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5G FOR ADVANCED AUTOMOTIVE USE CASES: THE 5G-HEART PERSPECTIVE

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5G-HEART Transport Leader

Workshop on 5G Experimentation Facilities & Vertical Trials

14 October 2020

5G HEALTH AQUACULTURE AND TRANSPORT VALIDATION TRIALS

Outline

- 5G-HEART overview
- Transport use cases
- Transport trial facilities
- Few highlights
- Summary

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5G-HEART overview

- **5G-HEART**: 5G HEalth AquacultuRe and Transport validation trials.
- **Call:** H2020-ICT-2018-3.
- **Topic**: ICT-19-2019 - Advanced 5G validation trials across multiple vertical industries.
- **Period**: 01/06/2019 to 31/05/2022.
  - ✓ A recent 6-month extension (COVID-19).

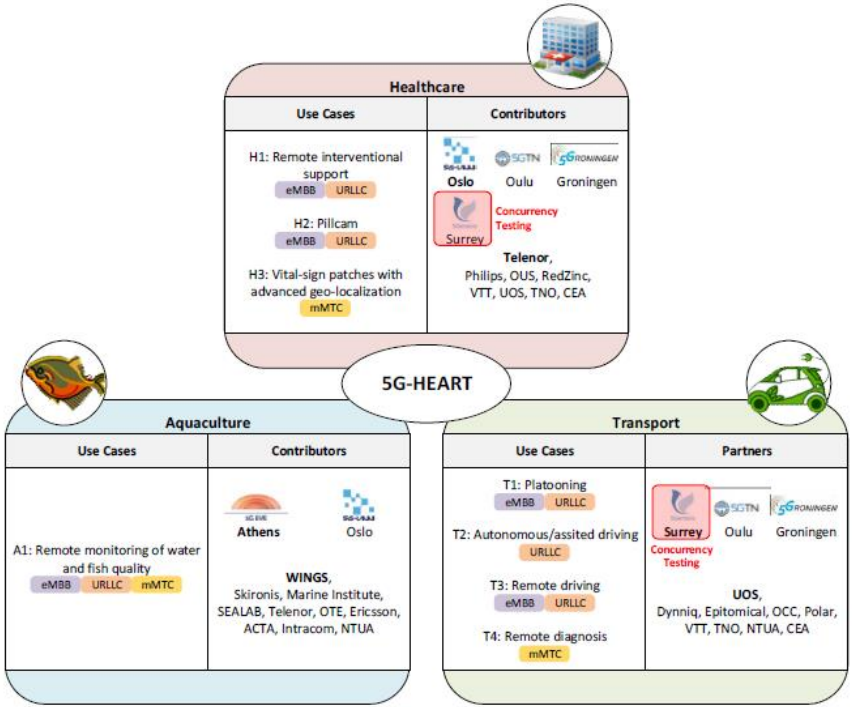

Figure 1 5G-HEART Ecosystem

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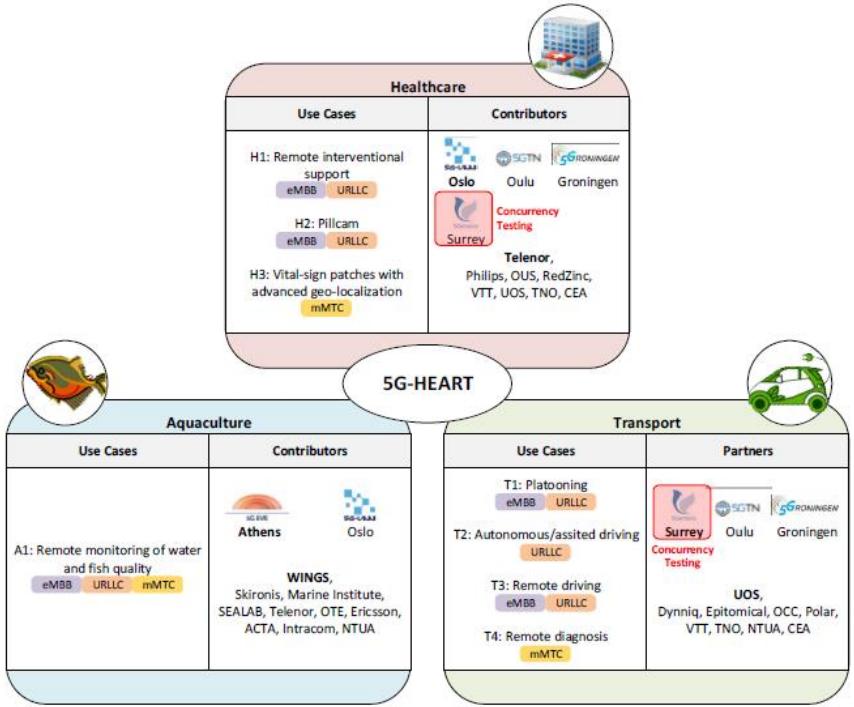
- **Three target verticals**:
  - ✓ Transport
  - ✓ Aquaculture
  - ✓ Healthcare



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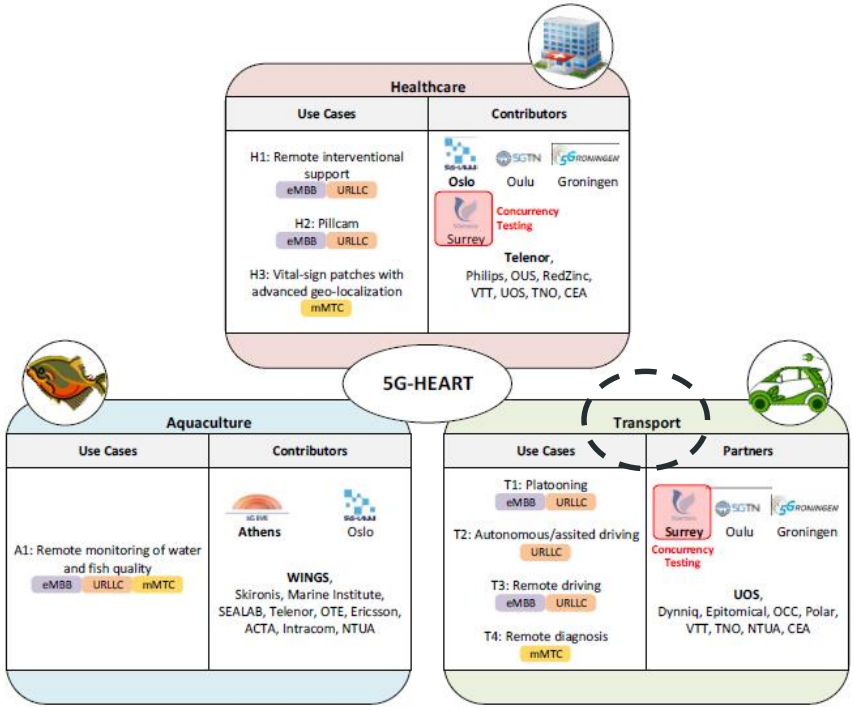

Figure 1 5G-HEART Ecosystem

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Transport use cases – T1 platooning

- Vehicles move like a train with virtual strings.
- Reduces the distance between vehicles, overall fuel consumption and number of needed drivers.
  - ✓T1S1&T1S2: High bandwidth in-vehicle situational awareness and see-through for platooning.
  - ✓T1S3: Dynamic channel management for traffic progression.
  - ✓Trial facility: 5GENESIS (Surrey)
  - ✓**eMBB and URLLC requirements.**

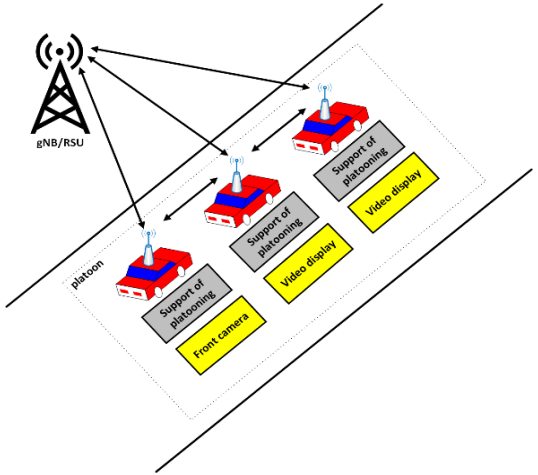

Figure 2 See-through for platooning

Transport use cases – T2 autonomous/assisted driving

- Combine sensor data and communication capabilities to support advanced driving modes.
  - ✓ T2S1&T2S2: Smart junctions and network assisted & cooperative collision avoidance (CoCA).
  - ✓ T2S3: QoS for advanced driving.
  - ✓ T2S4: Human tachograph.
  - ✓ Trial facilities: 5GTN (Oulu), 5GRONINGEN (Groningen) and 5GENESIS (Surrey).
  - ✓ **URLLC requirement**.

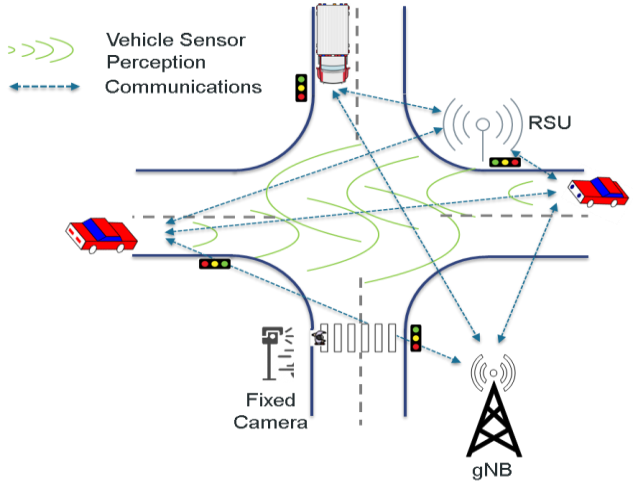

Figure 3 Network-assisted collision warning

Transport use cases – T3 support for remote driving

- Remote driving is a concept in which a vehicle is controlled remotely by either a human operator or cloud computing.
  - ✓ Efficient road construction, control of multiple autonomous vehicles from a single human operator (e.g., snow plowing).
  - ✓ Cost-efficient step towards purely automated driving.
  - ✓ Trial facility: 5GENESIS (Surrey)
  - ✓ **eMBB and URLLC requirements.**

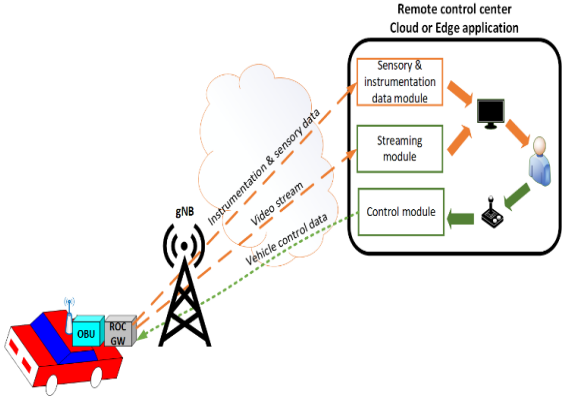

Figure 4 Remote Driving

Transport use cases – T4 vehicle data services

- The network collects actionable information from the vehicles and road users to provide various services.

  - ✓ T4S1: Vehicle prognostics.
  - ✓ T4S2: Over-The-Air (OTA) updates
  - ✓ T4S3: Smart traffic corridors
  - ✓ T4S4: Location based advertising
  - ✓ T4S5: End-to-End (E2E) slicing
  - ✓ T4S6: Vehicle sourced HD mapping
  - ✓ T4S7: Environmental services
  - ✓ Locations: 5GENESIS (Surrey) and 5GTN (Oulu).
  - ✓ **mMTC requirement.**

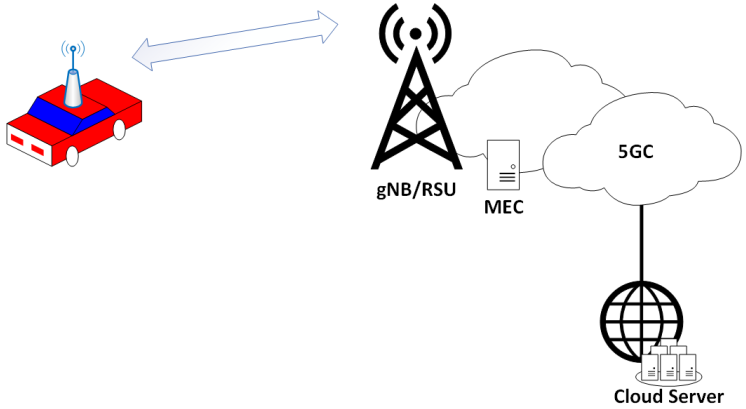

Figure 5 Indicative architecture for vehicle data services

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Transport trial facilities

- The main Transport trial facility is ICT-17 5GENESIS (Surrey, UK).
  - ✓ Employs the best of evolving NFV and SDN implementations and features.
  - ✓ Testbed covers the main campus of the University of Surrey (area of around 4 km^2).

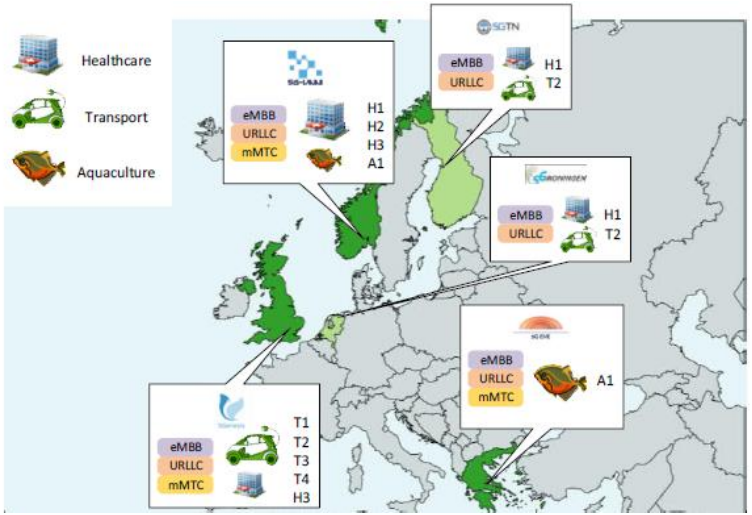

Figure 6 Transport trial facilities

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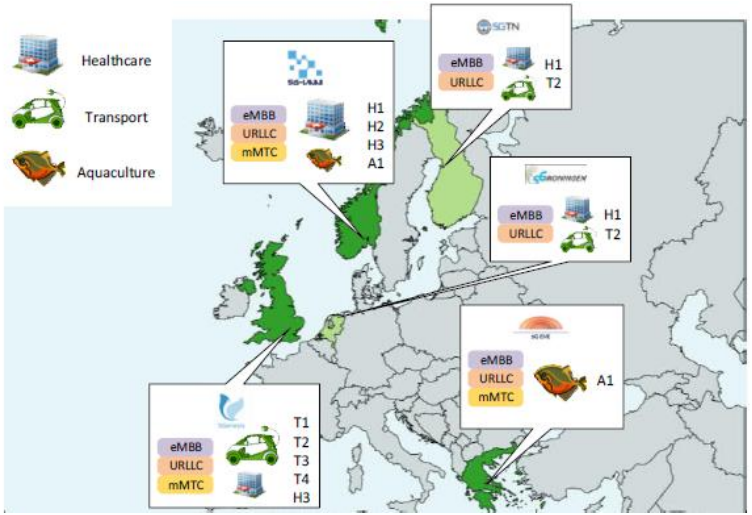
  - ✓ 5GTN in Oulu, Finland.
  - ✓ 5GRONINGEN in the Netherlands.



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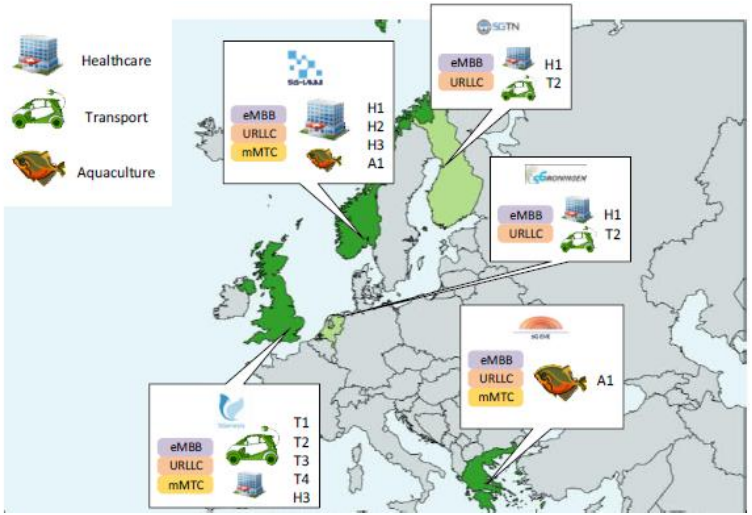
- Trials will start with local tests and evolve towards interconnected multi-site scenarios.



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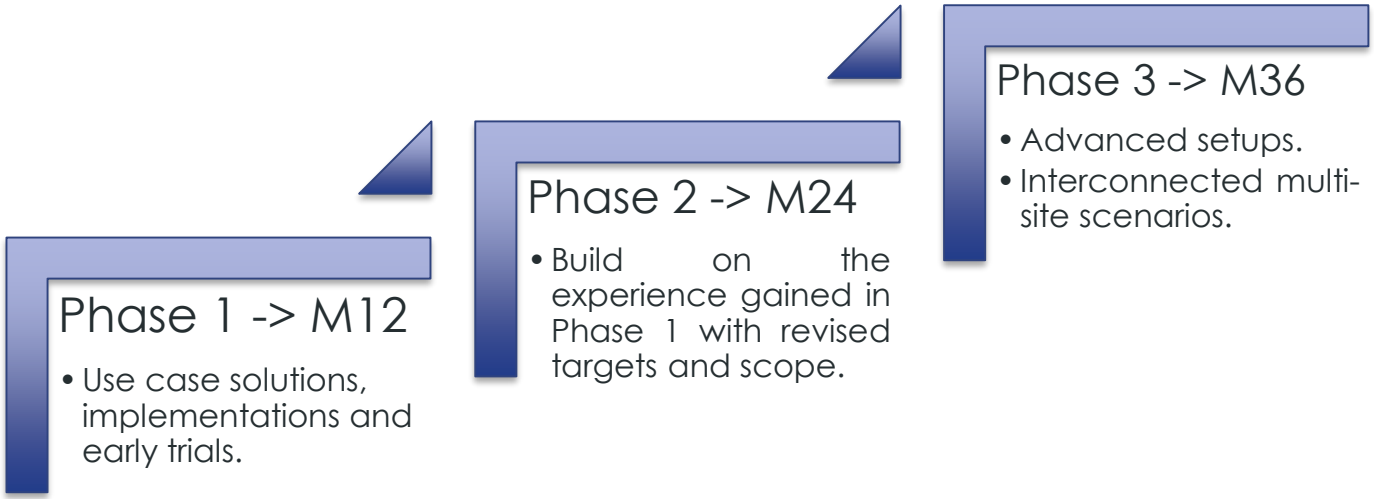
Few highlights, phased trial approach



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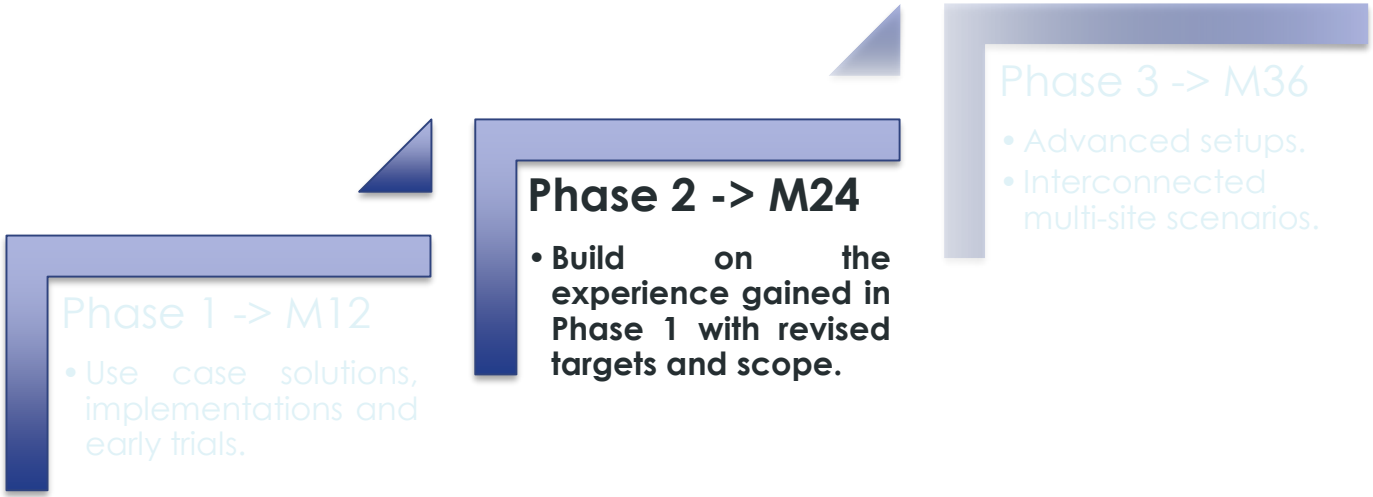

5GENESIS - T4S5, Setup

- **End-to-end slicing**
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  - ✓ Experimenters' entry point (i.e., user friendly portal or Open API).
  - ✓ Work with 5GENESIS on low-level details.

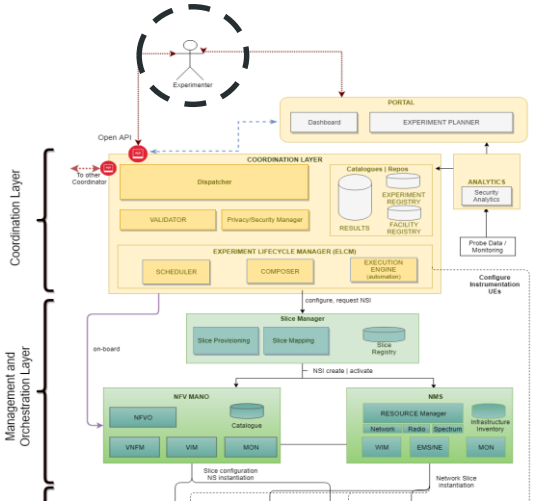

Figure 7 Extract of the 5GENESIS blueprint [1]

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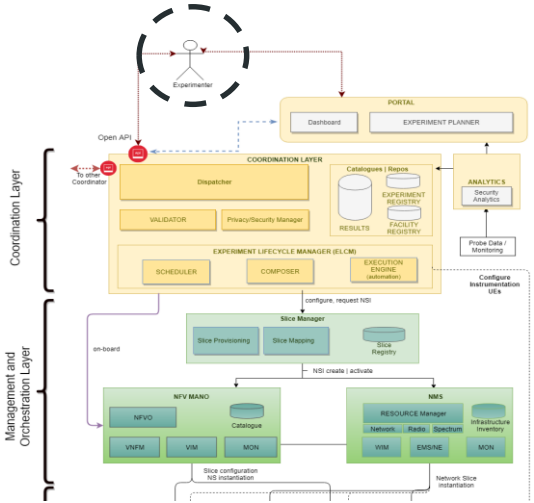
  - ✓ Work with 5GENESIS on low-level details.
- **Next steps**
  - ✓ A customised 5GENESIS instance with the required extra capabilities (e.g., URLLC support and V2X functionalities).



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5GENESIS - T4S5, Initial Results

- **eMBB slicing (Phase 1)**
  - ✓ Core: Rel.15 4G Core NSA.
  - ✓ Control Plane: 4G RAN.
  - ✓ User Plane: 5G RAN (Huawei Commercial).
  - ✓ UE: 5G customer premises equipment (CPE).

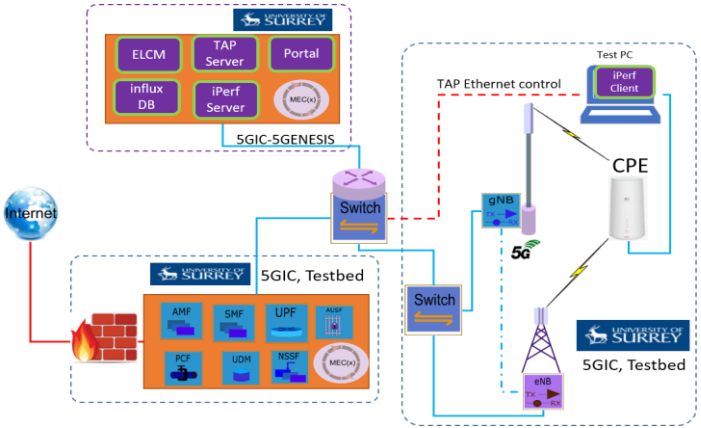

Figure 8 Initial setup for eMBB slicing

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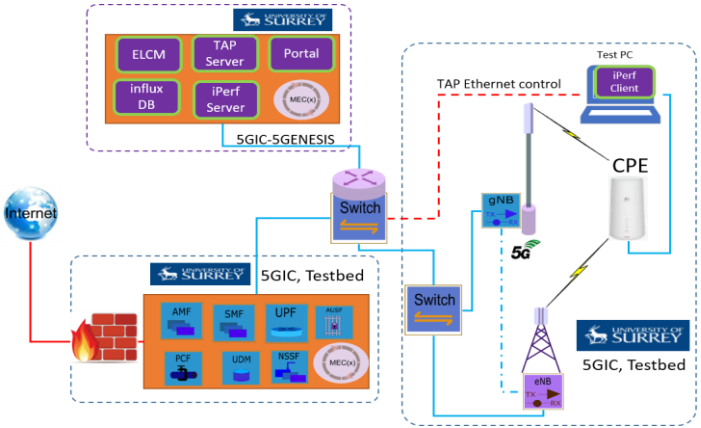

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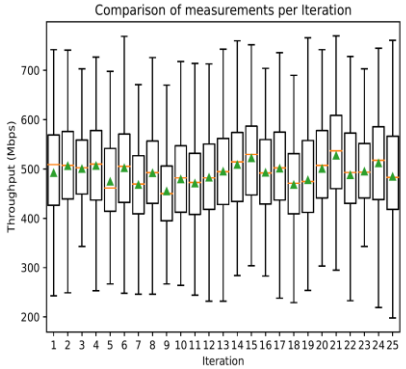

Figure 9 Throughput test results (DL. TCP)

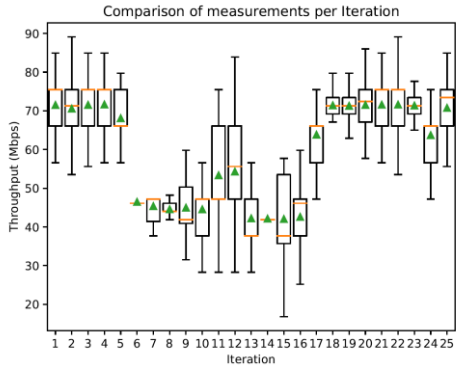

Figure 10 Throughput test results (UL. TCP)

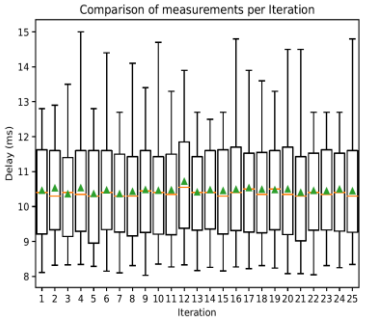

Figure 11 Round Trip delay test results

5GTN – T2S4, Setup

- **Wearables-based human tachograph**
  - ✓ Provides direct measurement and assessment of the driver's physiological status.
  - ✓ Monitor the state of the driver and potential risks from history data (e.g., sleep deprivation and high stress) for proactive measures to improve safety.

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- **On-going**
  - ✓ UEs: Polar M600 sports watch, OnePlus 7 Pro 5G, Samsung Galaxy S10 5G and Nokia Fastmile 5G gateway device
  - ✓ RAN: Nokia 4G eNB and 5G gNB
  - ✓ CN: Nokia 4G EPC, 5GC NSA and emulated CN services.
  - ✓ Service cloud: Microsoft Azure.

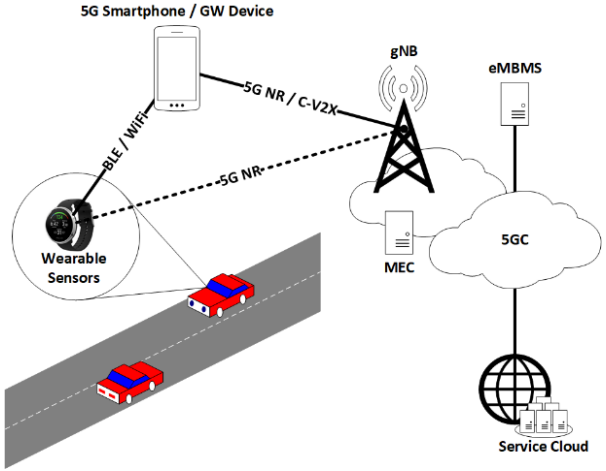

Figure 12 Human tachograph architecture

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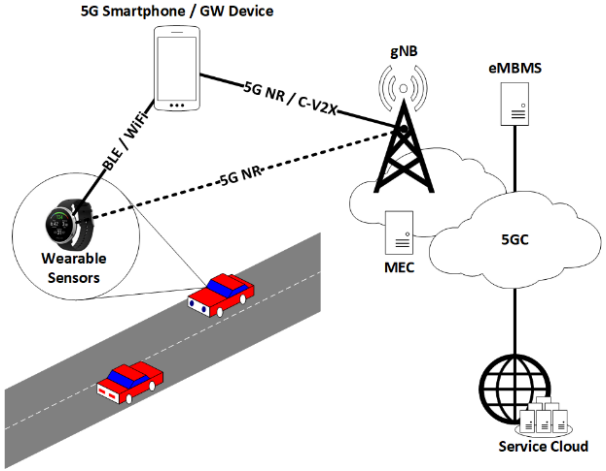
  - ✓ Service cloud: Microsoft Azure.
- **Next Steps**
  - ✓ Relocation of data fusion (live and history data) and analysis to the network edge.
  - ✓ Further optimisation of the 5G NR UL performance.
  - ✓ Setup upgrade (e.g., R16 gNB, 5GC SA and eMBMS).



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- **Reference measurements**
  - ✓ 4G LTE (2.6 GHz FDD with 10+5 MHz bandwidth).
  - ✓ 5G NR (3.5 GHz TDD with 60 MHz bandwidth).
- **Measurement and testing tools**
  - ✓ Qosium for E2E passive QoS/QoE measurements and monitoring.
  - ✓ Keysight Nemo Handy and Nemo Outdoor Playback.
  - ✓ Internal eNB/gNB counters for RAN measurements/monitoring.
  - ✓ InfluxDB (data storage) and Grafana (visualisation).

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- **Initial results**
  - ✓ Baseline 4G and initial 5G measurements.
  - ✓ Throughput DL/UL.
  - ✓ End-to-end latency (E2E) DL/UL.
  - ✓ Reliability.

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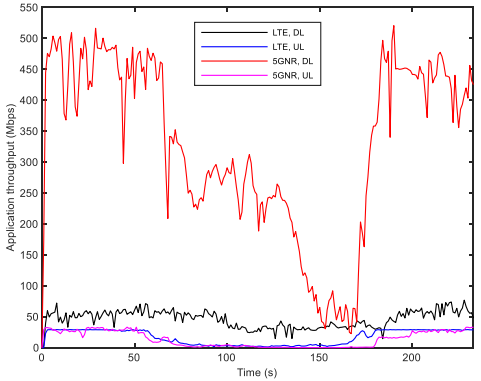
a) Driving route



(b) 4G and 5G throughputs

Figure 13 Phase 1 field trials

5GRONINGEN – T2S1&T2S2, Setup

- **Smart Junctions**
  - ✓ Provide network-assisted time-critical safety information at intersections.
  - ✓ Improve the overall traffic flow e.g., create a green light wave or give priority to certain vehicles.

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- **On-going**
  - ✓ OBU configured for both 5G-NR and C-V2X.
  - ✓ 5G NR gNB running 5G-NR @ 3650 MHz with a bandwidth of 100 MHz.
  - ✓ IP-based security camera with object detection, e.g. vehicle and vulnerable road user tracking via ETSI CPM.
  - ✓ Cloud server running an MQTT broker, hosting the object detections.

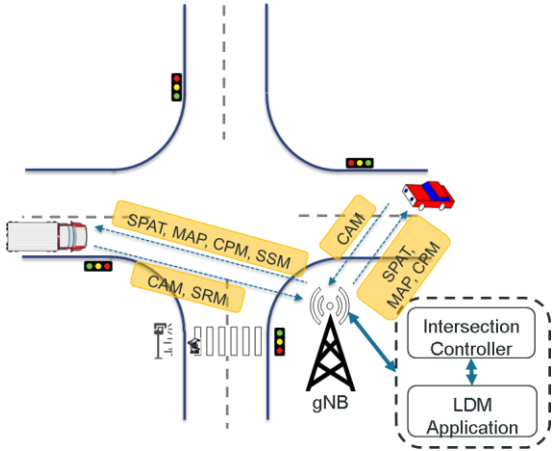

Figure 14 Emergency vehicle requesting green wave priority.

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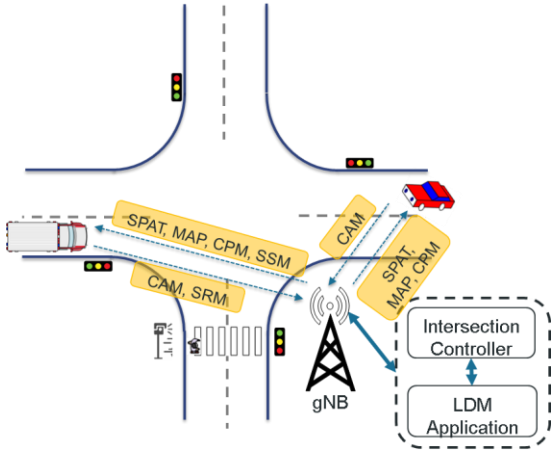
- **Next Steps**
  - ✓ Connect Intersection Controller to the 5GRONINGEN network.
  - ✓ Configure vehicle priority request over 5G.
  - ✓ Extra functionalities (i.e., edge computing and slicing).



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5GRONINGEN – T2S1&T2S2, Initial Results

Key target KPIs

The Phase 1 trials set the baseline of the current state-of-the-art (i.e., Rel-14 LTE) performance

- ✓ Throughput (DL and UL).
- ✓ Peak data rate / Message rate.
- ✓ E2E latency.

Measurement and testing tools

- ✓ Software probes for network performance measurements, e.g. Ping, IPerf2, IPerf3.
- ✓ CPM application for application layer E2E latency.
- ✓ Automatic logging analysis platform.

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Initial Phase 1 results

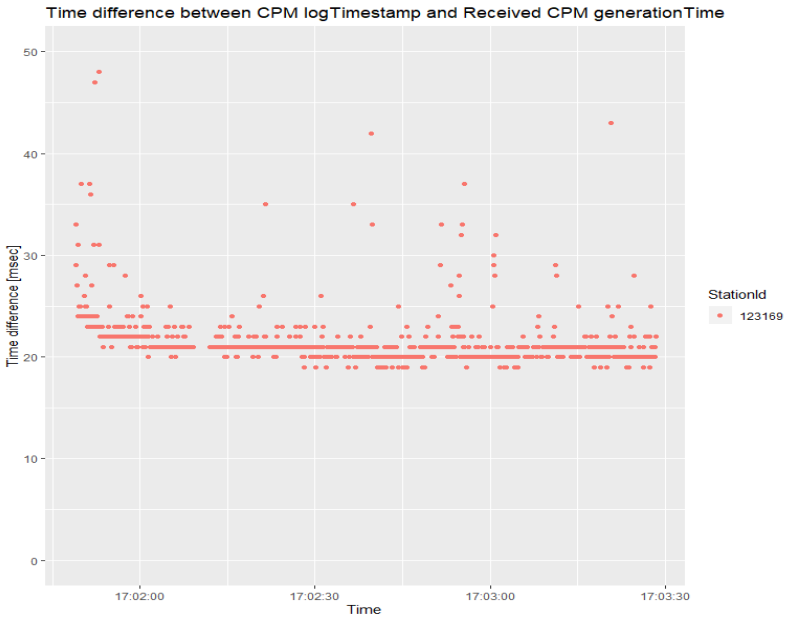

Figure 15 E2E latency (LTE)

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- **Phase 1**
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  - ✓ Tests and experiments using 4G and initial 5G setups.
  - ✓ Progress documented in public D4.2 (05/2020).

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- **Phase 2**
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- **Phase 3**
  - ✓ Concurrent testing.
  - ✓ Cross-vertical trials.

THANK YOU
FOR YOUR ATTENTION

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research and innovation programme under grant agreement No 857034