GR-TR Cross-Border Corridor

Overview

Dr. Nazlı GÜNEY - Presenter

IEEE 5G for CAM Summit, 11 May 2021

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 825496

Agenda

- Trial Location and GR-TR Partners
- User Stories
- 5G Network
- Verification and Integration
- CBC Trial Plan and Next Steps

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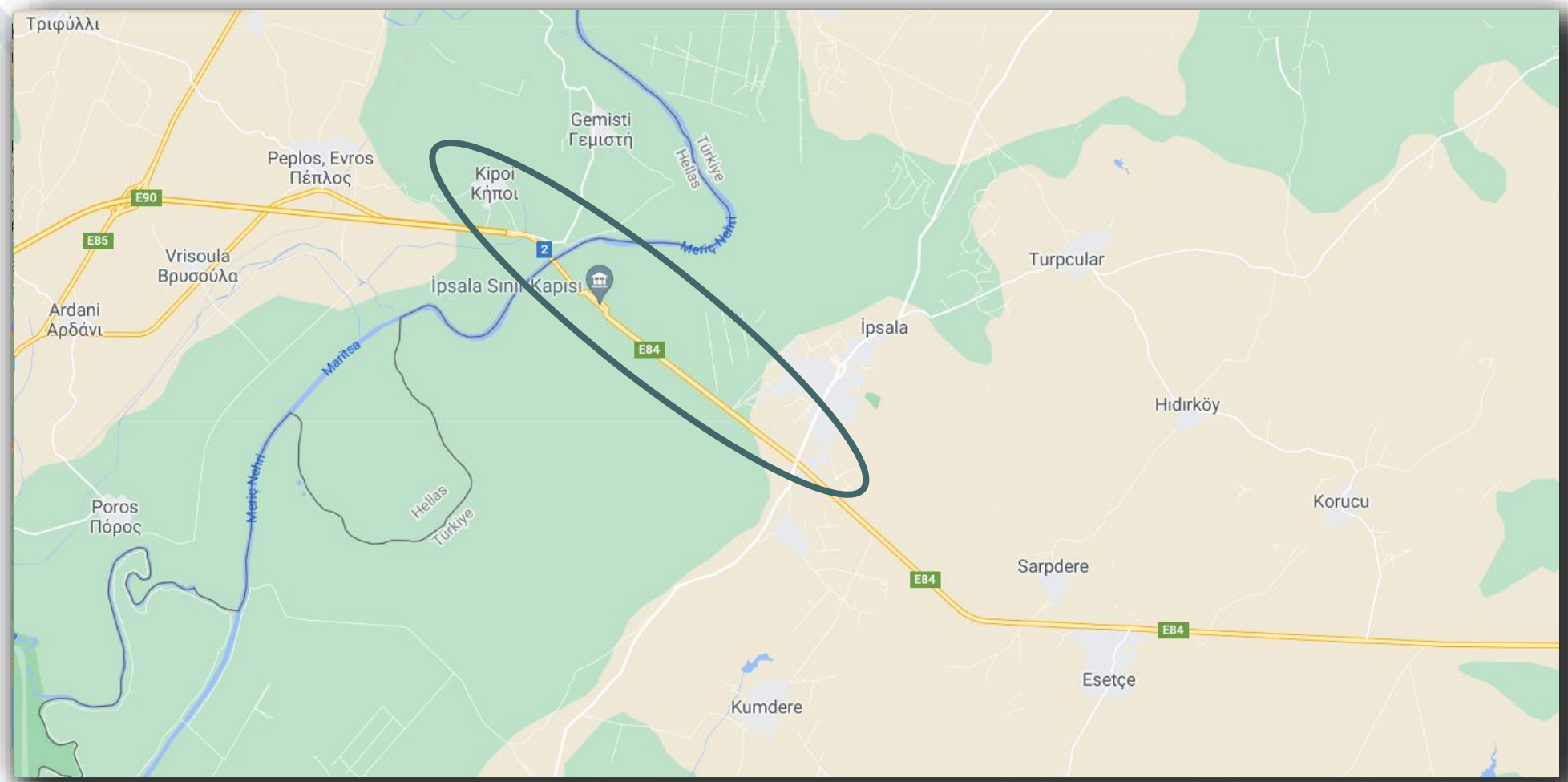
Trial Location and GR-TR Partners

Where is the GR-TR corridor?



The GR-TR Border in Pictures

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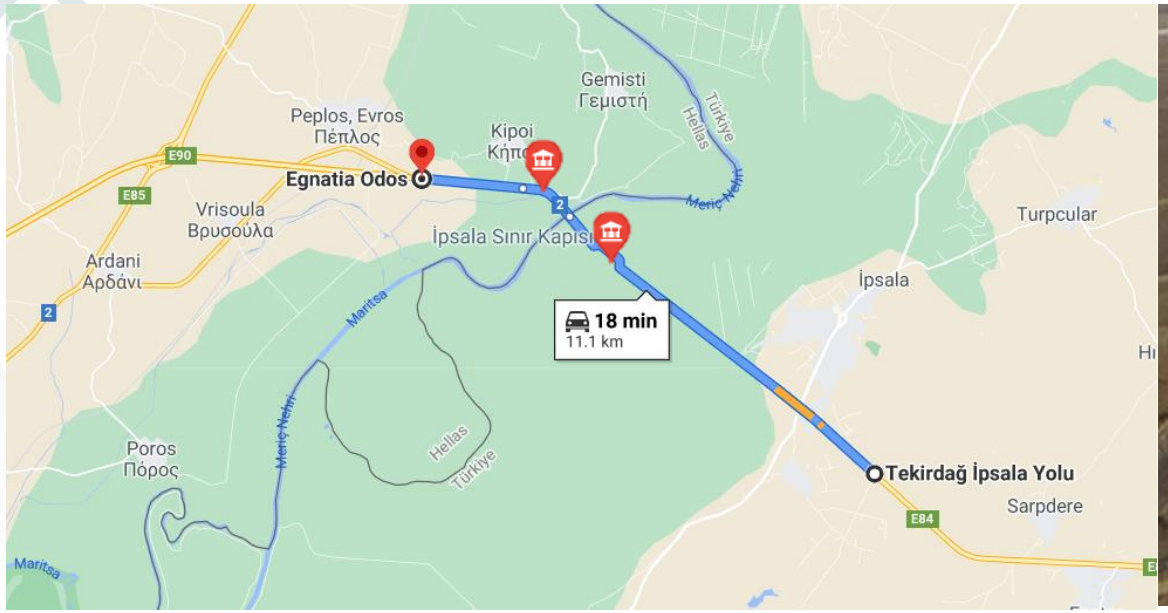
Test and Trial Locations



Ipsala – Kipoi cross-border site

Ford Otosan test site to be used for long-term functionality development & testing

Border crossing permissions are needed

Knowledge & technology

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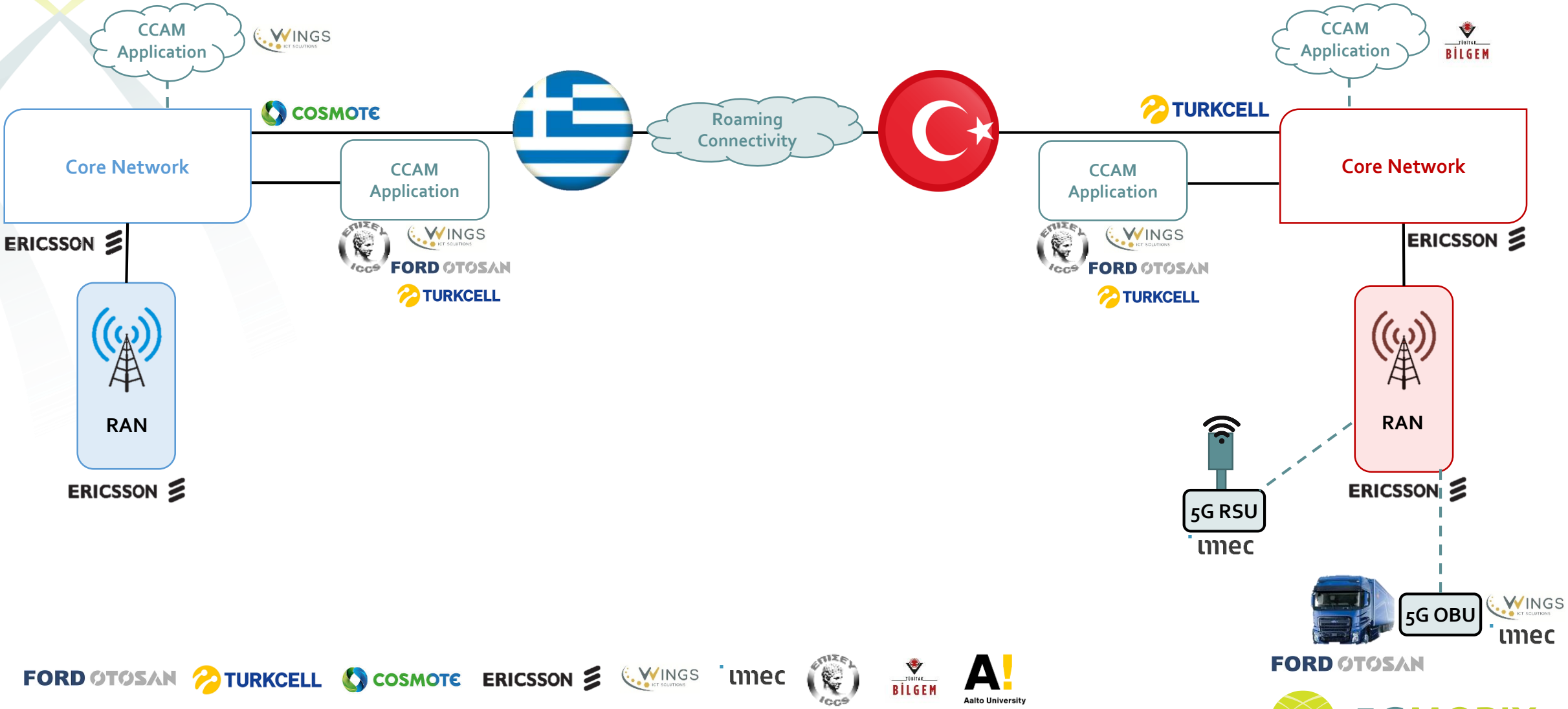
GR-TR Partners



FORD OTOSAN TURKCELL COSMOTE ERICSSON WINGS imec BILGEM Aalto University

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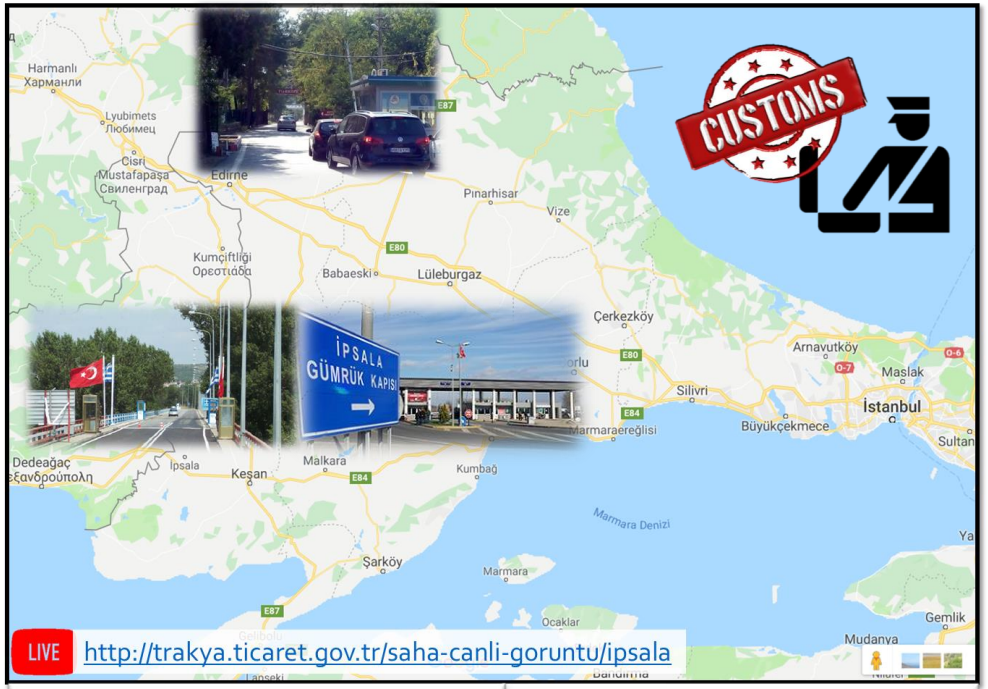
GR-TR Corridor in Numbers

Greece-Turkey Corridor		
Location	CBC	Ipsala – Kipoi border region
5G Networks	NSA 5 gNBs	NSA, 3 (TR) + 1 (GR) gNBs → 5 sites / 6 sectors + 1 additional gNB at the Ford Otosan plant
Vehicles	2	2 trucks from Ford Otosan
OBUs	3	2 OBUs from IMEC + 1 OBU from WINGS
RSU / Edge App / Cloud	3 / 3 / 2	3 RSUs from IMEC + RSI from WINGS 3 edge applications + 2 Cloud applications
User stories	4	• Platooning • See-what-I-see • Truck Routing • Assisted Border-Crossing



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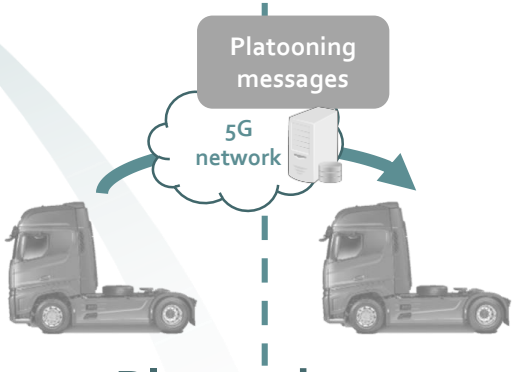
User Stories

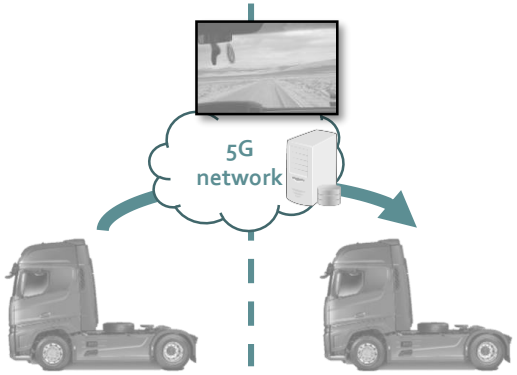
GR-TR User stories



Platooning

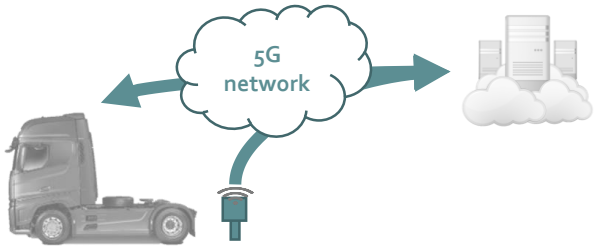
Platooning messages between leading truck and followers to affect their maneuvers

«Platooning» Use Case Category



See what I see

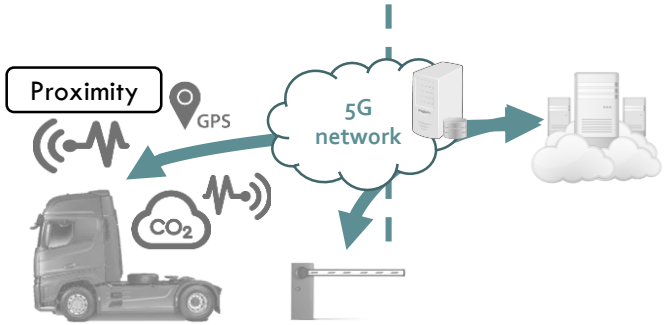
4K video streaming from one vehicle to the others



Truck routing

Remote operation of the vehicle at the customs site for X-ray checks

«Extended Sensors» Use Case Category

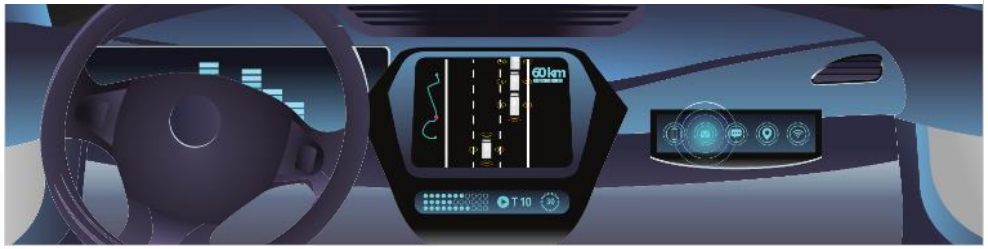


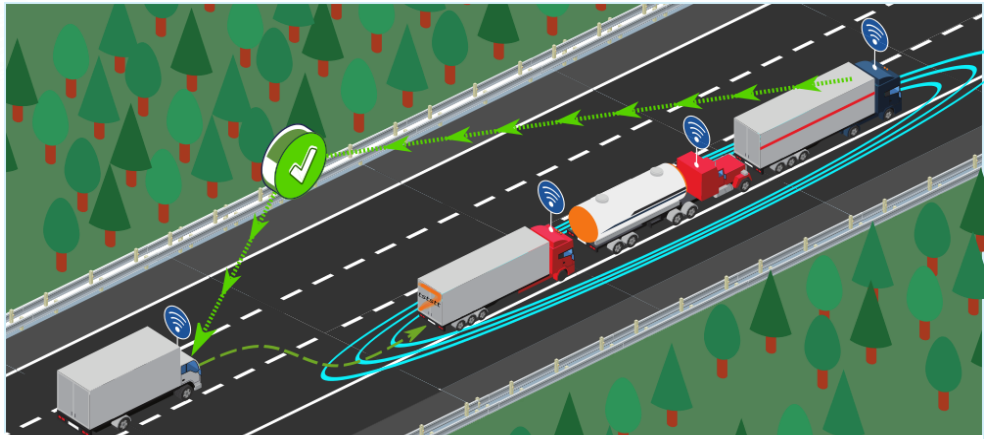
Assisted Border Crossing

Zero touch decision making: the vehicle is allowed to pass the border with no stops

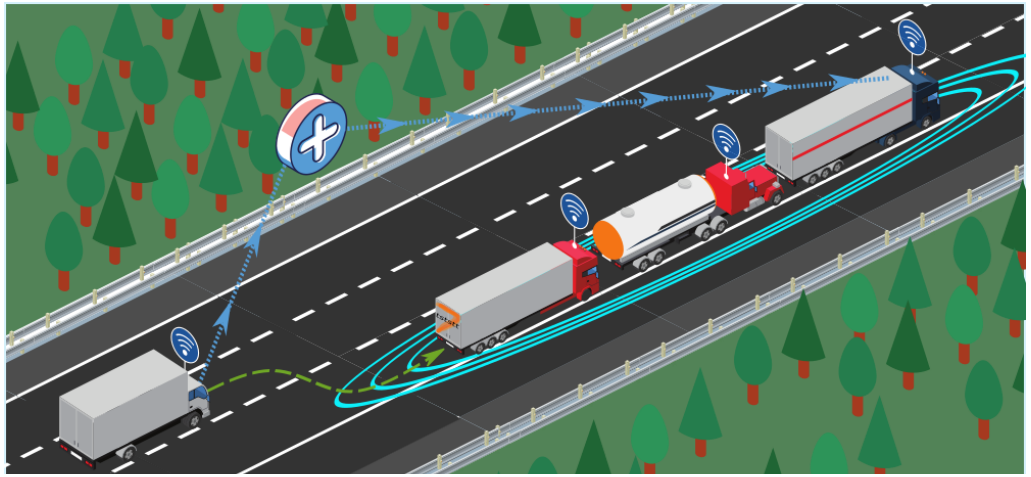
Platooning with See-What-I-See

In your truck, you have a touchscreen in which you can search for nearby platoons.





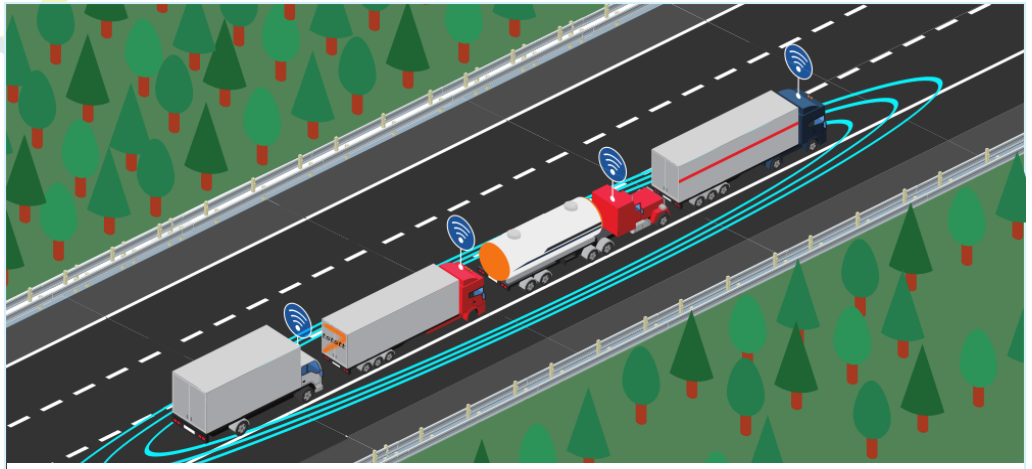
The platoon leader will have to approve the request. If she does, you can then approach the platoon



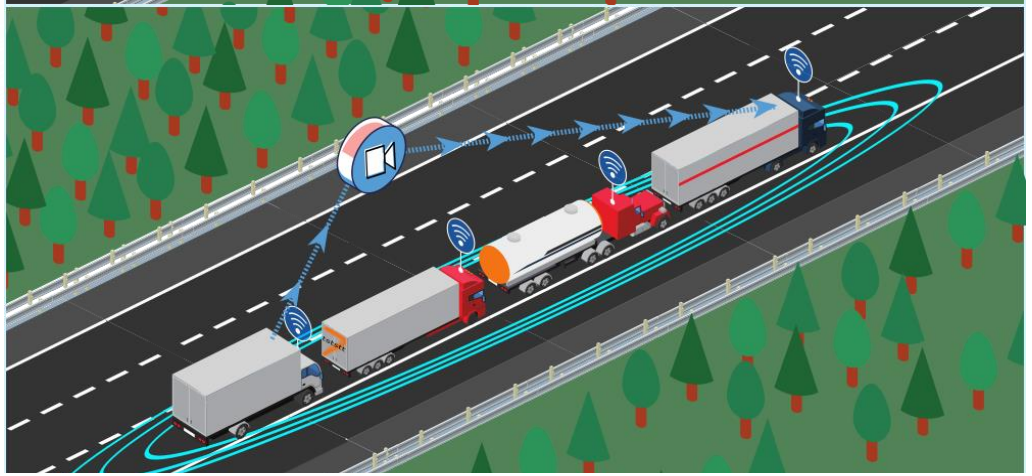
If one is found, then you can send a "join" request.

Approval and location is displayed on the touchscreen.

Platooning with See-What-I-See (2)



At this point, the automatic system will take over and your vehicle will be automatically driven.



Once this integration is complete, you can request access from the leading driver to a "see what I see" application.

Application allows you to see a continuous stream from a camera positioned on the leader's windshield and pointed forward.

You can have a continuous vision of the road ahead of the leader and your cruise will be safer and more comfortable.

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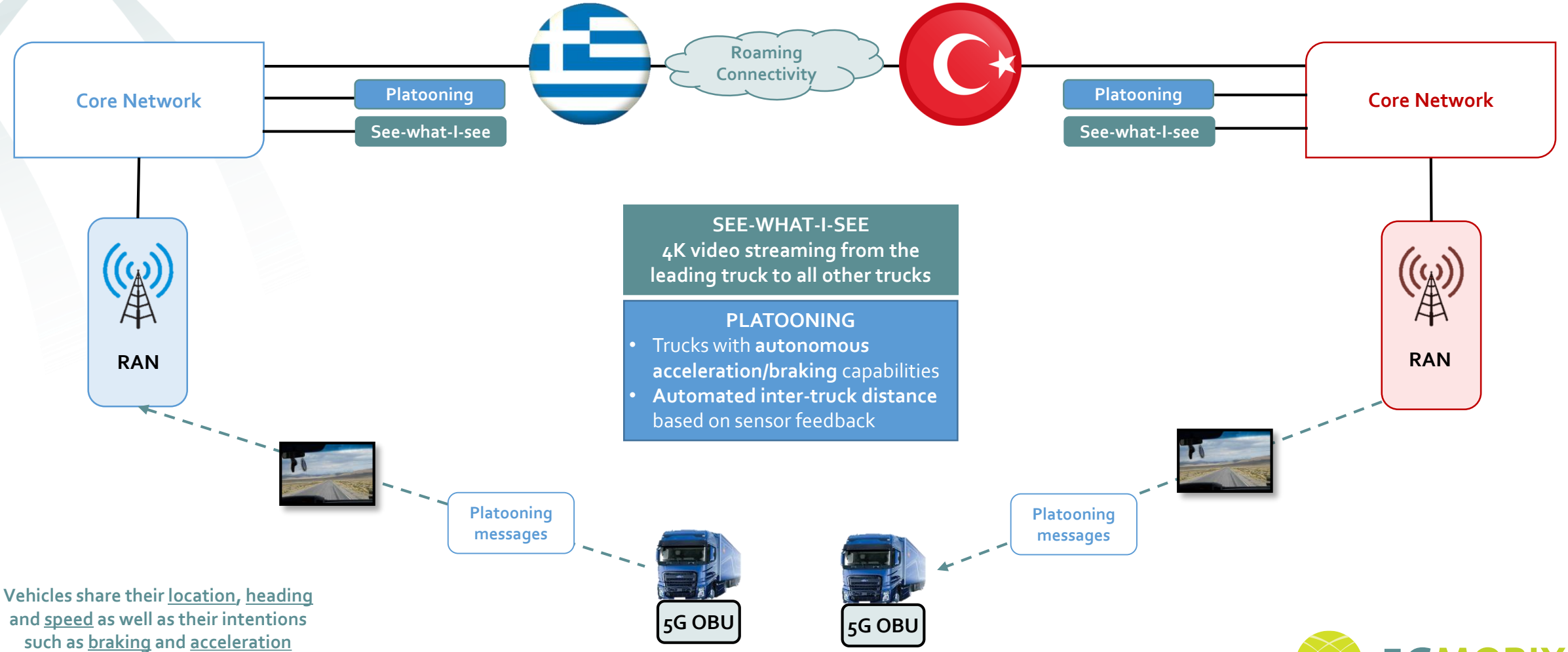
Use Case Category: Platooning



Vehicles share their location, heading and speed as well as their intentions such as braking and acceleration mainly over C-V2X Uu interface. PC5 will be available as redundancy.

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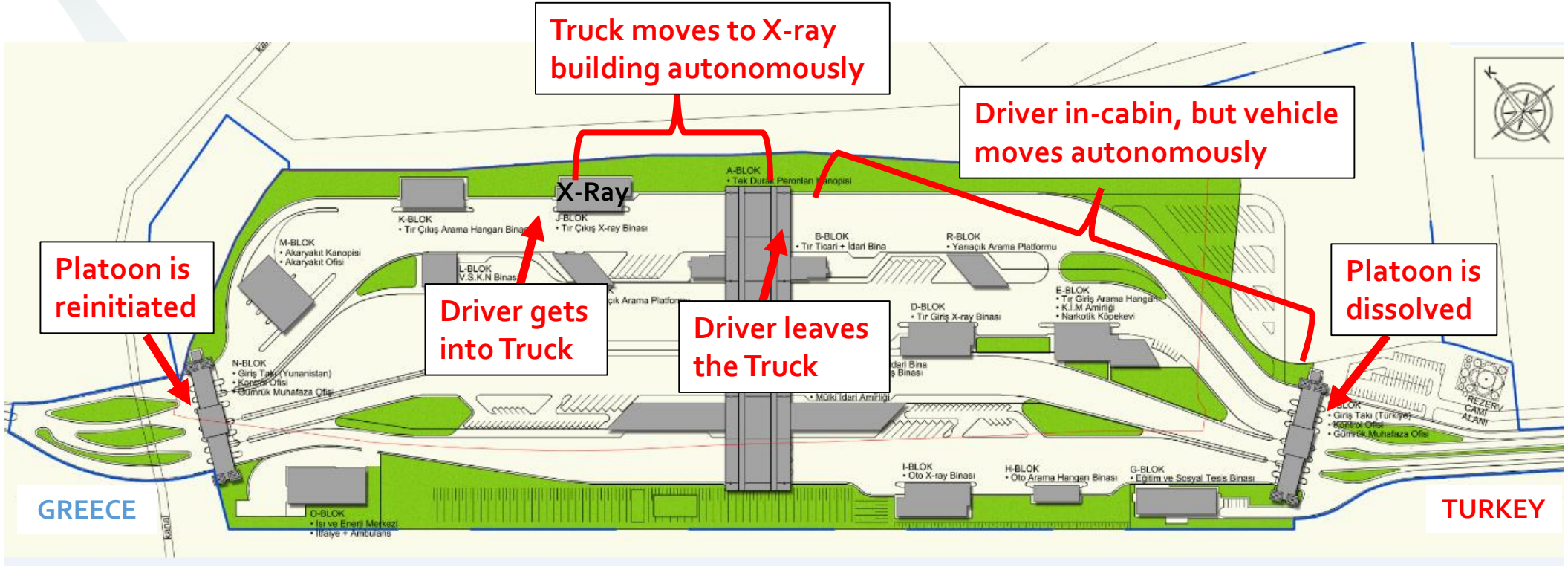
Truck Routing in Customs Site

Transfer platoon members from one end of the customs area the other much faster

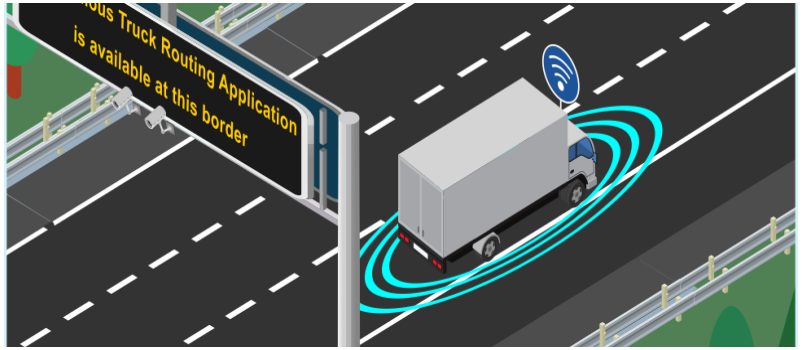


SOURCE: Site map received from the customs authorities during the Ipsala visit on August 1st, 2019.

Truck Routing in Customs Site (2)

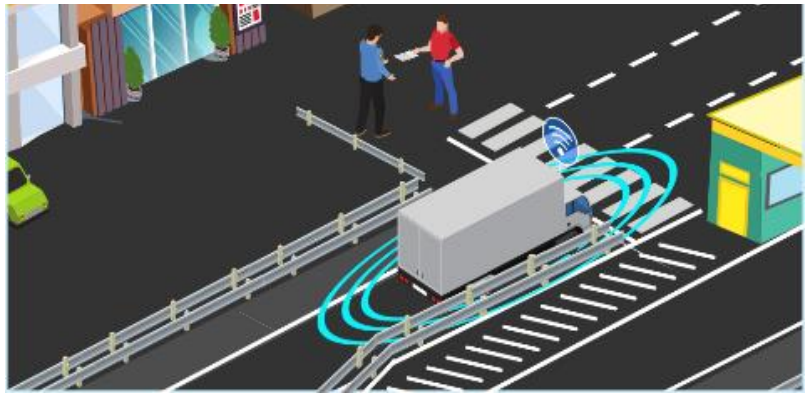
The road sign is seen

The driver is given the option to use the application. The plate is recognized.

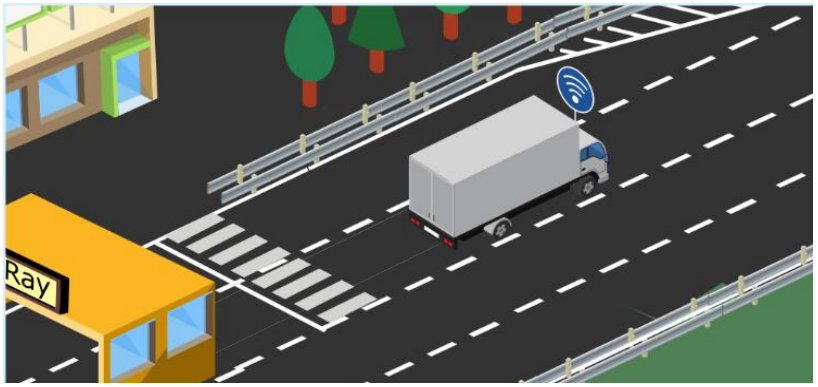


The decision for x-ray inspection is made at the entrance of the customs zone.

The driver gets off the truck for paper work and an x-ray check is requested by the authorities.



The truck will be driven by a centralized control system to the x-ray building.



After the x-ray inspection, if everything is ok, the truck will be on its way.

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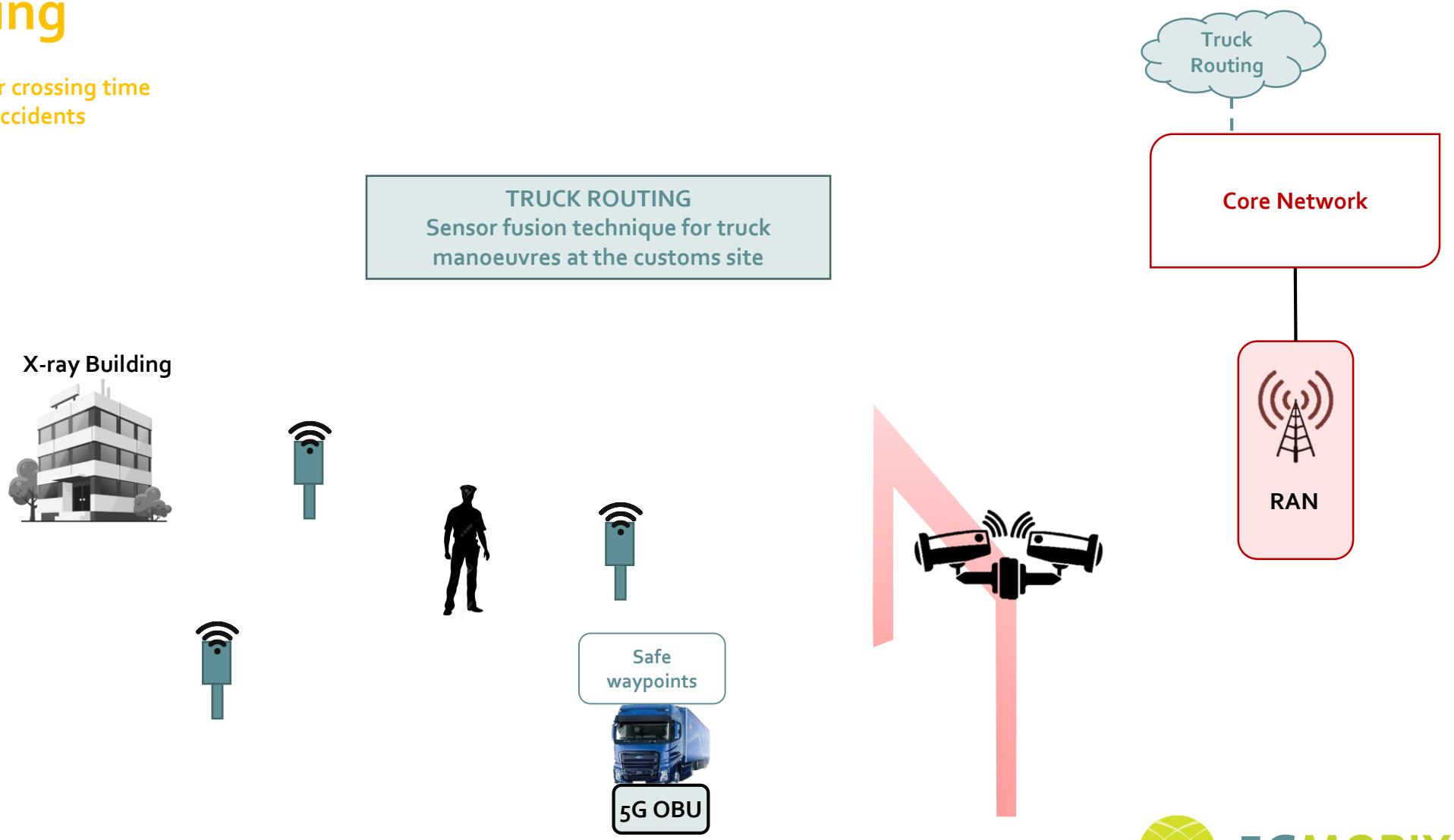
Use Case Category: Extended Sensors

Truck Routing

Decreased average border crossing time
and prevention of accidents



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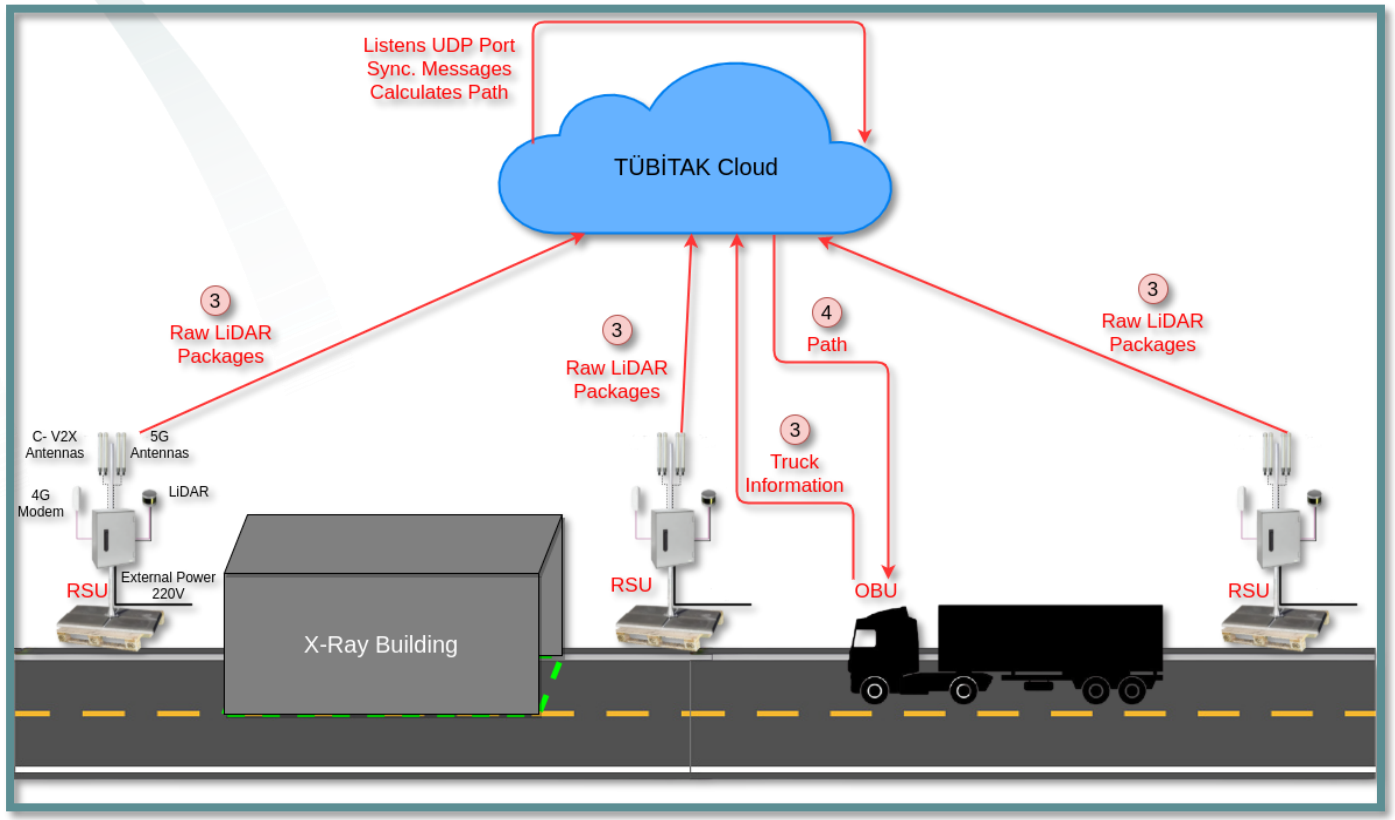
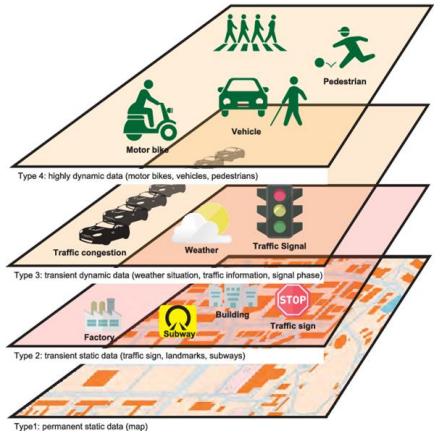
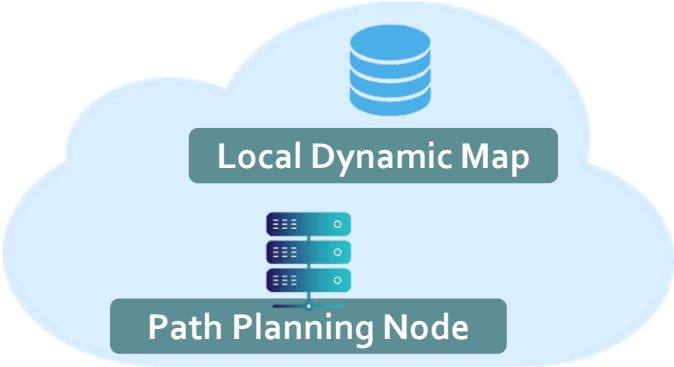
Truck Routing Application







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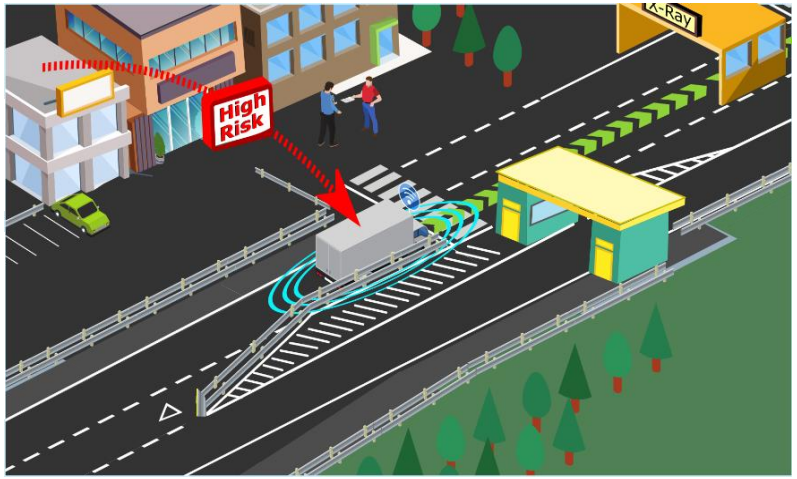
Assisted Border Crossing

Perform Risk / Threat assessment based on input from CO_2 sensor and truck manifest

All cargo in a vehicle is identified based on a wireless technology (e.g. NFC). Identified cargo inventory *cross-checked with the vehicle's documentation / manifest*



If NO human / livestock / unauthorized cargo, issue "Low Risk" and instruct a –zero touch-border crossing

Customs agents location monitored via Proximity & GPS readings

Autonomous vehicles are instructed to stop or change course

Once the vehicle's trajectory is determined to potentially lead to a collision or an accident with customs agents an alert is issued.

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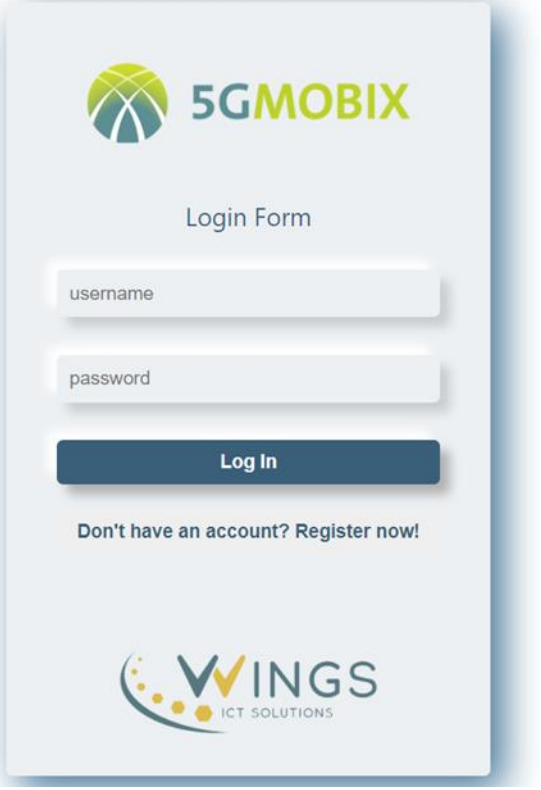
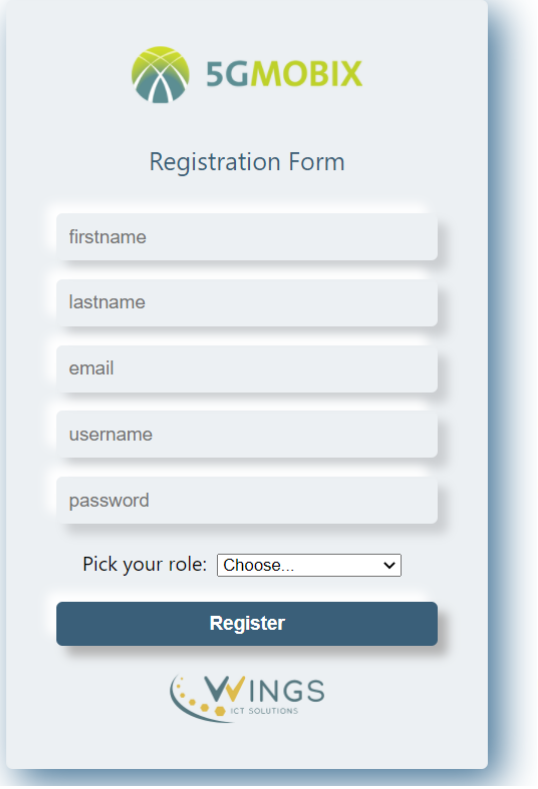
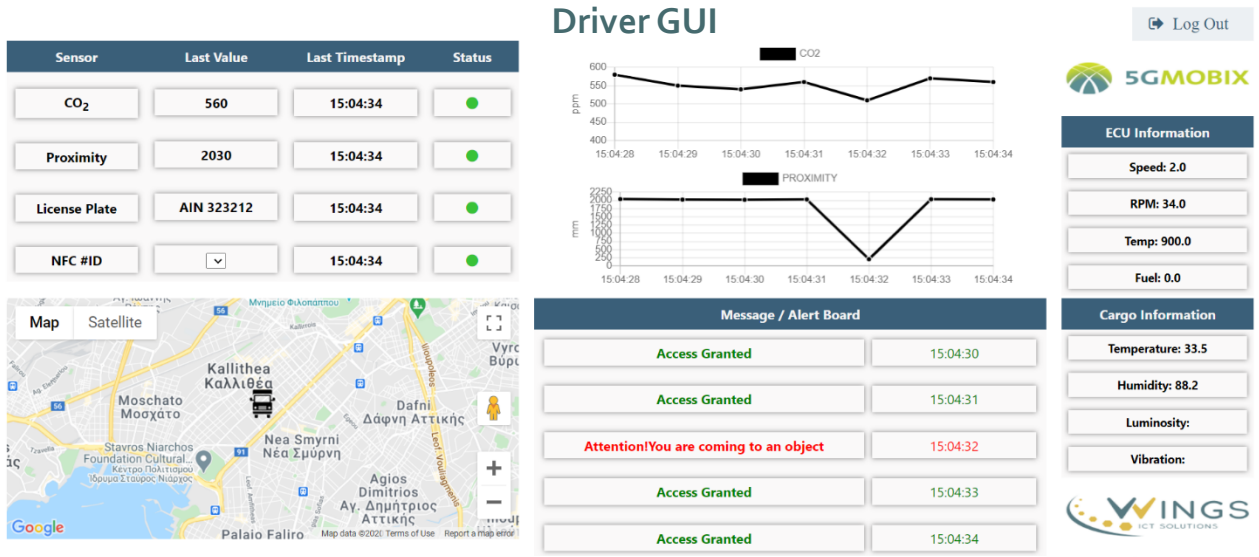
Assisted Border Crossing (2)

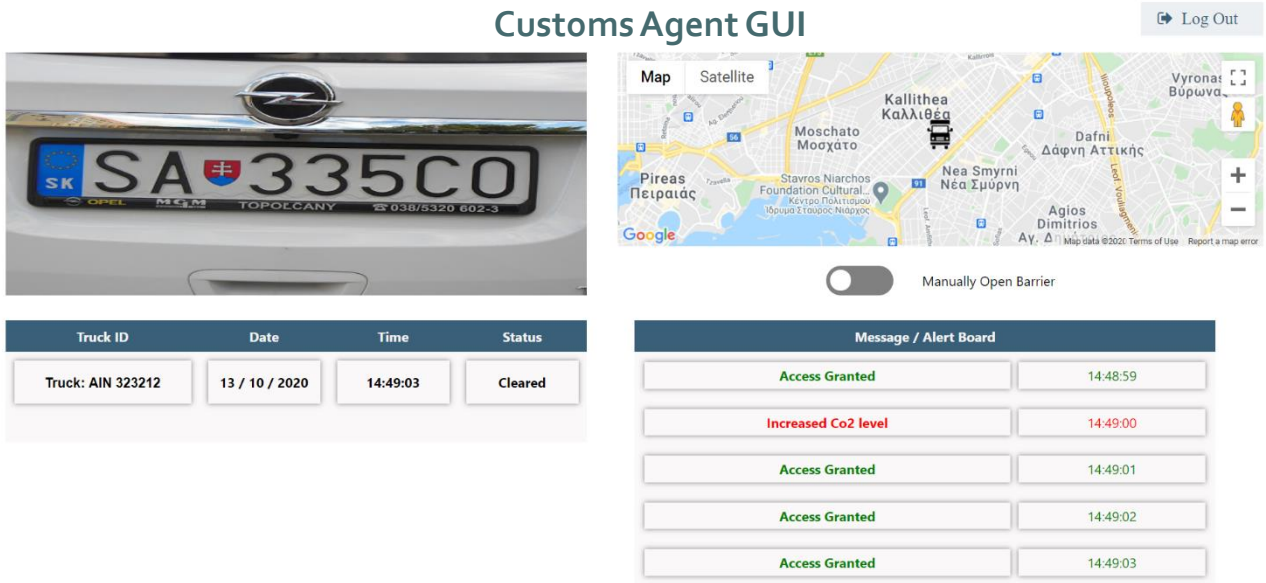




Driver GUI

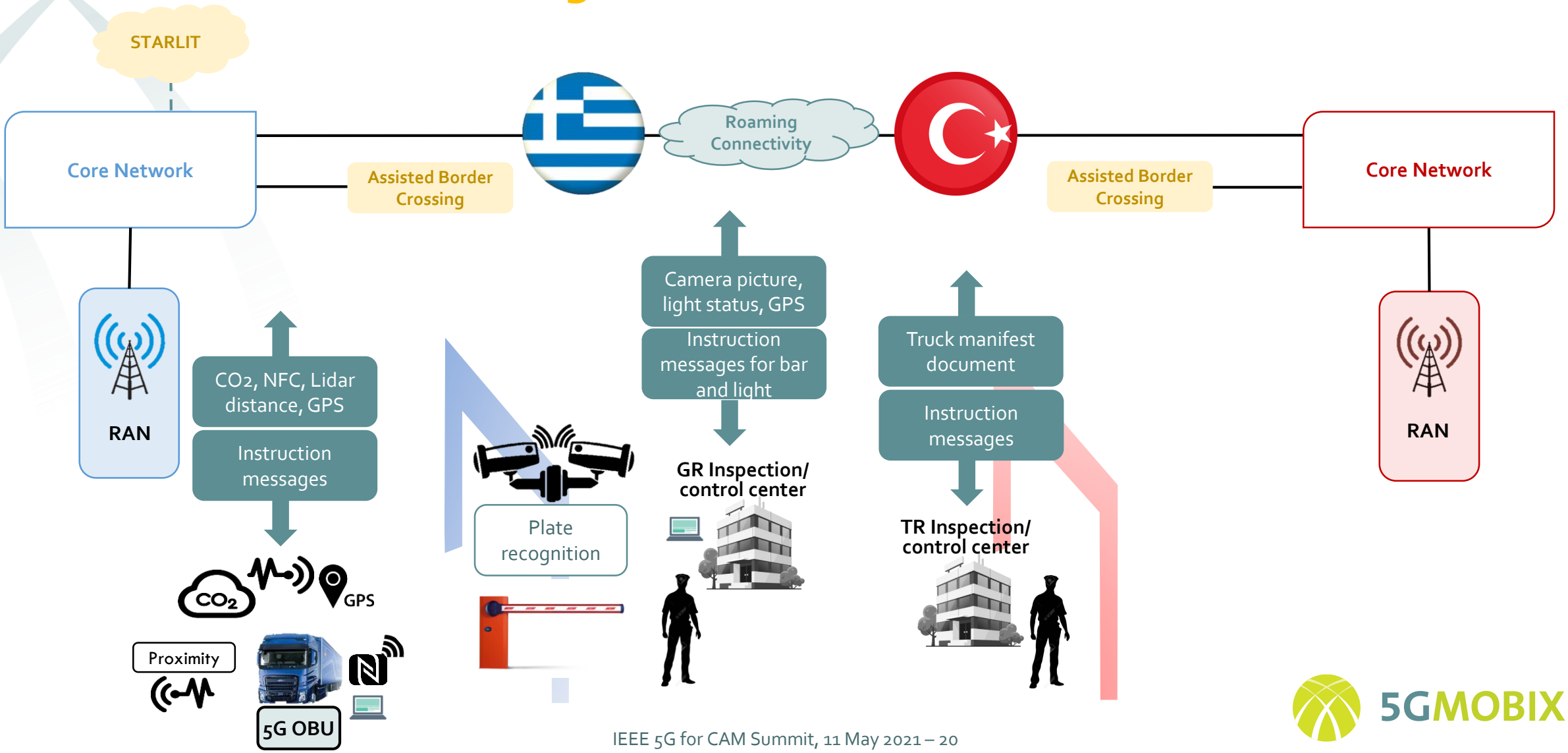


Customs Agent GUI



Use Case Category: Extended Sensors

Assisted Border Crossing



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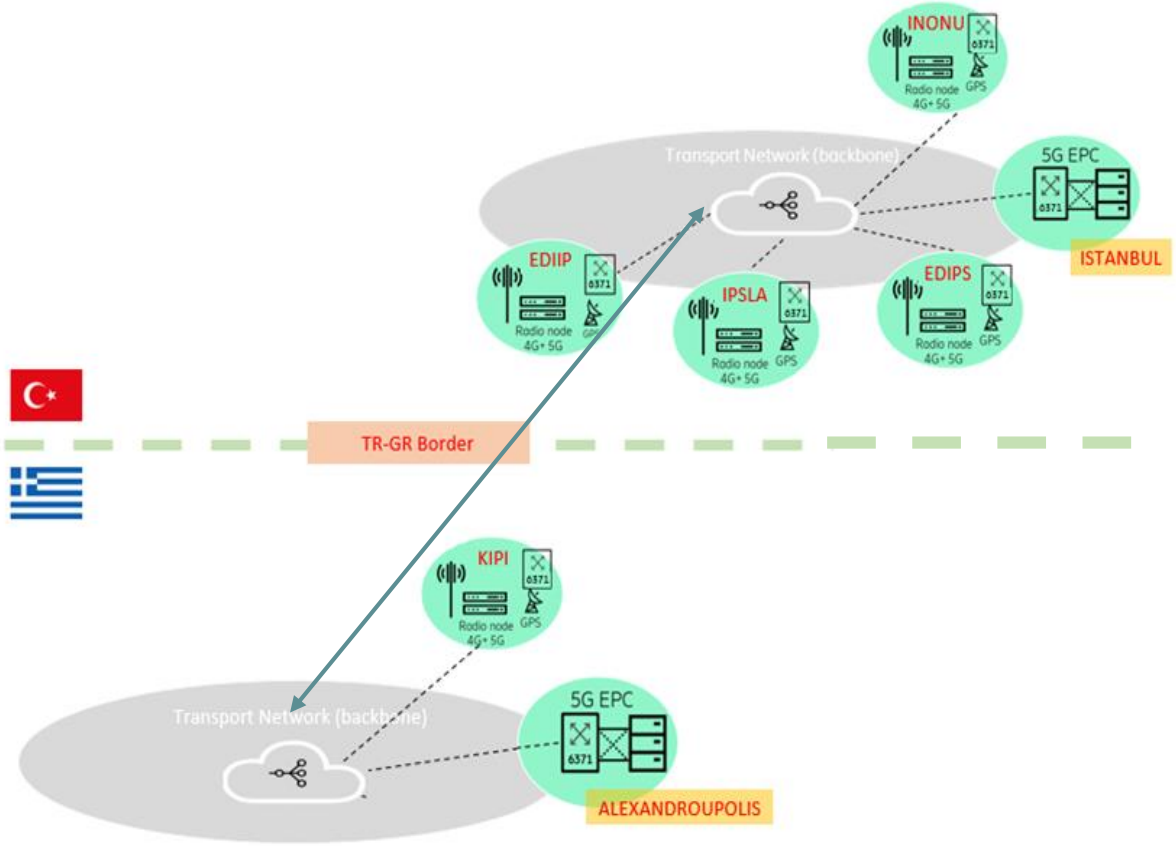
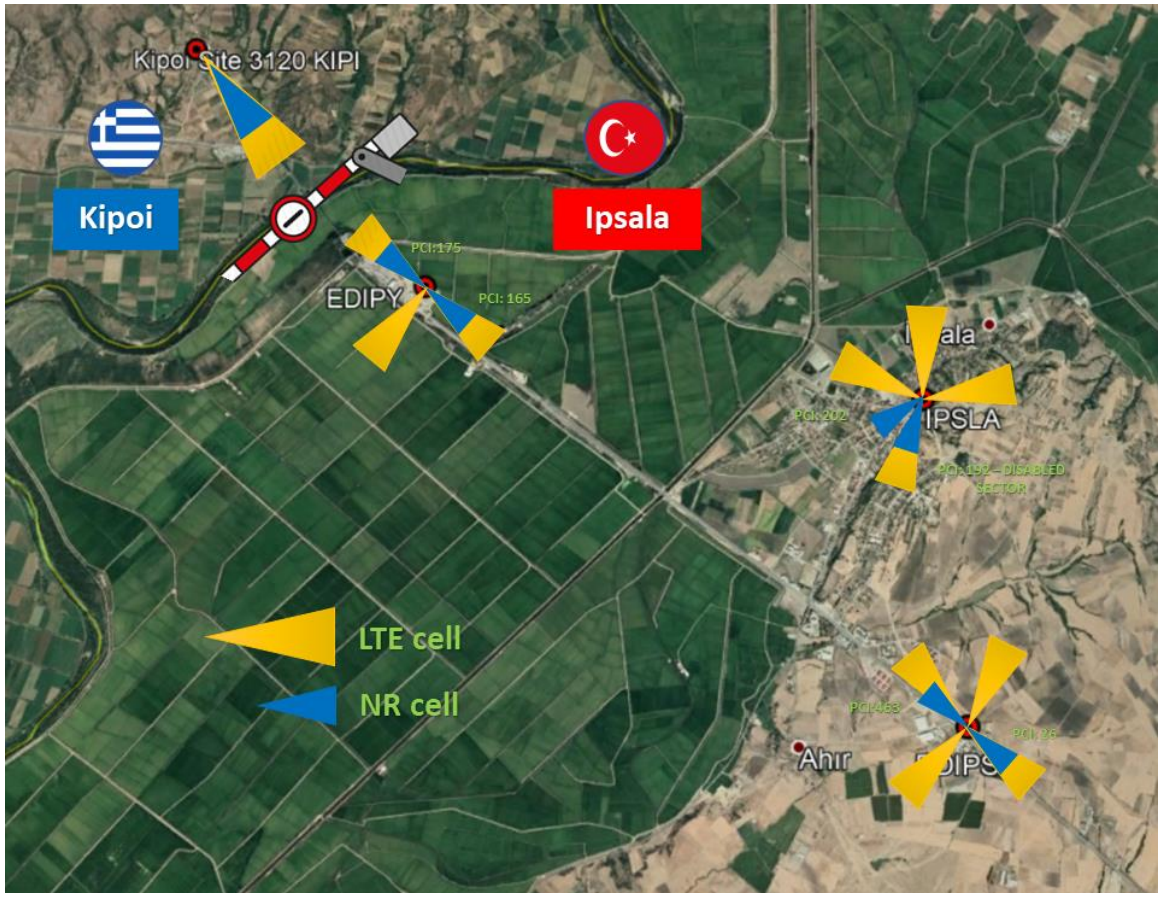
5G Network

5G Network - Architecture

Network type	Frequency bands	Sites
NSA Option 3X	LTE: 2600 MHz band NR: 3600-3800 MHz (B78G – B43)	EDIPY, IPSLA, EDIPS, INONU
NSA Option 3X	LTE: 2600 MHz band NR: 3420-3600 MHz (B78F – B42F)	KIPOI





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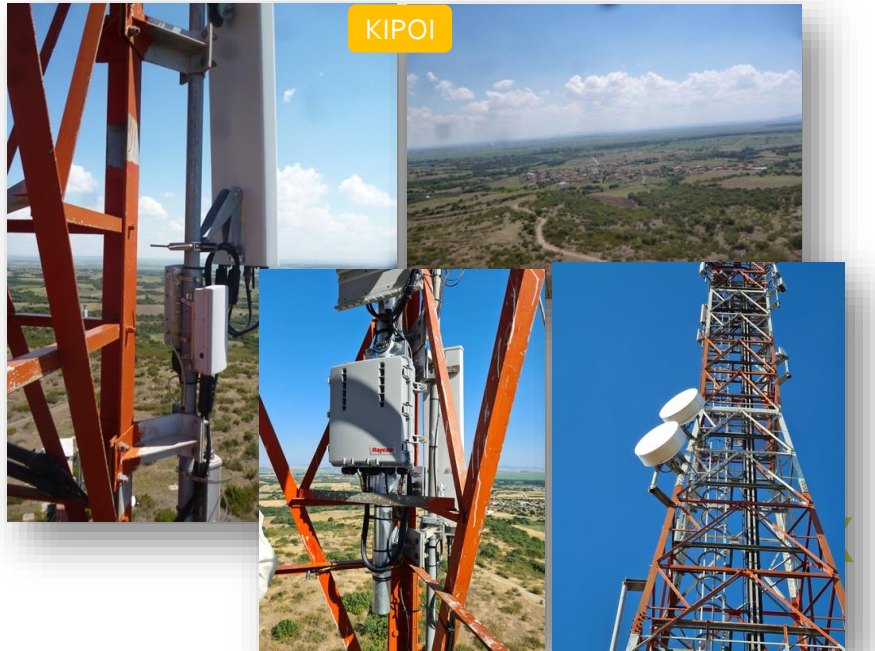
5G Network - Pictures

Radio Access Network

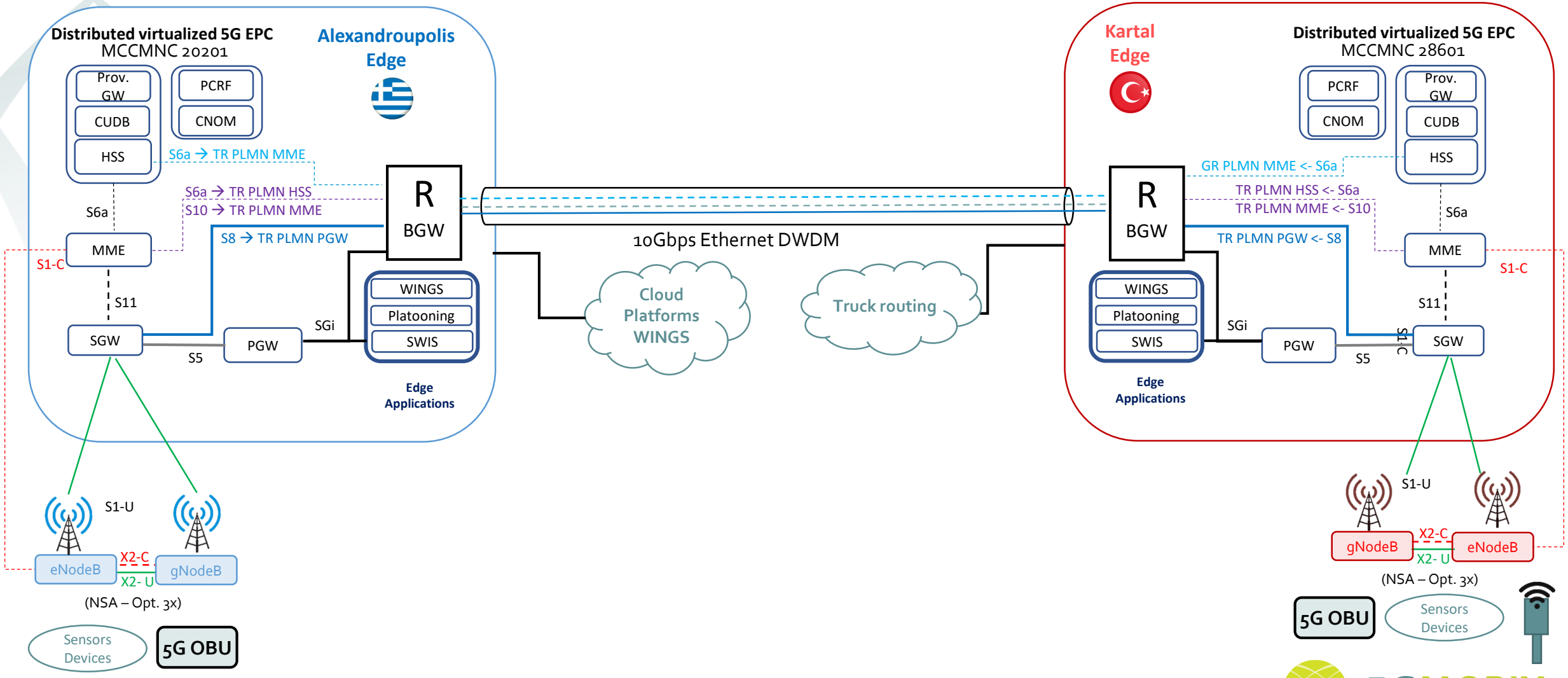
NETWORK ENGINEERING STEPS	
Network Design	
Radio Access Network	Deployment
	Integration
Transport Network Upgrades	
Core Network	Installation
	Configuration
End-to-end Network Testing	
IP Network Implementation	
Inter-operator Testing	

ENM@Psalidi (Management Servers at COSMOTE Athens)

Core at the Edge of @Alexandroupoli



5G Network - Interfaces



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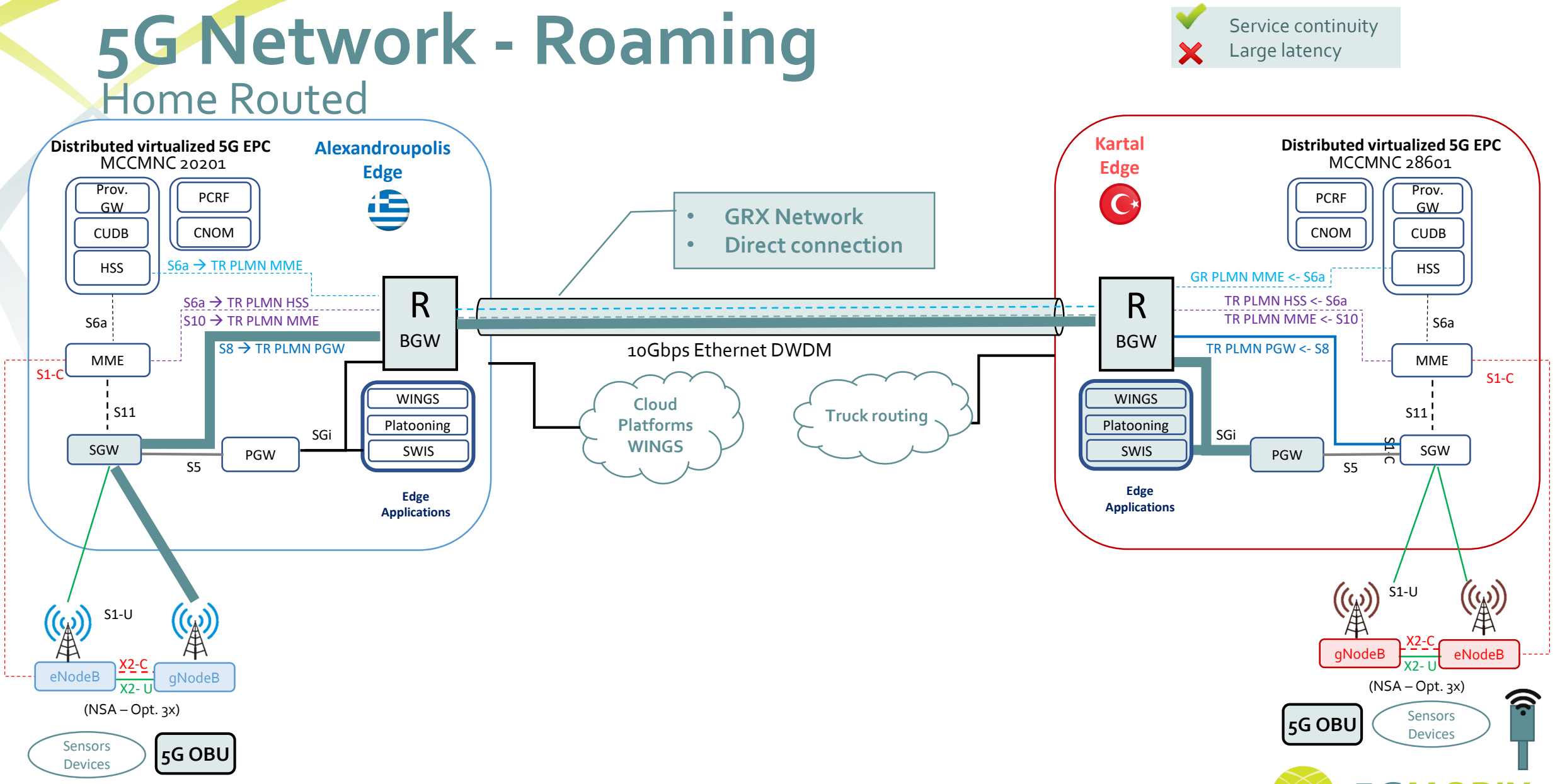
5G Network - Roaming

Home Routed



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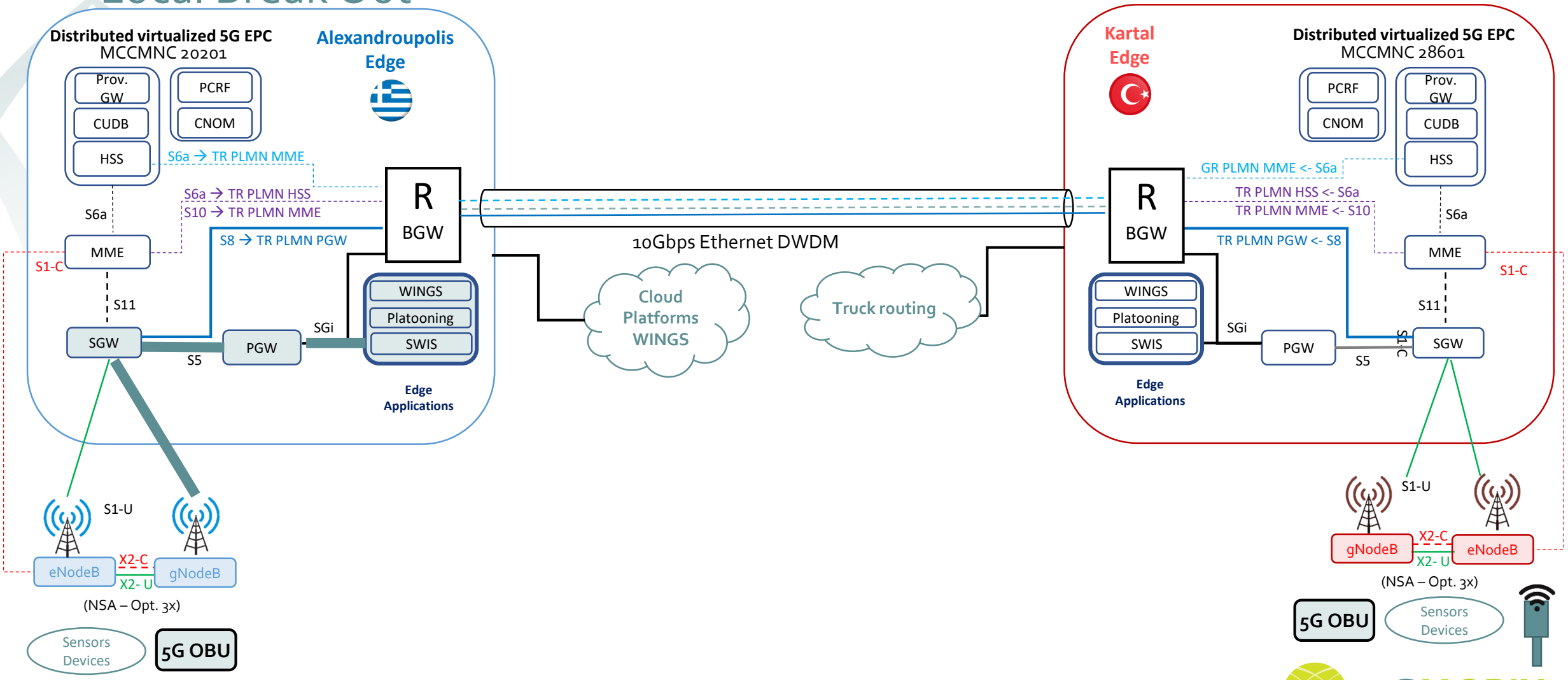
5G Network - Roaming

Local Break Out

Service disruption
Short latency



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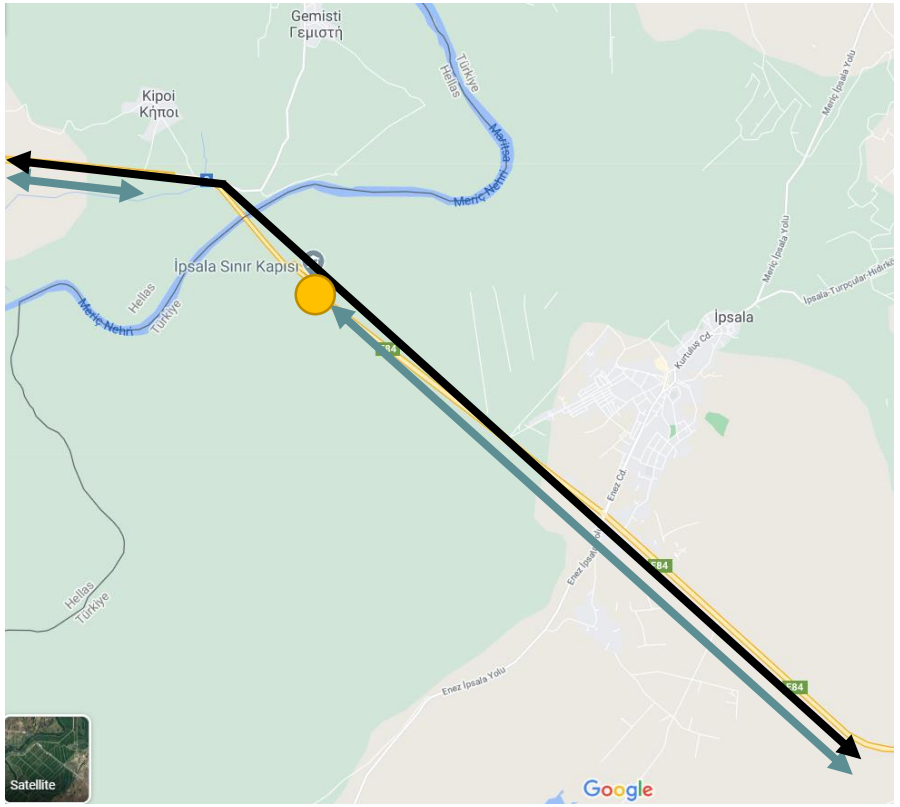
5G Network - Inter-PLMN Handover

GR-TR inter-PLMN handover area



Platooning

Truck Routing

See-what-I-see / Assisted Border Crossing

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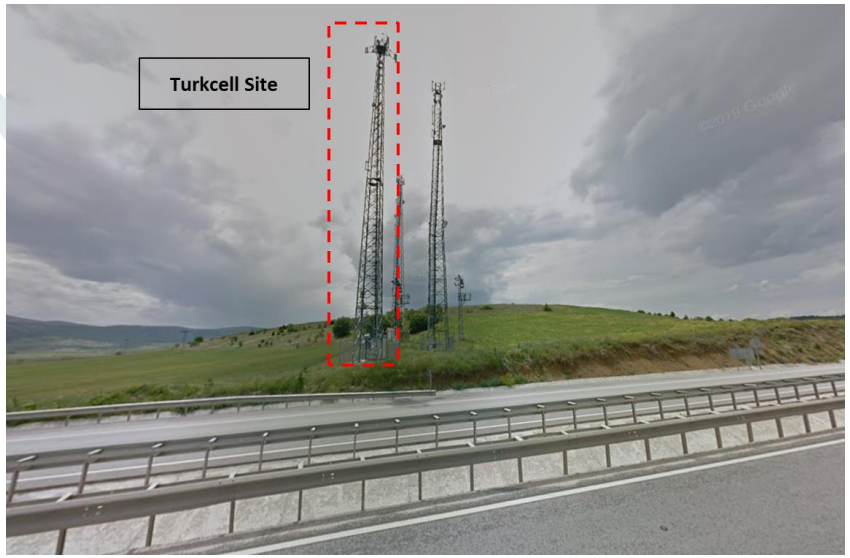
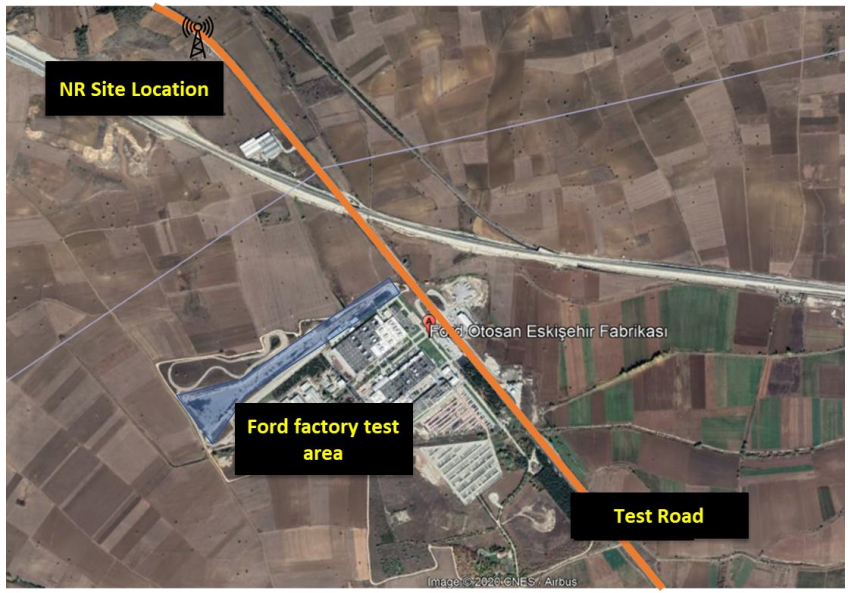
5G Network - Test @Eskişehir





MAC DL Throughput during mobility (UDP Test Scenario)

TEST TYPE	Test Run 1	COMMENTS
TCP_UL Cell Capacity	✓	Succesfully Completed

- **L2600MHz [5MHzBW]** was the anchor cell and **NR3500 [100MHz BW]** is used for the 5G service.
- IPERF server is used for **synthetic traffic**. The server wasn't directly connected to the PGW.
- **Transmission backbone supports 900Mbps and also carries live traffic.**

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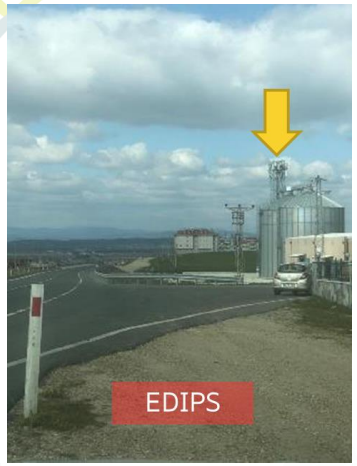
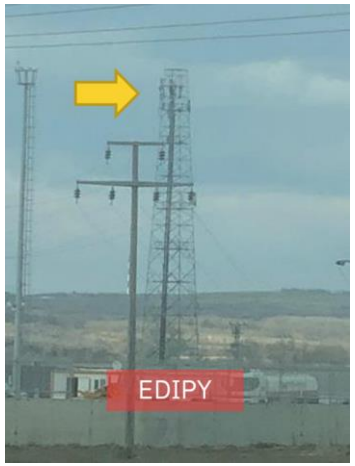
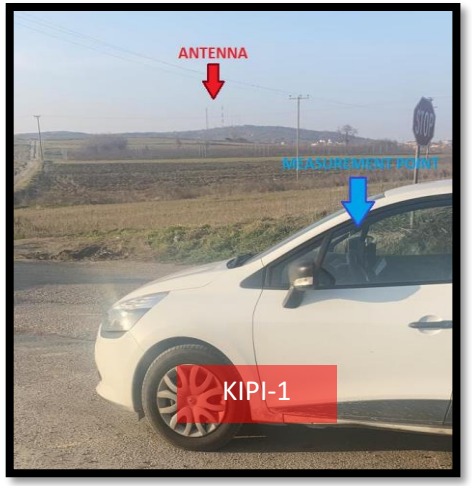
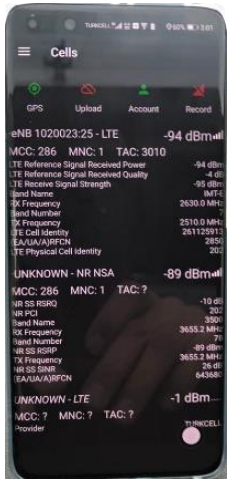
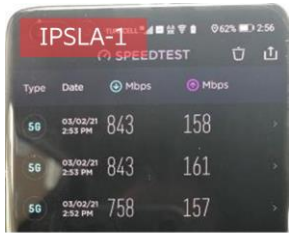
Stationary Tests

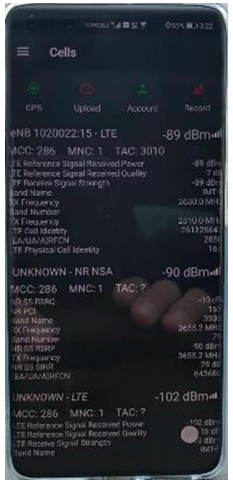


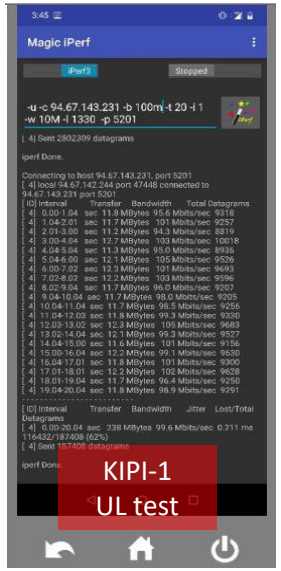








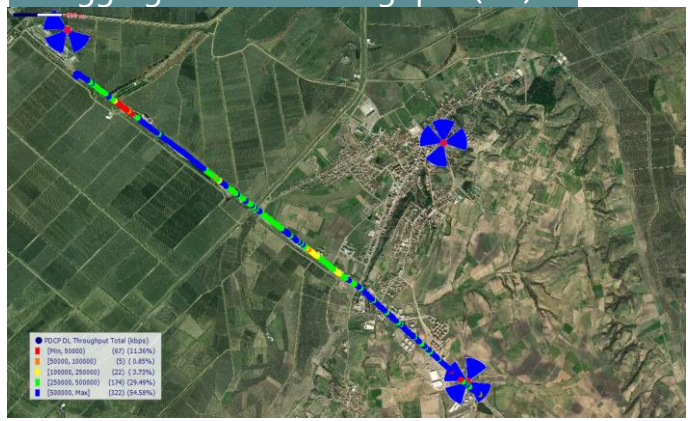




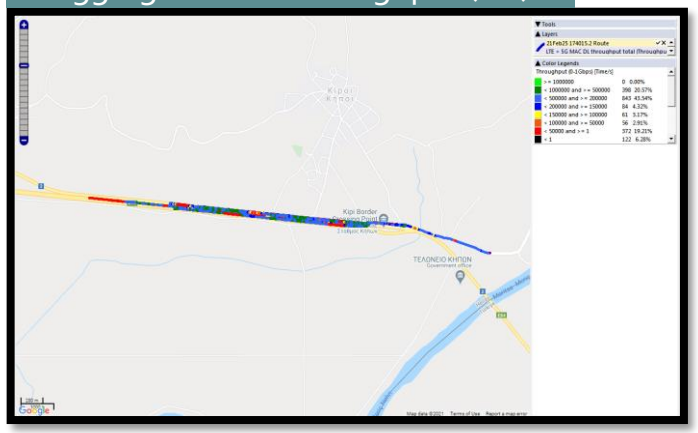
All sectors were tested individually close to the site location. Their UL/DL performances were checked. TDD:424 (SSC:383) was used and UL&DL Carrier aggregation was activated at Turkcell's cells.

Mobility Test results - Download

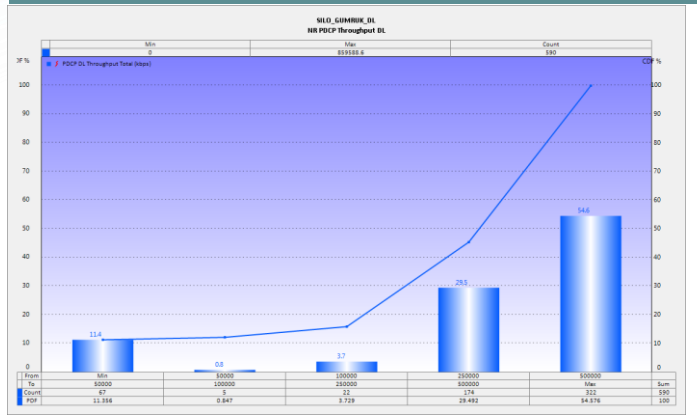
Aggregated DL Throughput (TR)



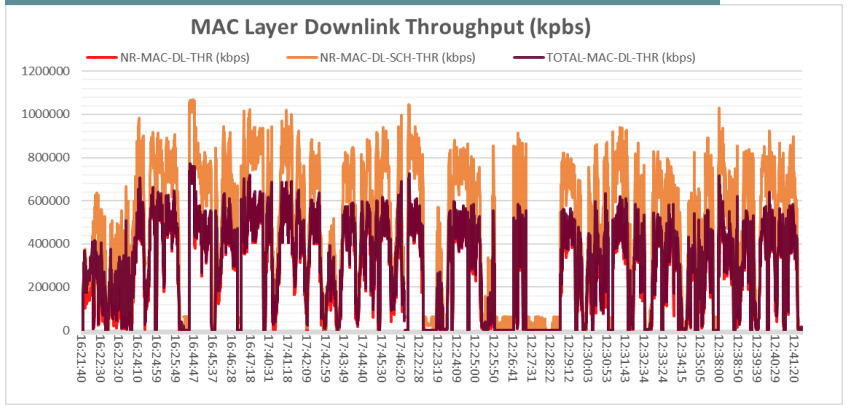
Aggregated DL Throughput (GR)



Aggregated DL Throughput distribution (TR)



Aggregated DL Throughput distribution (GR)



! Transmission backbone capacity is important for reaching peak rates. Transmission links are shared with the live network.

LOCATION	Peak DL	Average DL
Ipsala	862 Mbps	88% of total samples >100Mbps for DL
Kipoi	716 Mpbs/	100% of total samples >100Mbps for DL

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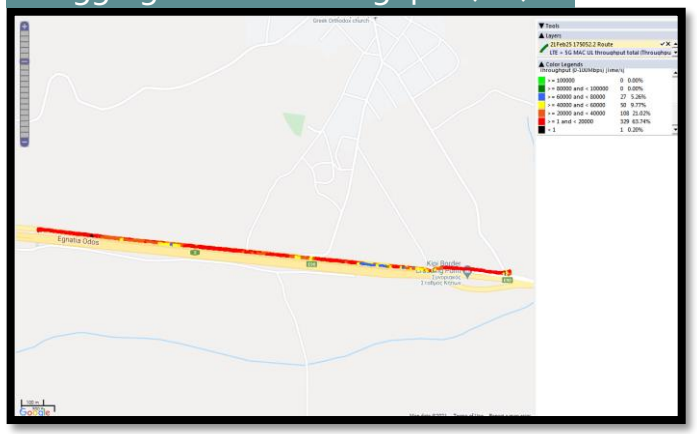
Mobility Test results - Upload

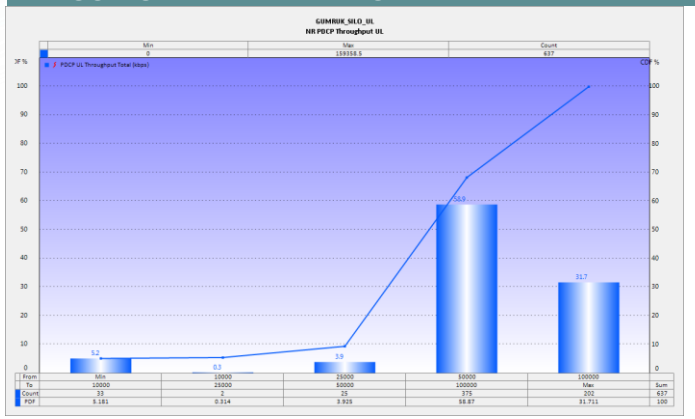
Aggregated UL Throughput (TR)

Aggregated UL Throughput (GR)

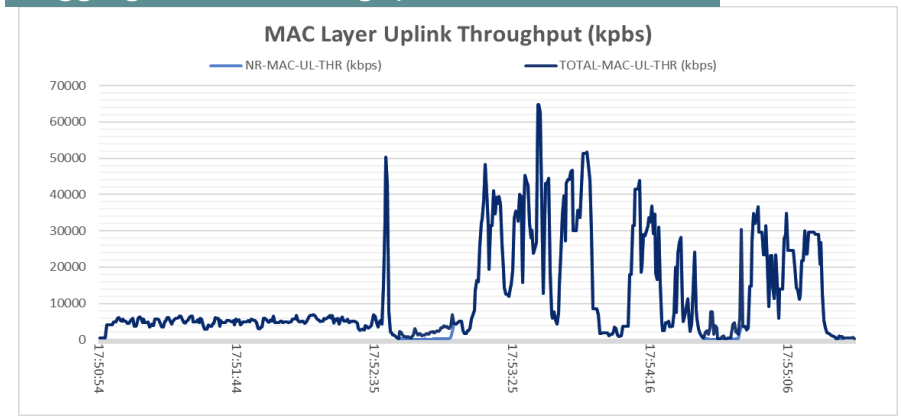


! LTE-NR Uplink Carrier aggregation feature was not activated on the GR site.

Aggregated UL Throughput distribution (TR)



Aggregated UL Throughput distribution (GR)



LOCATION	Peak DL	Average DL
Ipsala	159 Mbps	94% of total samples >100Mbps for DL
Kipoi	65 Mbps	80% of total samples >100Mbps for DL

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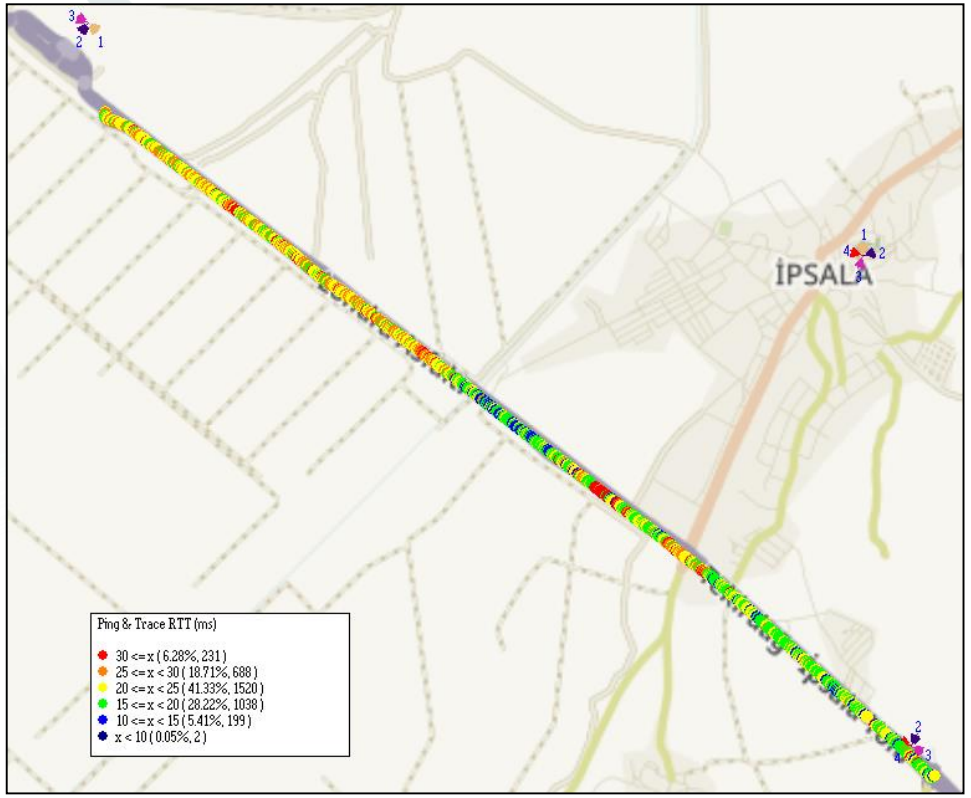
Mobility Test results - Latency



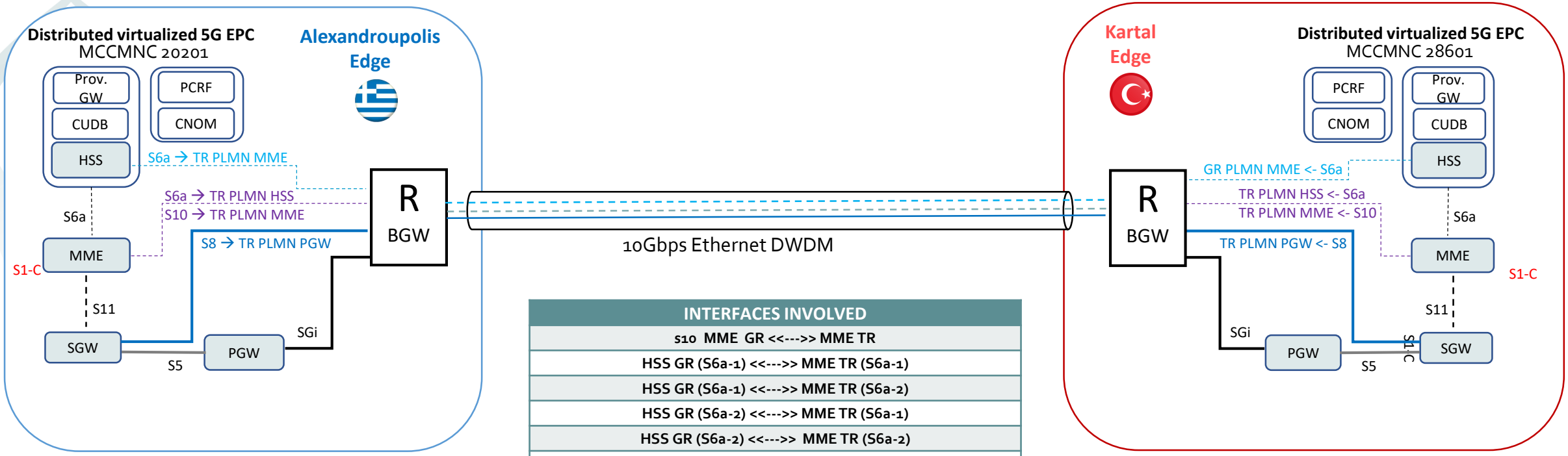
LOCATION	Latency
Ipsala	Min 12msec
	Avg 21msec
Kipoi*	Min 15msec
	Avg 21 msec

* Latency measurement plot is not available for the Greece test.

Mobility tests - Crossing the border!

- Various tests have been carried out to check the performance of existing sites on the approximately 7 km road in Turkey and 3km in Greece.
- Due to the COVID-19 restrictions, the physical border crossing tests cannot be performed.

Core-to-Core Connectivity Testing



INTERFACES INVOLVED
s10 MME GR <<--->> MME TR
HSS GR (S6a-1) <<--->> MME TR (S6a-1)
HSS GR (S6a-1) <<--->> MME TR (S6a-2)
HSS GR (S6a-2) <<--->> MME TR (S6a-1)
HSS GR (S6a-2) <<--->> MME TR (S6a-2)
MME GR (S6a-1) <<--->> HSS TR (S6a)
MME GR (S6a-1) <<--->> HSS TR (S6a)
MME GR (S6a-2) <<--->> HSS TR (S6a)
MME GR (S6a-2) <<--->> HSS TR (S6a)
PGW-C GR (S5S8-C_PGW, Gn-C) <<--->> SGW-C TR (SGW-S5S8-C)
SGW-C GR (S5S8-C) <<--->> PGW-C TR (PGW-S5S8-C)
PGW-U GR (Gn-U, S5S8-U_PGW) <<--->> SGW-U TR (SGW-S5S8-U)
PGW-U GR (Gn-U, S5S8-U_PGW) <<--->> PGW-U TR (PGW-S5S8-U)
SGW-U GR (S5S8-U_SGW) <<--->> SGW-U TR (SGW-S5S8-U)
SGW-U GR (S5S8-U_SGW) <<--->> PGW-U TR (PGW-S5S8-U)

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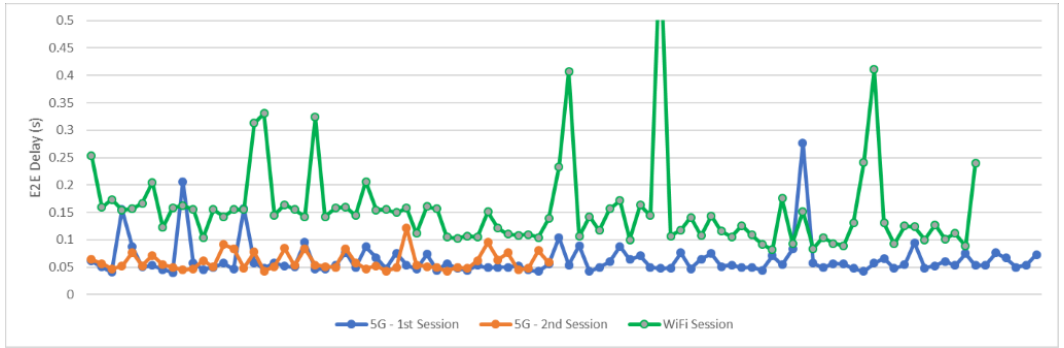
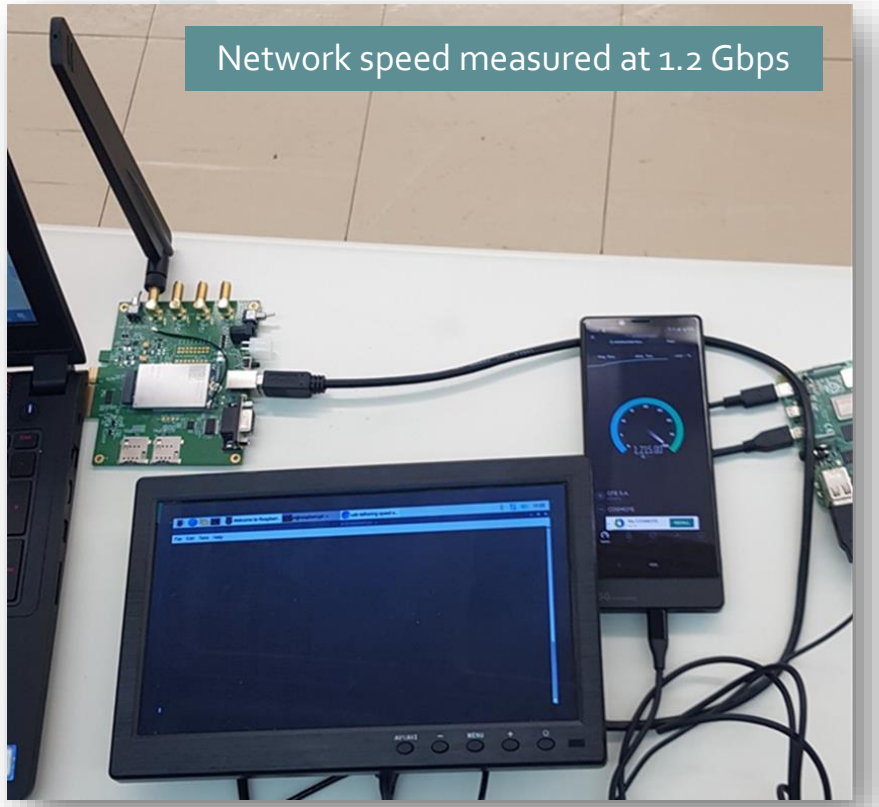
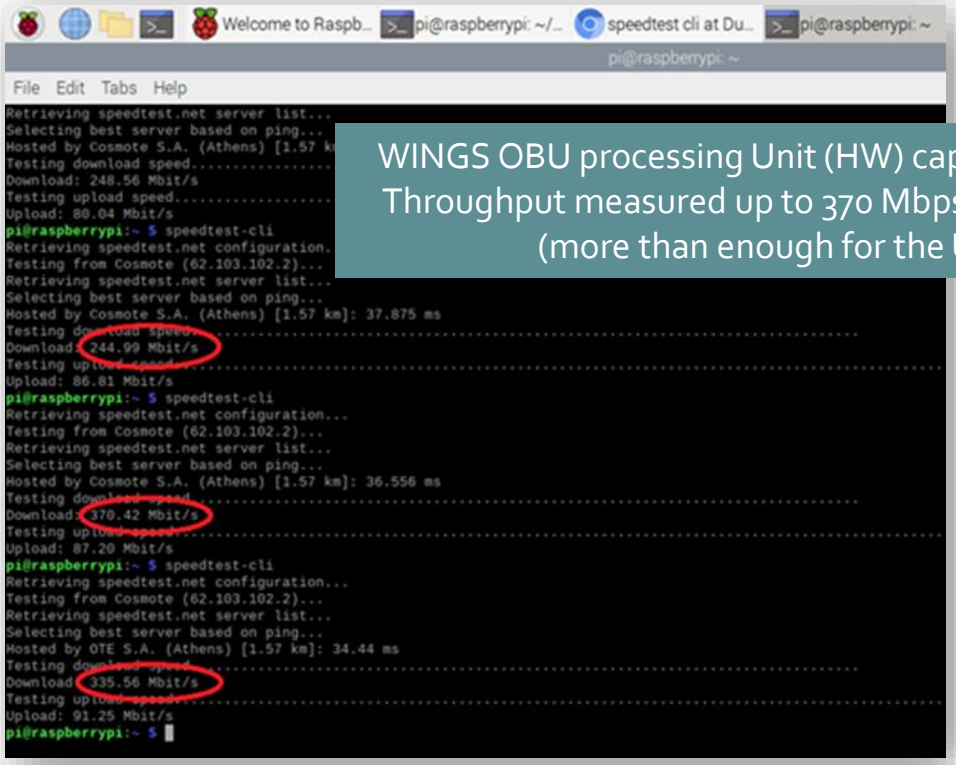
Verification and Integration

WINGS OBU





WINGS OBU & testing board under test in COSMOTE premises, Athens



WINGS OBU processing Unit (HW) cap at 400 Mbps
Throughput measured up to 370 Mbps is very good
(more than enough for the UC)

Throughput test via the WINGS OBU ~370 Mbps

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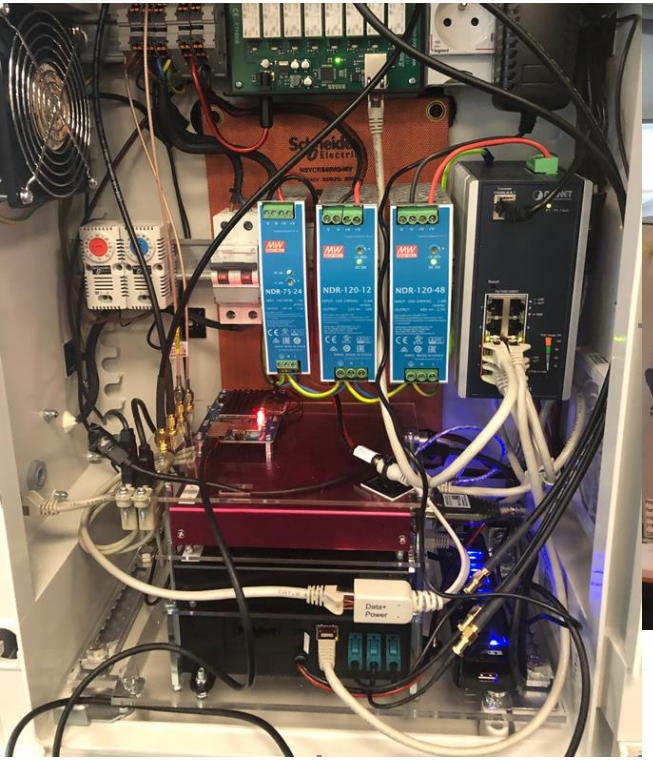
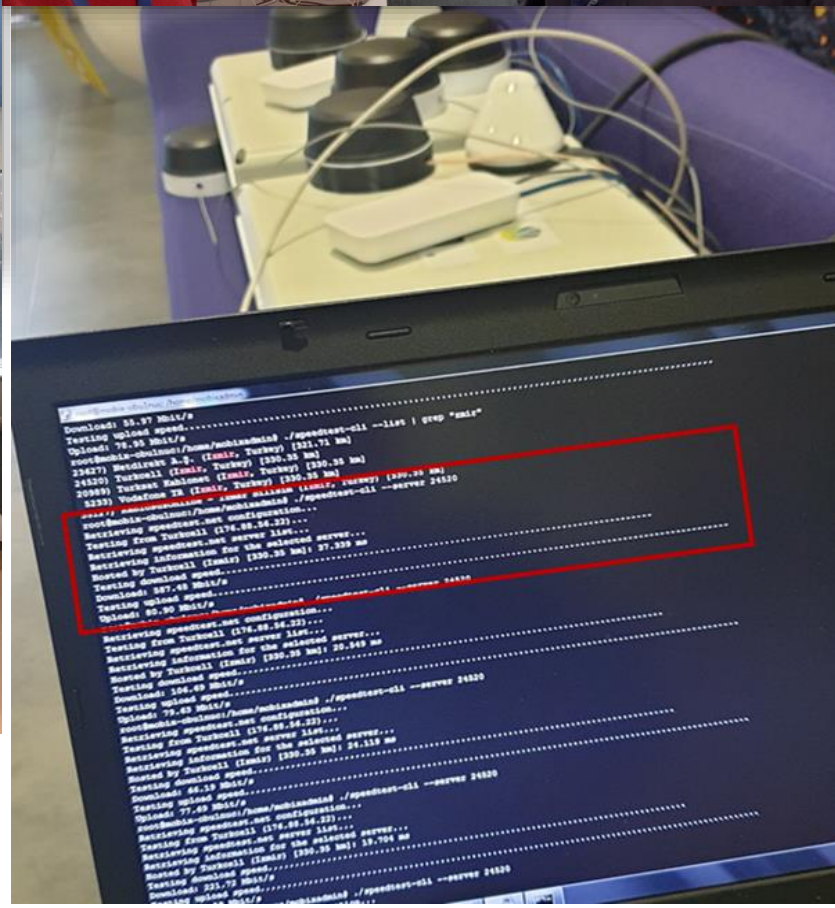
IMEC OBU/RSU

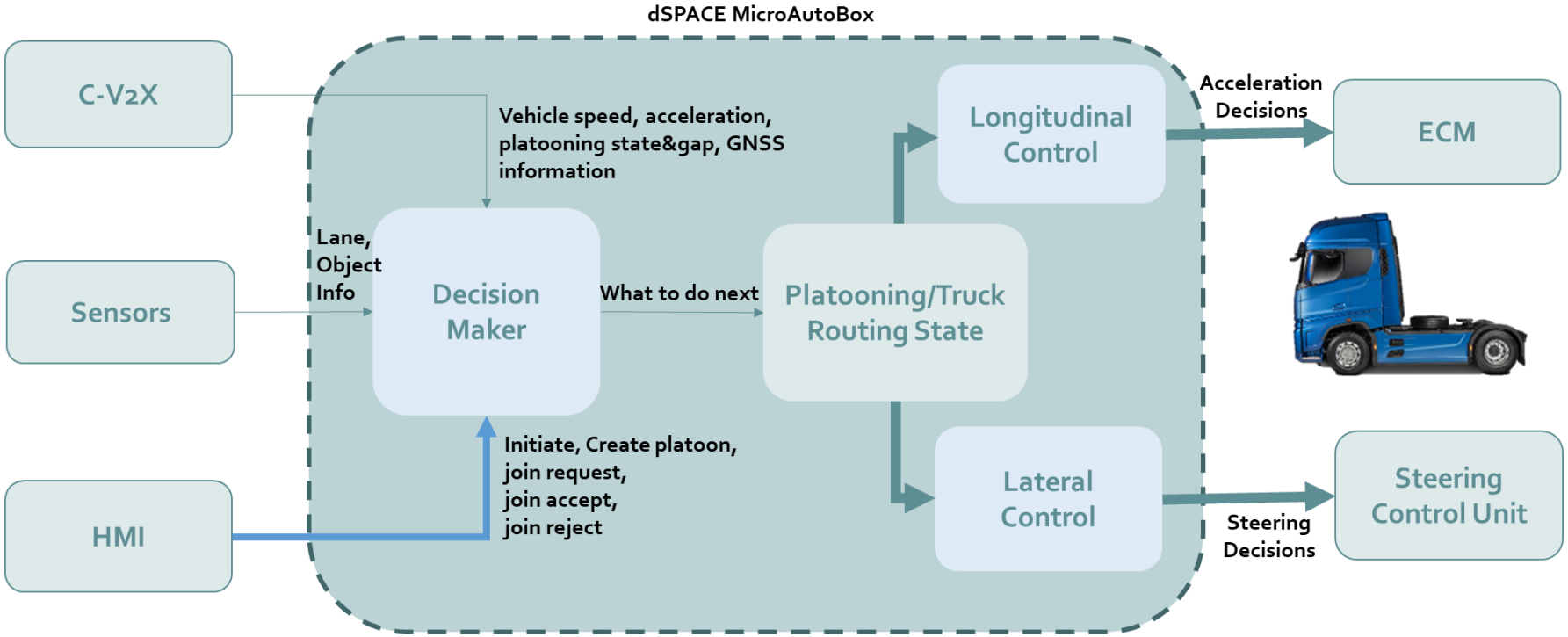
IMEC Belgium → Ford Otosan Turkey → Turkcell Kartal Plaza → Turkcell Maltepe Plaza

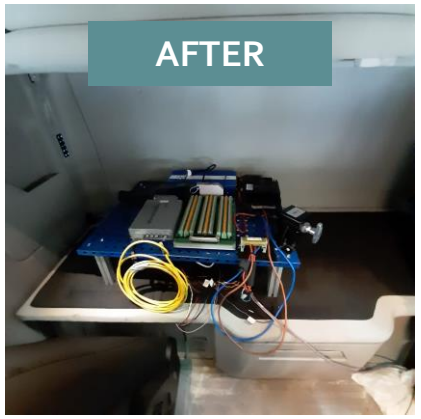
Peak Downlink Throughput: 587 Mbps (2x2 MIMO)
Uplink Throughput ~ 80-85 Mbps
Latency ~10-15 ms



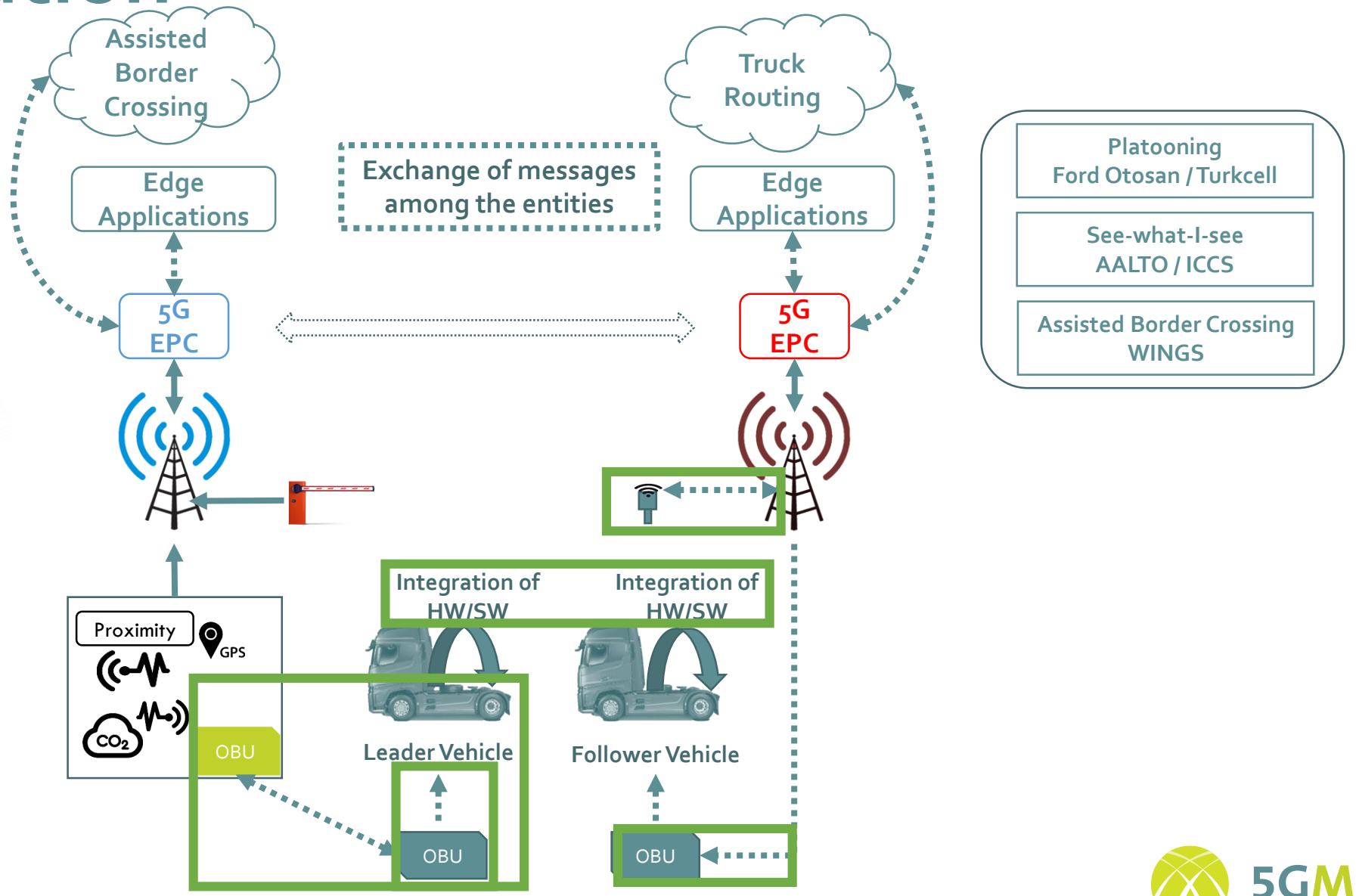


Ford Otosan Truck





Integration



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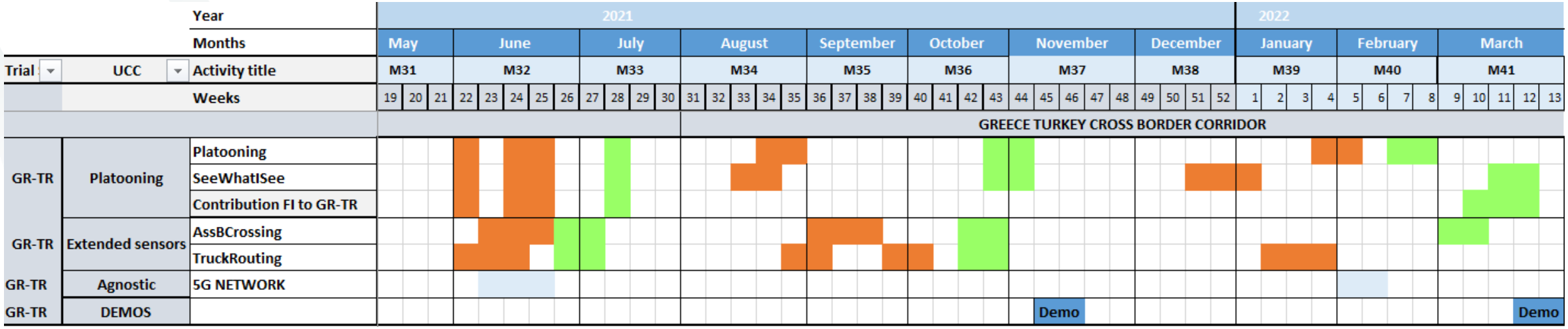
CBC Trial plan & next steps

Trial & Demo plan

Final Demo March 2022



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Thank you

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