



September 2020

5GToP workshop

Validating 5G in vertical industries: the 5Growth project

5G-enabled Growth in Vertical Industries

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Outline

- **Project overview**
- 5Growth architecture
- 5Growth innovations
- Vertical pilot use cases
- Final remarks

5Growth

- **Objectives**

- The main objective is the technical and business validation of 5G technologies from the verticals' points of view, by performing field-trials on 4 vertical sites
- Leverage on the results of 5G-PPP Phase 2 projects, mainly 5G-TRANSFORMER
- Apply and enhance two ICT-17-2018 5G End-to-End platforms: 5G EVE and 5G-VINNI

- **Pilots and field trials**

- 4 pilots across 4 vertical industries
- 9 use cases will be field-trialed on 4 vertical-owned sites (in Spain, Italy, Portugal) in close collaboration with the vendors (Ericsson, Interdigital, NEC, Nokia) and the operators (Telefonica, Telecom Italia and Altice Labs/PT)

- **Consortium (21 partners)**

- Verticals: Innovalia, EFACEC Engineering/Systems, COMAU
- Operators: Telecom Italia, Telefonica, Altice Labs
- Vendors: NEC, ERICSSON Spain/Italy, NOKIA Bell Labs, IDCC
- SMEs: Nextworks, Mirantis, Telcaria
- Research Centers: CTTC
- Universities: POLITO, SSSA, UC3M, NKUA, ITAv



5growth.eu



twitter.com/5growth_eu



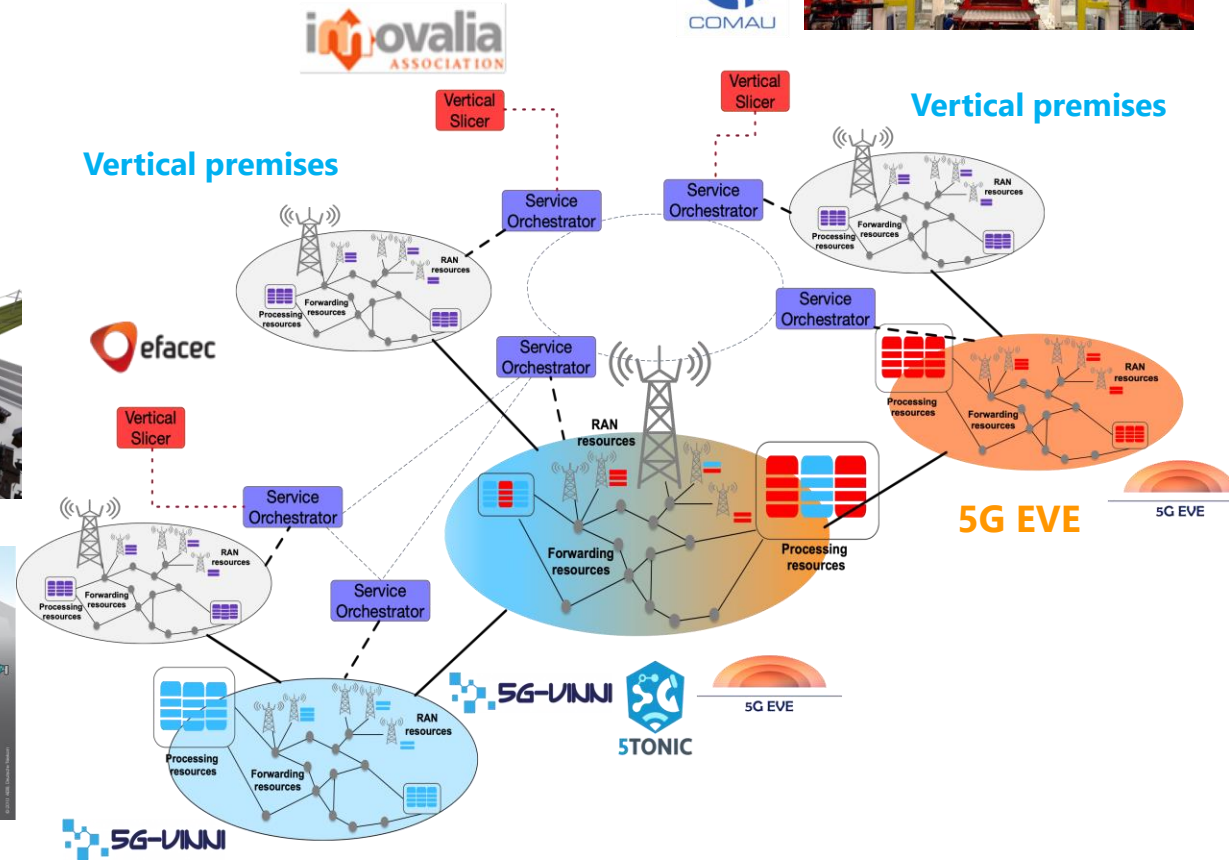
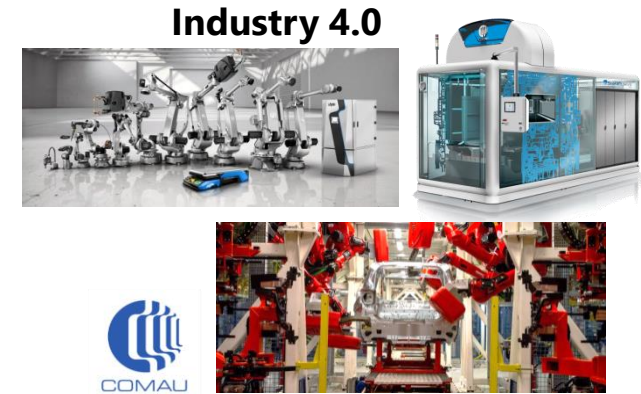
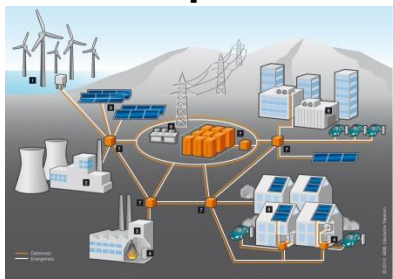
linkedin.com/in/5growth-project

Vertical pilots

- 5Growth aims to perform real field trials involving customer sites of four vertical locations in Portugal, Spain & Italy
- This requires the development, installation, validation and testing of pre-commercial 5G radio, transport and core technology in vertical sites, connected via the ICT-17 platforms

Pilots

- **Industry 4.0:**
 - INNOVALIA
 - COMAU
- **Energy:**
 - EFACEC_E
- **Transportation:**
 - EFACEC_S



Interactions with ICT-17 projects

- ICT-17 platform (**5G-EVE** and **5G-VINNI**) are key for us



- We use ICT-17 platforms for
 - **First tests** and **validations** of our vertical pilots
 - A gap analysis (what 5Growth needs vs what ICT-17 can provide) was performed at the beginning of the project
 - **Designing, implementing** and **deploying** the **missing functions** required for the vertical trials into ICT-17 platforms (and vertical sites)
 - This includes the 5Growth platform (which adds new innovations)
 - **Integration** with **vertical systems** and execution of the different vertical pilots



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5Growth architecture: building blocks

Vertical Slicer (5Gr-VS)

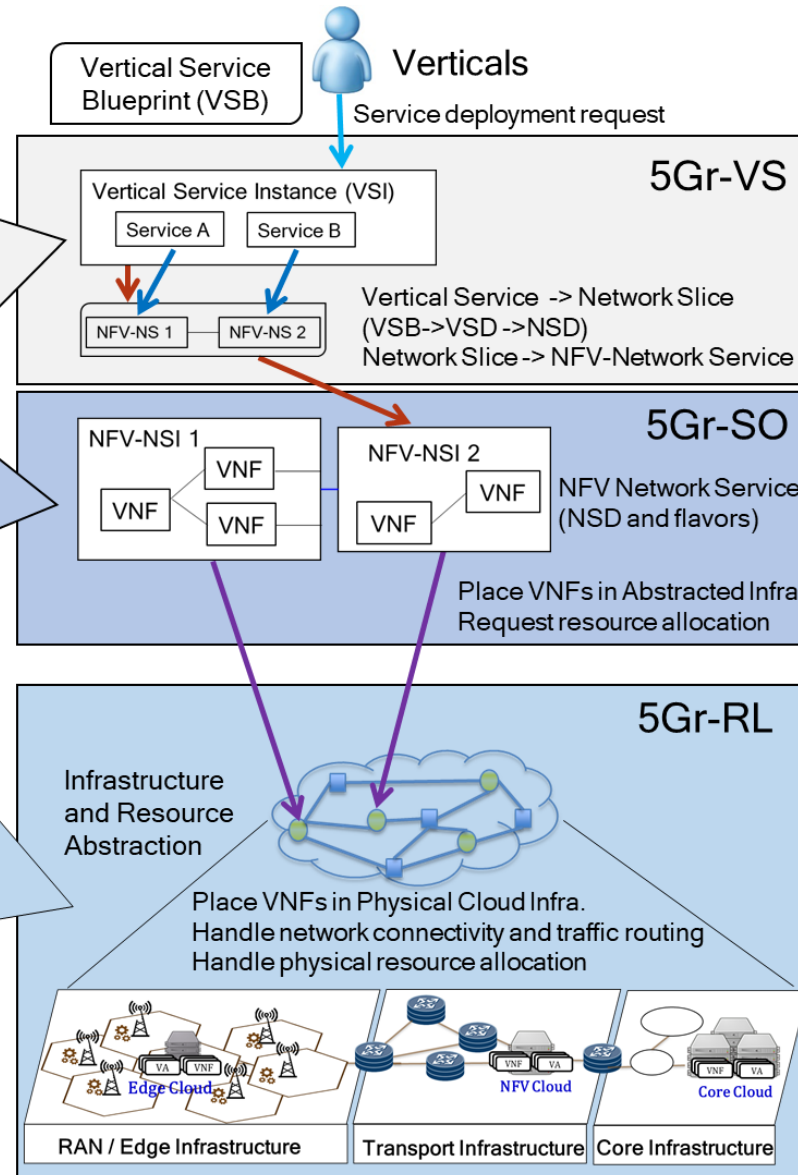
- Acting as a single entry point for all verticals to request their custom network slice.
- Mapping vertical services onto network slices (realized through Network Services, NFV-NS).
- Managing vertical service and respective network slices.

Service Orchestrator (5Gr-SO)

- E2E Orchestration of NFV-NSs
 - Multi-domain service and resource orchestration.
- Managing NFV-NSs
 - Life-cycle Management
 - SLA management

Resource Layer (5Gr-RL)

- Manage the physical/virtual transport, mobile/RAN, MEC and Cloud resources to deploy NFV-NS requested by 5Gr-SO.
- Provide a unified view of the underlying networks to 5Gr-SO with a suitable abstraction and configuration of heterogeneous resources via different plugins.



↓ Vertical Services (VSB)

↓ VSB->VSD->NSD
Vertical Service -> Network Slice
Network Slice -> NFV Network Service

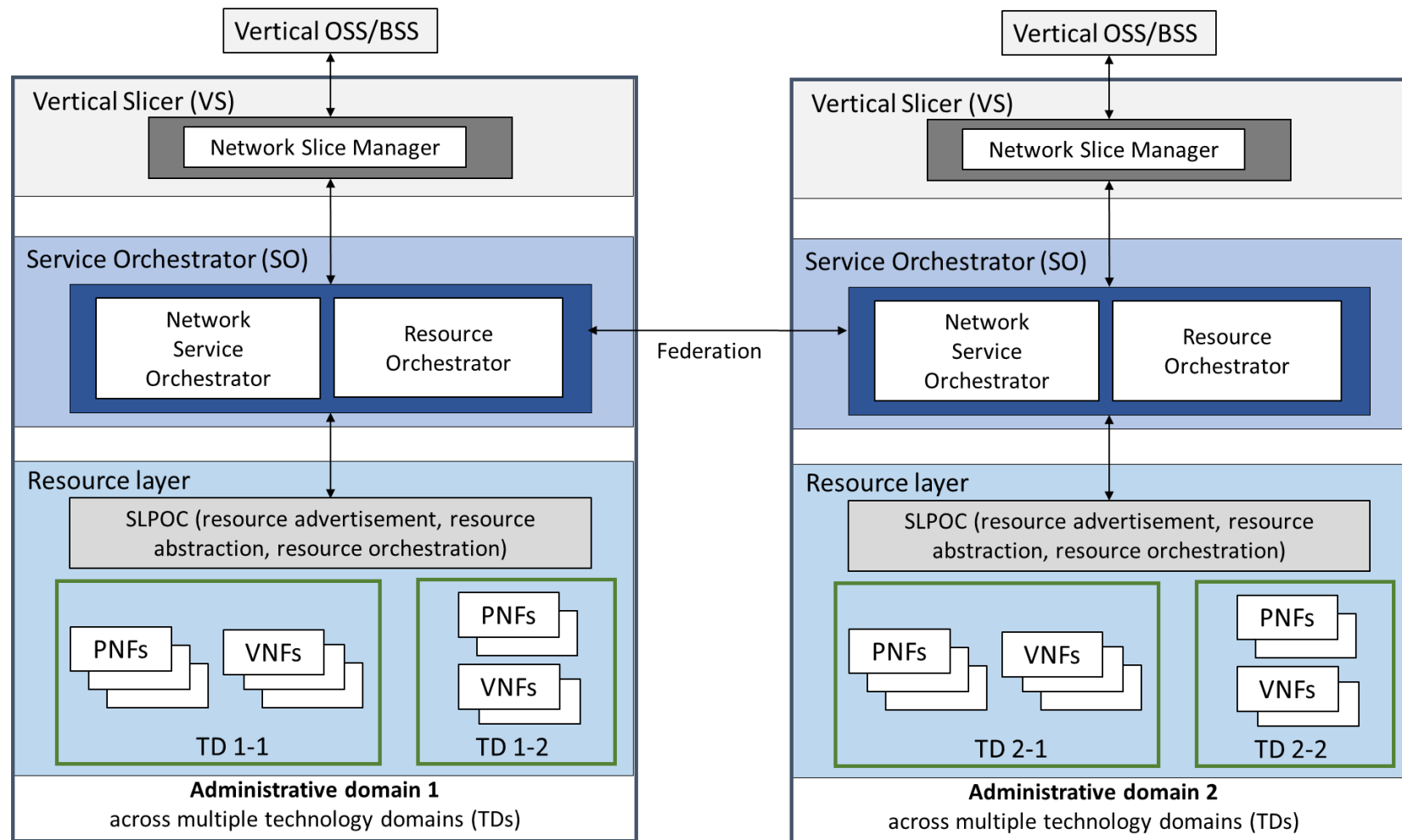
↓ NFV Network Service (NSD and flavors)

↓ Request resource allocation and instantiation of NFV-NS on the underlying infra.

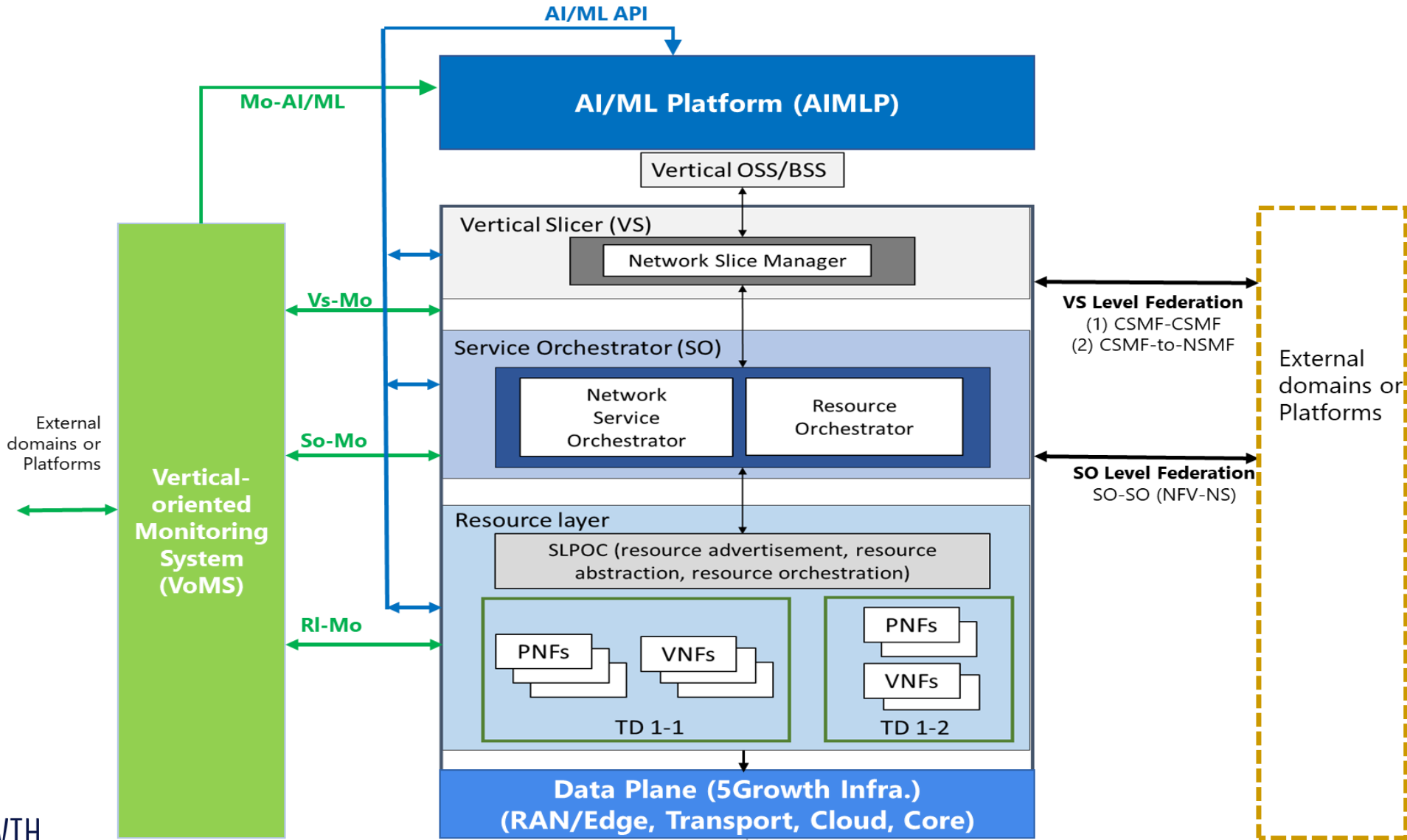
↓ Manage various infra. Resources and execute actual mapping of a logical network (network slice) on the shared physical network

5Growth baseline architecture

Evolution based on the 5G-TRANSFORMER reference architecture



Extending Baseline Architecture



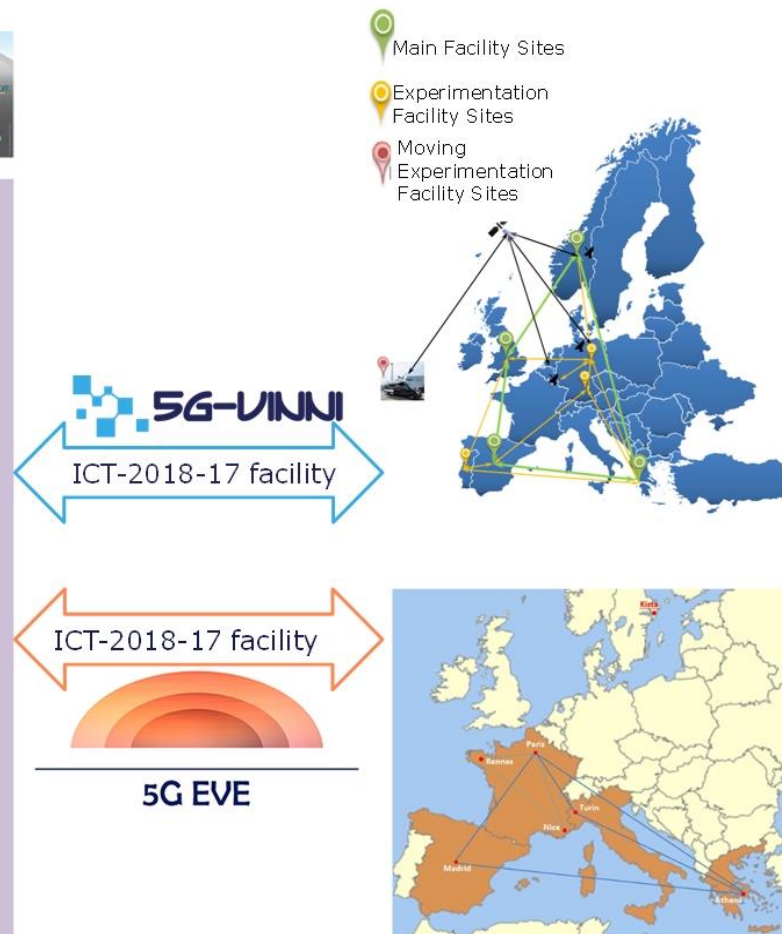
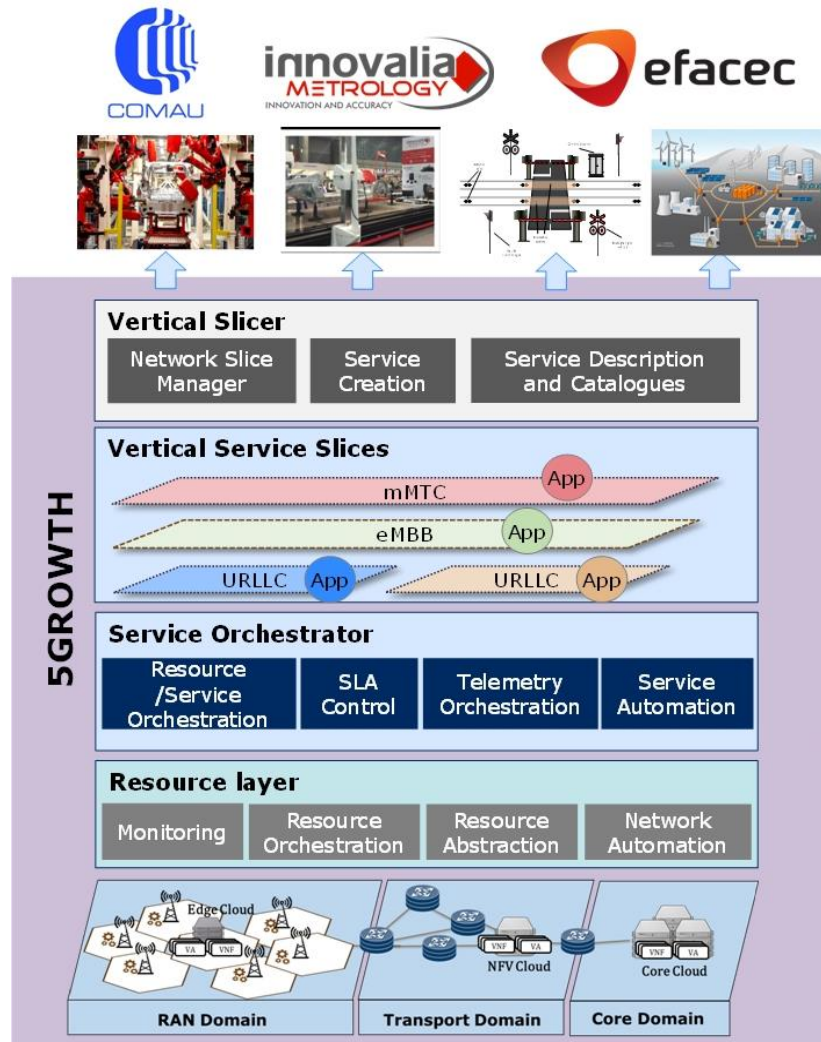


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5Growth Vision on Innovations

To **empower vertical industries**, such as Industry 4.0, Transportation, and Energy with an **AI-driven Automated and Shareable 5G End-to-End Solution**



Develop the 5Growth platform to create, provision and manage the vertical services with AI-driven innovations

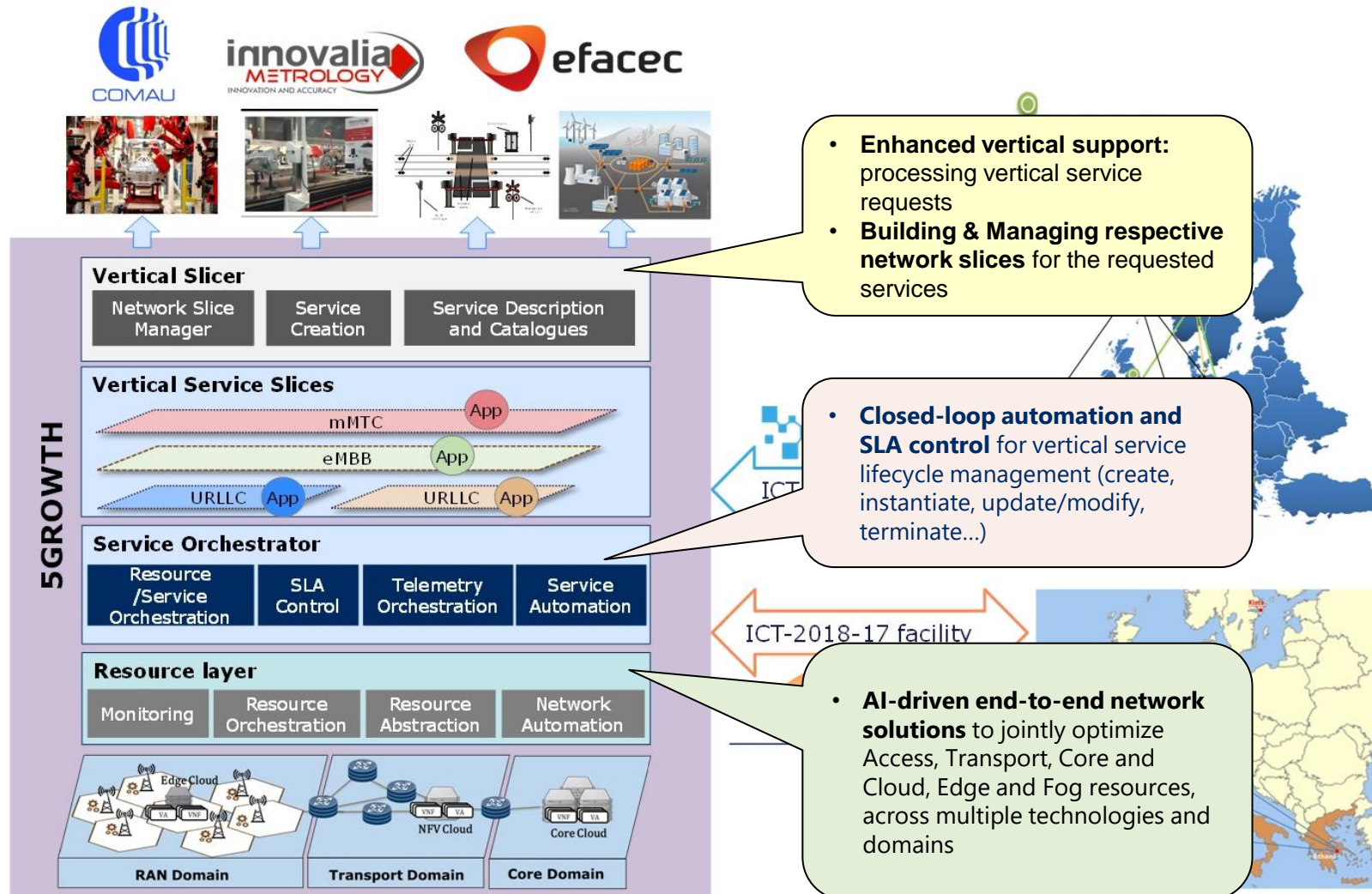
- Leverage on the 5GPPP Phase 2 project 5G-TRANSFORMER platform

Interaction with ICT-17 Platforms to provide E2E Solution

- Via standard Interfaces
- Develop adaptations to each platform

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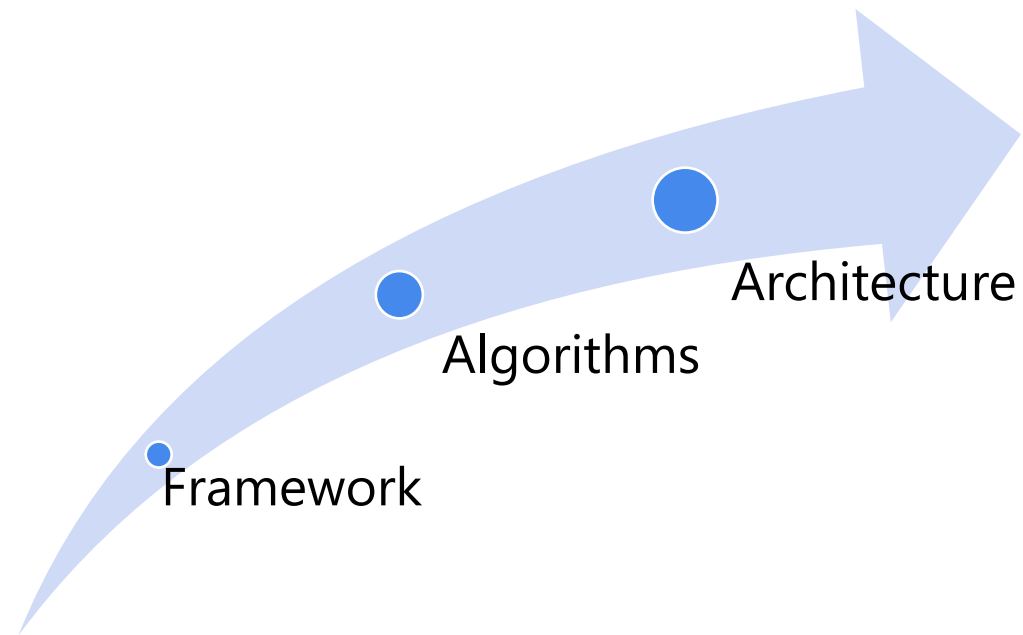
- Via standard Interfaces
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Feature/Functionality Gaps

- Support of **Next-Generation RANs** to meet the target 5G requirements
- **Zero-touch AI-based LCM** of vertical services to enhance service automation
- **Closed-loop management and SLA control**: automated adaptation to dynamic changes on infrastructure resources to ensure service performance
- **Vertical service federation** to enable integration of NPN and PN deployment
 - To request a sub vertical service or a network slice from the PN
 - Dynamically modify the size and the composition of network slices
 - Dynamic network service composition based on an on-boarded VSB by decomposing it in an ad-hoc manner
- **Enhance vertical service slice sharing** to improve resource use efficiency
- **Enhance vertical service monitoring** to provide telemetry monitoring, analytics and orchestration
- **Security support**

5Growth Innovation Clusters



New Features per Layer (Indic.)

- **Vertical Slicer:** dynamic service composition, service arbitration, RAN support in network slicing ...
- **Service Orchestrator:** self-adaptation, auto network service scaling, anomaly detection ...
- **Resource Layer:** geo-specific resources, next generation RAN (O-RAN)
- **Monitoring System:** providing monitoring for all layers, Vertical-oriented monitoring support

5Growth Innovations

- ✓ Smartness
- ✓ Flexibility
- ✓ Efficiency
- ✓ Automation
- ✓ Performance
- ✓ Security

Framework



Security and
Auditability
5Growth CI/CD &
containerization

Architecture



Vertical Support
Monitoring Orchestration
Control & Management
(Closed-loop, AI/ML)
End-to-end orchestration

Algorithms

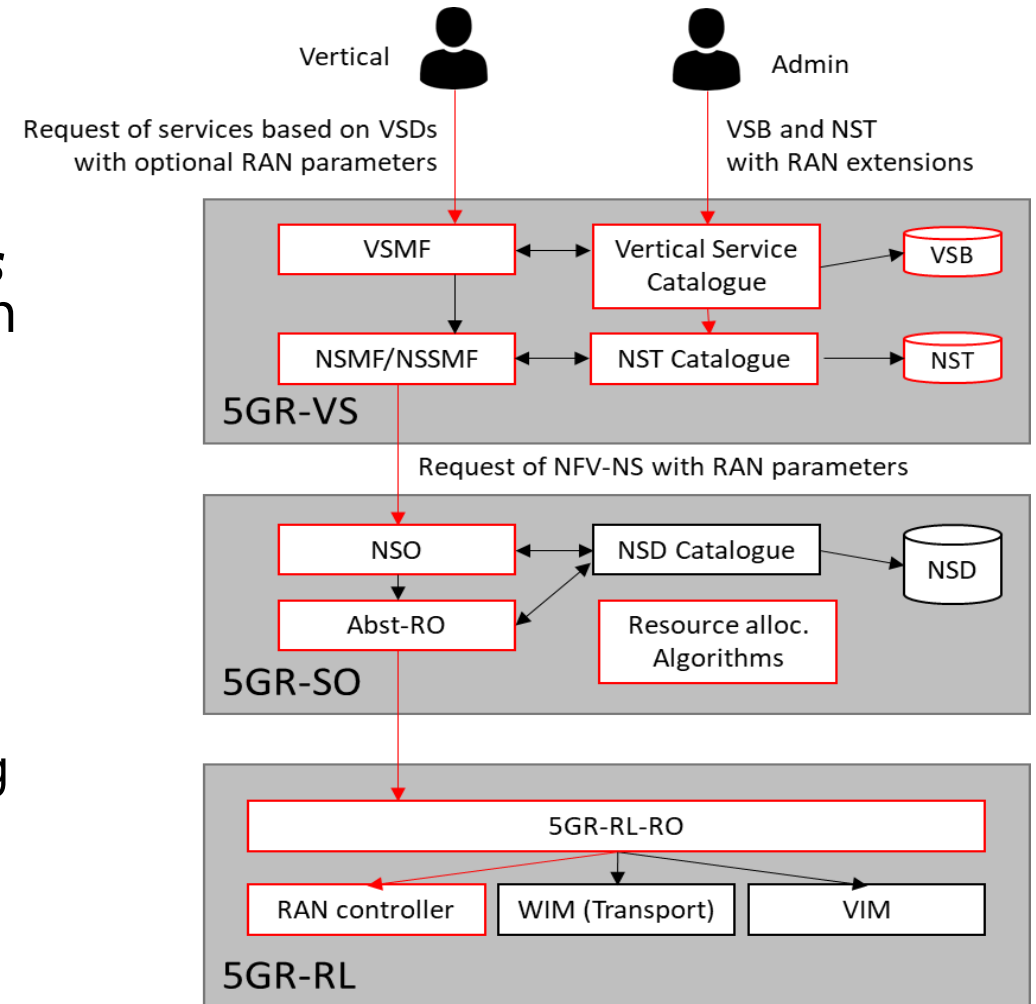


Smart
Orchestration &
Control
Anomaly
Detection
Forecasting and
Inference

Innovation example: support of NG RANs

Extending 5Growth stack to support the management of RAN segment of network slices to guarantee true E2E network slicing

- 5Gr-VS: **Modelling of the RAN requirements** in network slice information models, based on latest 3GPP specs.
- 5Gr-SO: **RAN orchestration** including RAN-aware resource placement and allocation of radio and computing resources over a RAN abstraction exposed by the 5Gr-RL.
- 5Gr-RL:
 - Provide a technology-agnostic **abstraction of the RAN domain** to the 5Gr-SO, including the management of related PNFs.
 - The **enforcement of RAN configuration** is mediated through a specialized radio plugin that interacts with radio controllers



1st Software Release of 5Growth Platform

The first release software (R1) of the 5Growth platform has been published as open source on public github in May 2020 (<https://github.com/5growth>)

Innovation	Repository	License
RAN segments in network slices	https://github.com/5growth/5gr-vs	Apache v2.0
	https://github.com/5growth/5gr-rl	GPL
Vertical-service monitoring	https://github.com/5growth/5gr-mon	Apache v2.0
Control-loops stability	https://github.com/5growth/5gr-so	Apache v2.0
Smart orchestration and resource control algorithms	https://github.com/5growth/5gr-rl/tree/master/5gr-rl-ra-server/	Apache v2.0
	https://github.com/5growth/5gr-rl/tree/master/rl/plugins/WIM/ONOS-OpenFlow-Slicing	Apache v2.0
	https://github.com/5growth/5gr-rl/tree/master/rl/plugins/WIM/ONOS-P4-Slicing	Apache v2.0



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Vertical use cases

Field-trial-based approach on vertical sites (TRL 6-7). In total, 4 pilots across 4 verticals and 9 use cases:

Industry 4.0 (INNOVALIA1): Connected Worker Remote Operation of Quality Equipment

Industry 4.0 (INNOVALIA2): Connected Worker Augmented Zero Defect Manufacturing (ZDM) Decision Support System (DSS)

Industry 4.0 (COMAU1): Digital Twin Apps

Industry 4.0 (COMAU2): Telemetry/Monitoring Apps

Industry 4.0 (COMAU3): Digital tutorials and remote support

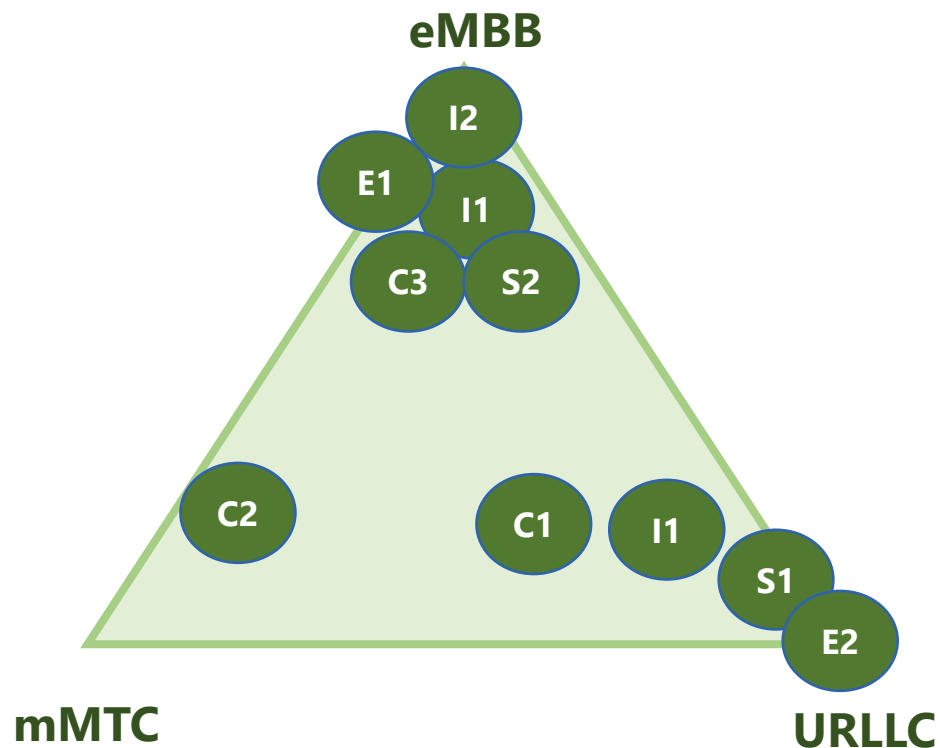
Transportation (EFACEC_S1): Safety Critical Communications

Transportation (EFACEC_S2): Non-safety Critical Communications

Energy (EFACEC_E1): Advanced monitoring and maintenance support of secondary substation - Medium Voltage/Low Voltage (MV/LV) distribution substation

Energy (EFACEC_E2): Advanced critical signal and data exchange across wide smart metering and measurement infrastructures

Technical KPIs



	I1	I2	C1	C2	C3
	INNOVALIA1	INNOVALIA2	COMAU1	COMAU2	COMAU3
Availability / Reliability (A/R)	99,9999%	99,9999%	99,9999% /80%	99,9999% /80%	99,9999% /80%
Latency (LAT)	<5ms	<5ms	<15ms	<30ms	<50ms
Bandwidth (BW)	1 Gbps	10-20 Gbps	200 Mbps (total)	500 Mbps (total)	500 Mbps (total)
Connection Density (DEN)	< 1000 devices per km ²	< 1000 devices per km ²	< 1000 devices per km ²	< 1000 devices per km ²	< 1000 devices per km ²
Mobility (MOB)	3 km/h	3-50 km/h	3-50 km/h	3-50 km/h	3 km/h
Wide-Area Coverage (COV)	5-8 km ²	5 km ²	5 km ²	5 km ²	5 km ²

	EFACEC_S1	EFACEC_S2	EFACEC_E1	EFACEC_E2
Availability / Reliability (A/R)	99,99%	99,99%	99,99%	99,99%
Latency (LAT)	<10ms	<100ms	-	< 7ms for AR < 5ms for last-gasp < 1ms for synchronization Control plane latency: < 20ms
Bandwidth (BW)	>1200 bit/s	Downlink user experience data rate: > 100 Mbps	Downlink user experience data rate: > 100 Mbps	-
Mobility (MOB)	-	Speed < 160 km/h (expected to have 80 km/h in pilot scenario)	Speed < 120 km/h	-
Wide-Area Coverage (COV)	2-30 km ²	2-30 km ²	10 km ²	10 km ²



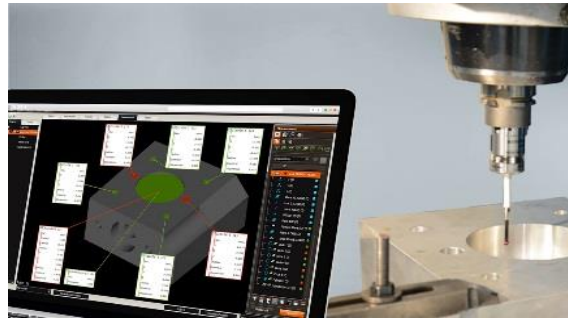
Business KPIs

	INNOVALIA	COMAU	EFACEC S	EFACEC E
Business KPIs	<ul style="list-style-type: none"> • Reduce cost of production by 10% • Increase the production throughput by 15% • Reduce customer visits by 40% • Reduce scrap of at least 10% with an objective of 100%. • Predict up to 30% of form and/or welding errors. • Reduce service response time by 50% 	<ul style="list-style-type: none"> • Reduce infrastructure cost by 20% • Reduce MTTR by 20% • Reduce of technicians' travels by 30% • Reduce of failure rate at least of 20% with objective 90% • Service response time reduced by 30% 	<ul style="list-style-type: none"> • Reduce system capex by 20% • Reduce system installation cost by 50% • Reduce installation time by 50% • Reduce cable cost by 80% • Reduce maintenance visits by 20% • Reduce service response time by 20% 	<ul style="list-style-type: none"> • Reduce SAIDI for LV (Low Voltage) in 15%: System Average Interruption Duration Index (SAIDI) measures the average of the total long duration of interruptions affecting the average delivery point for a given year. • Reduce ENS in 5%: Energy not supplied.⁹

Example: Industry 4.0 Pilot

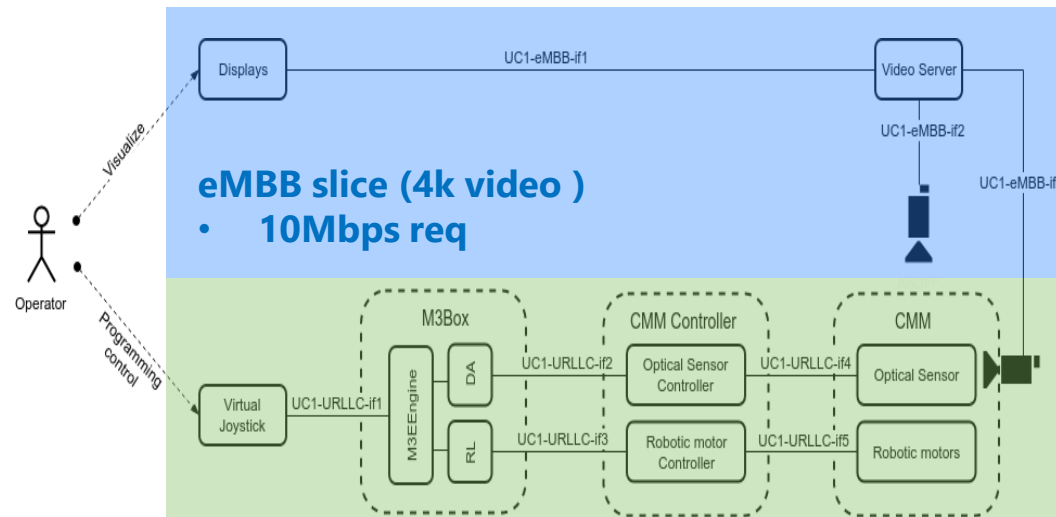
Motivation for this Pilot

1. Every time the measuring machine is reconfigured (for example changes in the piece design), an expert metrologist has to go there and help defining the measuring trajectories for the optical sweep.
2. High volume of data transmitted in real time needs a reliable, high-capacity connection, that nowadays is only available by a wired network. This limits the mobility of operators and may require expensive infrastructures.



Example of Industry 4.0 UC1: Connected Worker Remote Operation of Quality Equipment (INNOVALIA Pilot)

- Remote real-time operation via a virtual joystick by worker for remote control and programming of CMM
- 5G requirements: high data rate, reliability and low latency
- Potential benefits: Remote expert manpower and time/travel savings



Stakeholders

- **Vertical:** INNOVALIA
- **Operator:** Telefonica
- **HW/SW provider:** Ericsson
- **Video streaming service provider:** InterDigital
- **Operation Support Provider:** TELCA

- URLLC slice (control)**
- **Reliability: 99.99%**
 - **E2E Latency < 5ms**

Coordinate Measuring Machine (CMM)

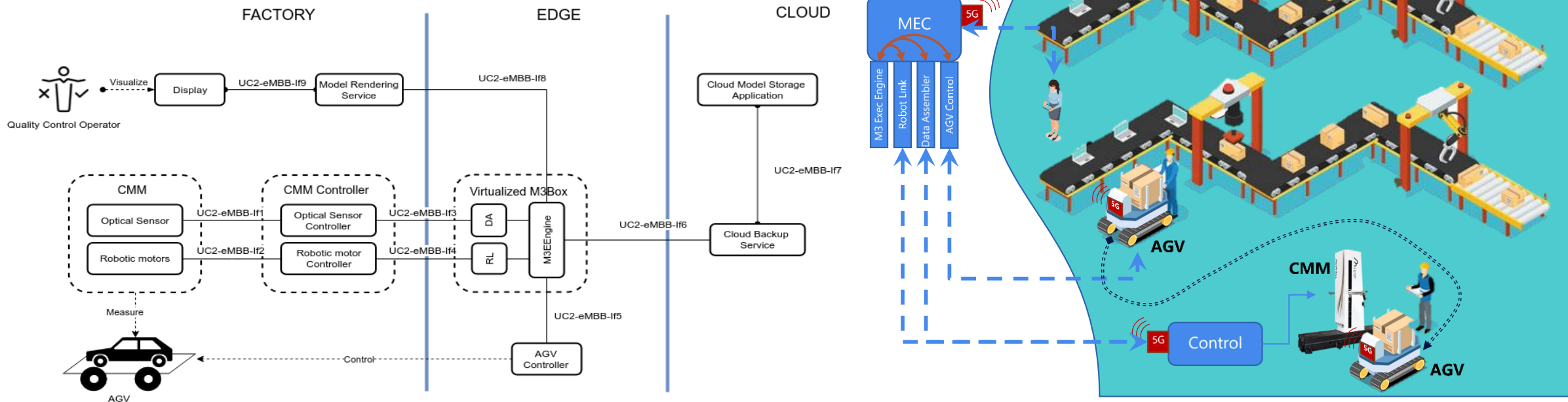
This block contains several key elements:

- 5G:** A large 5G logo indicating the network technology used.
- Hybrid Sensors:** An image showing a sensor probe measuring a part.
- Manufacturing Process:** An image of a CNC machine with a digital overlay.
- Measurement machine:** An image of a Coordinate Measuring Machine (CMM).
- 4K Video Camera:** An image of a camera used for remote monitoring.
- Production Facility 1: Automotive Smart Factory:** A detailed 3D diagram of a smart factory floor with various machines, robots, and data integration points. Labels include: Measurement machine, Interface with Factory Analytics Server & logistics and planning, Design & Planning Station, Machine Group Execution Coordination, Material & Consumable automated management, eTracking, and Process Quality Assurance & Traceability.



Example of Industry 4.0 UC2: Connected Worker Remote Operation of Quality Equipment (INNOVALIA Pilot)

The edge components used on the metrology process (M3ExecutionEngine, RobotLink and Data Assembler) will be deployed on a cloud-edge service provided by the operator, as well as the component that controls the AGV.



eMBB slice

- **Reliability: 99.99%**
- **Data rate: 1Gbps**
- **Mobility: 3-50km/h**

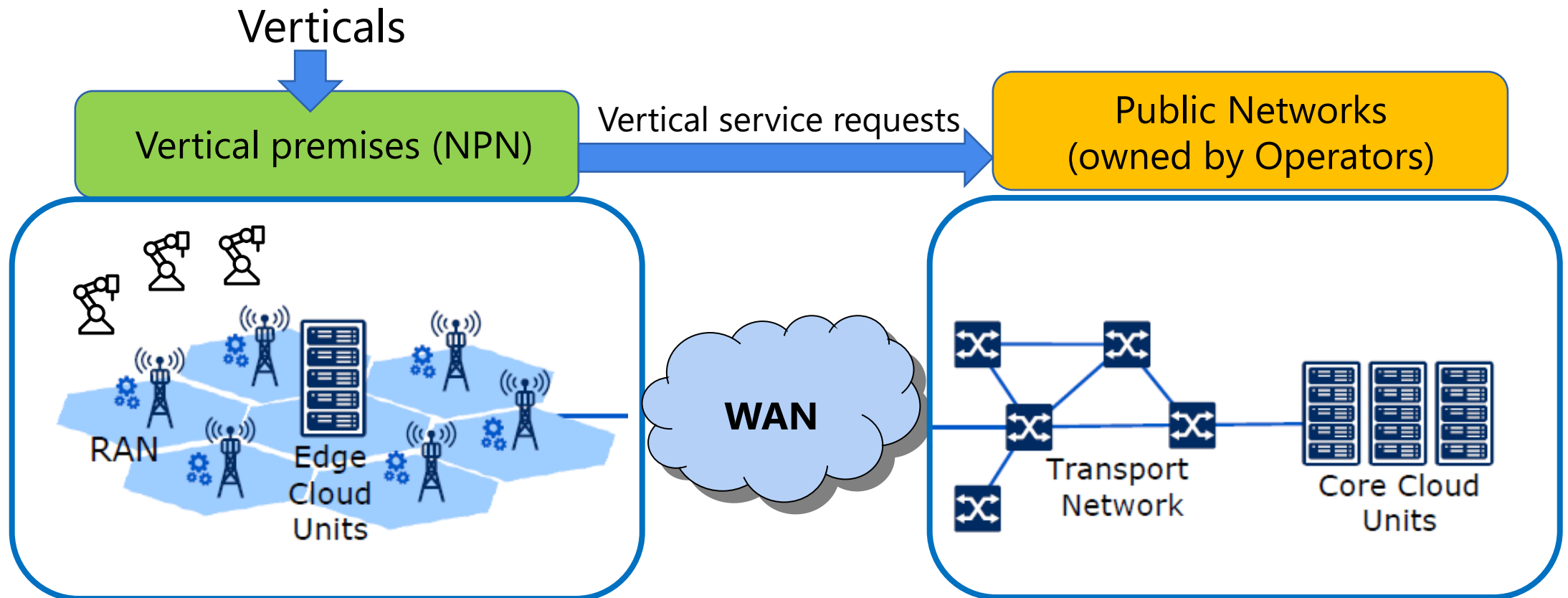
Stakeholders

- **Vertical:** INNOVALIA
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- **Operation Support Provider:** TELCA

Automated Guided Vehicle (AGV)

Pilot Deployment Scenarios

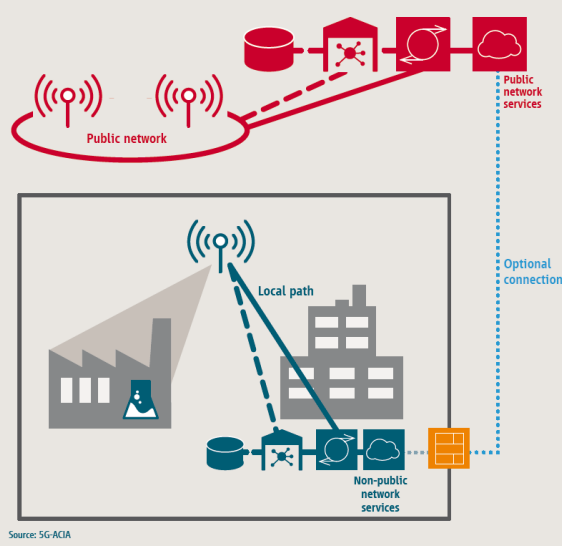
The pilot scenarios consist of a Non-Public Network (NPN) at vertical premises and public networks owned by operators providing E2E service and infrastructure that may partly or entirely use the ICT-17 platforms.



4 different scenarios for deployment of Private networks (a.k.a Non-Public Networks)

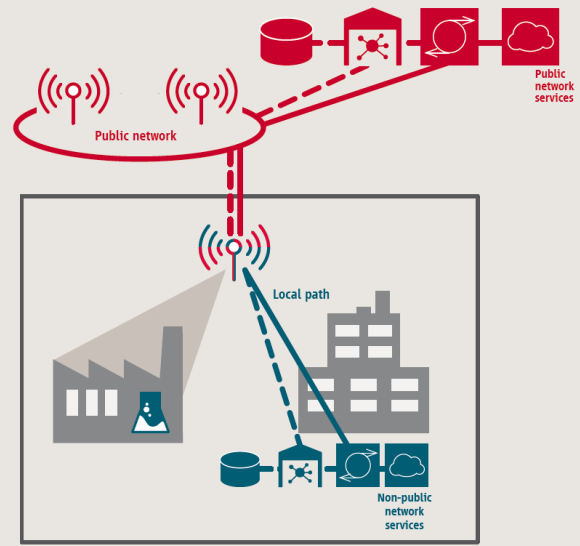
To be explored in 5Growth, depending on pilot UCs

Fig. 1: Deployment as isolated network



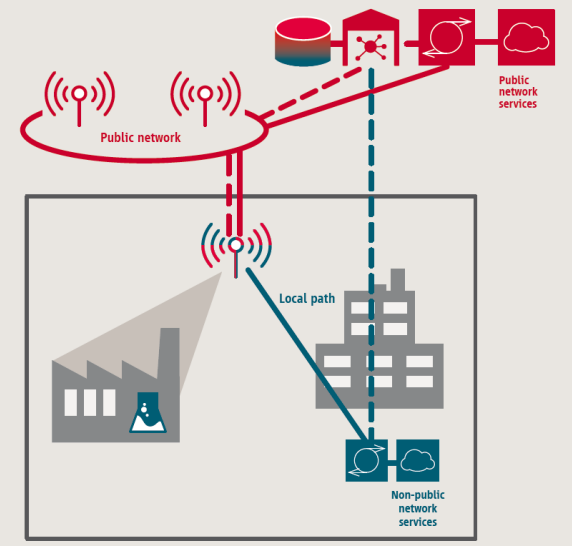
**1) Standalone NPN
(Isolated Deployment)**

Fig. 2: Deployment with shared RAN



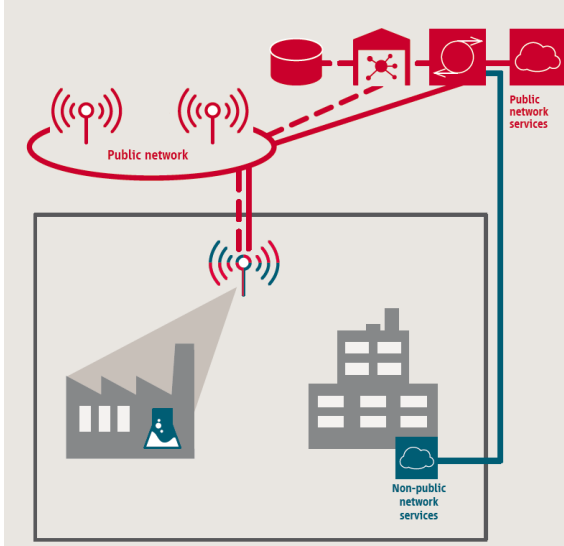
2) Shared RAN

Fig. 3: Deployment with shared RAN and control plane



**3) Shared RAN
and Control Plane**

Fig. 4: NPN deployed in public network



**4) NPN hosted by
public network**

Source from 5G ACIA: <https://www.5g-acia.org/publications/5g-non-public-networks-for-industrial-scenarios-white-paper/>



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Final remarks

- 5Growth is evolving 5G-TRANSFORMER work to both:
 - bring key innovations for verticals, and
 - validate 5G in realistic pilots.
- 4 pilots addressing 3 different vertical industries:
 - Industry 4.0
 - Transportation
 - Energy
- Collaboration with 5G-EVE and 5G-VINNI to perform end-to-end validation and address PN-NPN integration models



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 856709.