAD TUNNEL ACCIDENTS (UC7-SACBT)

❖ **NetApp category:** Hazard Notification

❖ **Description:** Increase situational awareness in a cross-border tunnel road accident by understanding the exact location of the incident, the number of involved vehicles and people and other critical situational information, such as temperature, smoke and CO level status.

❖ **Partners involved:** ININ, TS, NOKIA, LINKS, BYL

❖ **Communication modes:** V2X **|Network slice types:** URLLC & eMBB **|MEC use:** YES

❖ **TRL: Current:** 2 **Target:** 6

❖ **KPIs:**
  ❖ **Service Creation time**: < 3 minutes;
  ❖ **Latency**: < 20 ms;
  ❖ **User experience data rate**: 50 Mbps everywhere (UL/DL);
  ❖ **E2E reliability:** 99,9%.

❖ **Impact:** Provide PPDR stakeholders with a platform for the inter-domain and cross-border operations of different first responder bodies providing cutting-edge situational awareness technologies and evolved warning methods, targeted for the most demanding disaster situations.

5G-IANA Test Networks

5G-IANA test networks

NOKIA (ULM, DE test network)

❖ 5 sites – 3 radio cells each:
  - ❖ 5G Base Stations operating in the 700 MHz band (band n28) in Frequency Division Duplex (FDD) mode with a bandwidth of 10 MHz. Maximum throughput rate of 100 Mbps in downlink direction and 25 Mbps in uplink.
  - ❖ At least one 5G Base Station operating in the 3.5 GHz band (band n78) in Time Division Duplex (TDD) with a bandwidth of 40 MHz ensuring maximum throughput rate of 300 Mbps in downlink direction and 25 to 37 Mbps in uplink.
  - ❖ Precise localization service based on Real Time Kinematik (RTK) with reference stations collocated with the radio base stations

❖ 100km^2 coverage (motorway A8, highway B10, high-speed train line S21, major part of Ulm city);

❖ 5G Standalone (SA) at least Base Station architecture 'Option 2';

TS (Ljubljana, SI test network)

The infrastructure consists of:

❖ A cloud and virtualisation environment;

❖ 4G – LTE radio access network (CA, Nb-IoT, VoLTE);

❖ 5G radio access network;

❖ 5G ready core network based on EPC extensions.

Expected Impact

Expected Impact

❖ Provide functionalities for easing the design and chaining of new Automotive-related services.

❖ Exploration of novel business models with new market actor landscapes.

❖ Increase the uptake of 5G services along Automotive-related services and thus increase the overall uptake of 5G.

❖ Low carbon and more energy efficient transport towards the use of automated driving and connectivity.

❖ Improvement of traffic flows, congestion and emissions through the use of real-life validation of a 5G infrastructure architecture enabling also DML techniques.

Thank you!

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