5G-TOURS
Athens – a mobility efficient city
Final results

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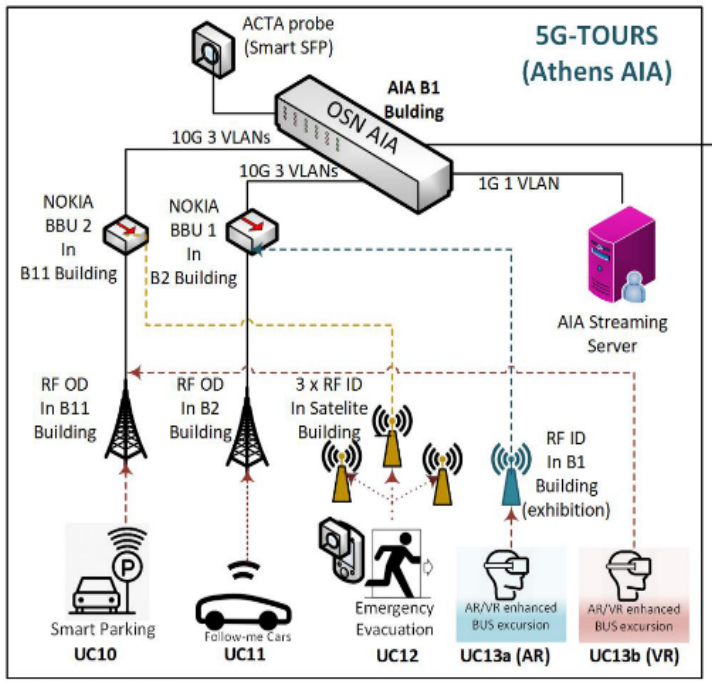
5G-Tours - Athens mobility efficient city

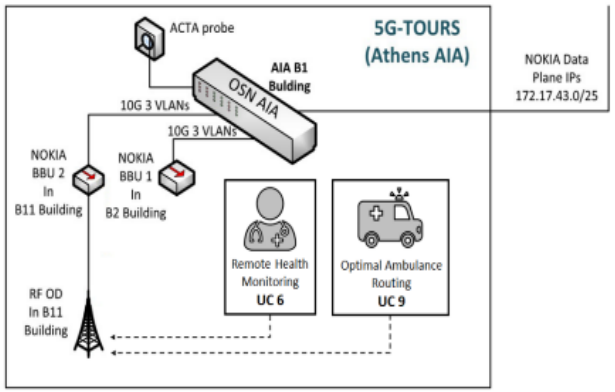
- The main objective of Mobility Efficient City in 5G-Tours is to implement 4 mobility-related use cases trials taking place in the **node of Athens**. The aim of these use cases is to demonstrate how 5G technology is expected to enhance applications related to mobility within a city covering various setups **that improve the tourism, tourism-related experiences and airport logistics** from various perspectives, by means of:
  - ***smart parking*** *applications with parking sensors and driver apps*
  - ***video-enhanced ground based vehicles*** *with live video transmission capabilities*
  - ***evacuation of the airport*** *in case of an emergency with personalized evacuation application*
  - *or the constructive* ***mobility of students for education purposes using AR/VR mobile applications****.*
- The implementation of the four UCs relied mainly on the 5G EVE Greek site infrastructure (developed by OTE and NOKIA-GR) at OTE facilities, which was upgraded and expanded at the AIA premises during the 5G-TOURS project.
- The complete final implementation of the **Athens node** spans two main areas:

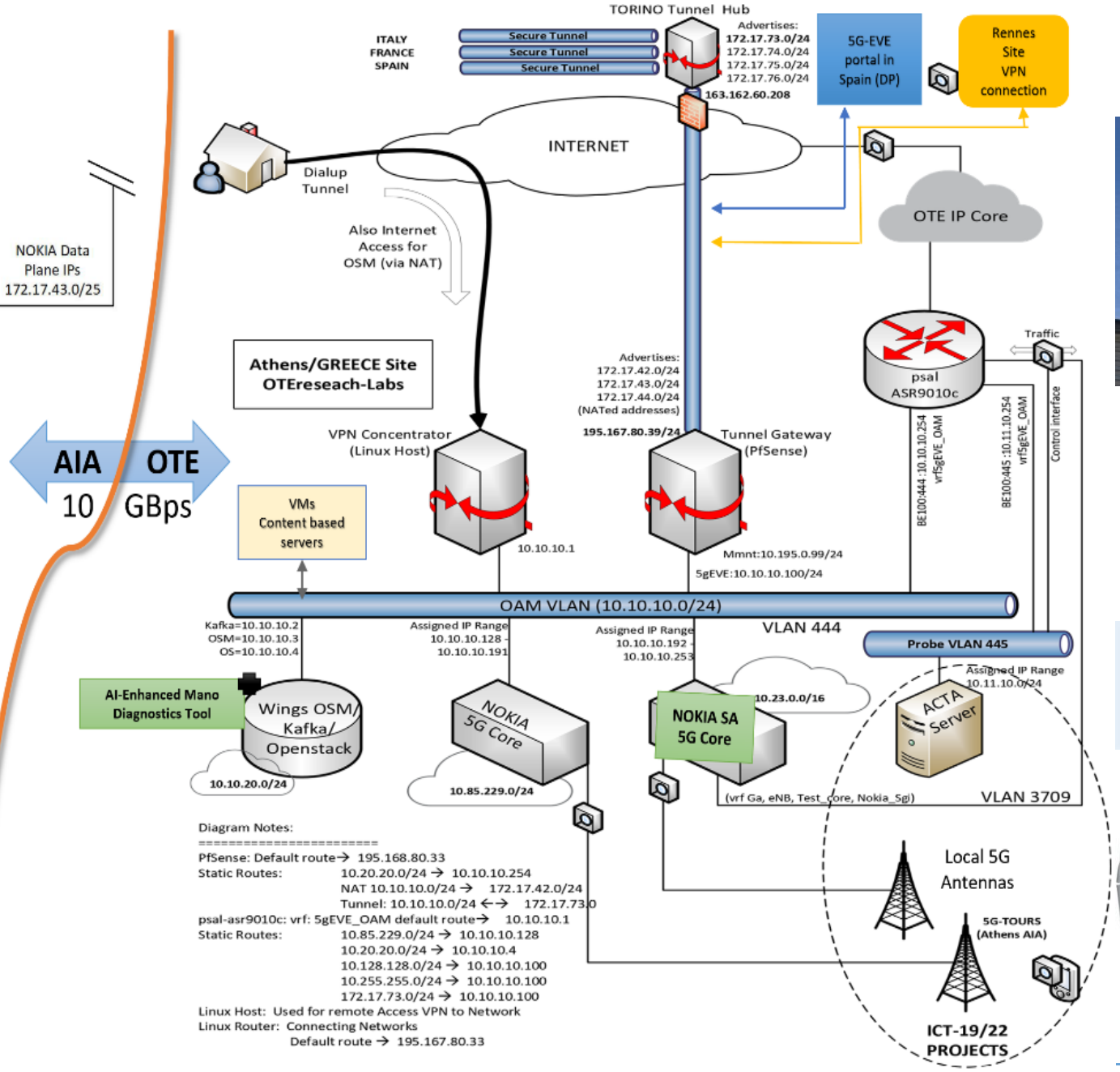
OTE facilities

AIA facilities

Athens node Infrastructure

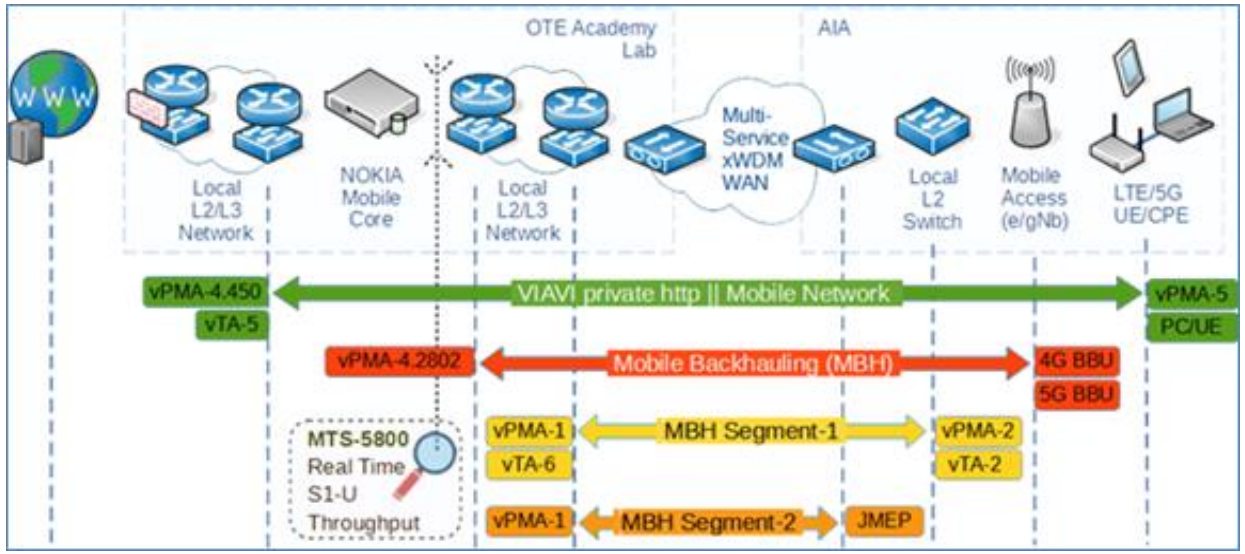






- **All Antennas: 3450 MHz – 3500 MHz, with 50 MHz bandwidth**
- **3 Pepling 5G car Routers** and **3 Fastmile NOKIA 5G routers**

WP6 - Probes for real-time KPI measurements



Viavi MTS-5800 probe

Viavi JMEP SFP network probe

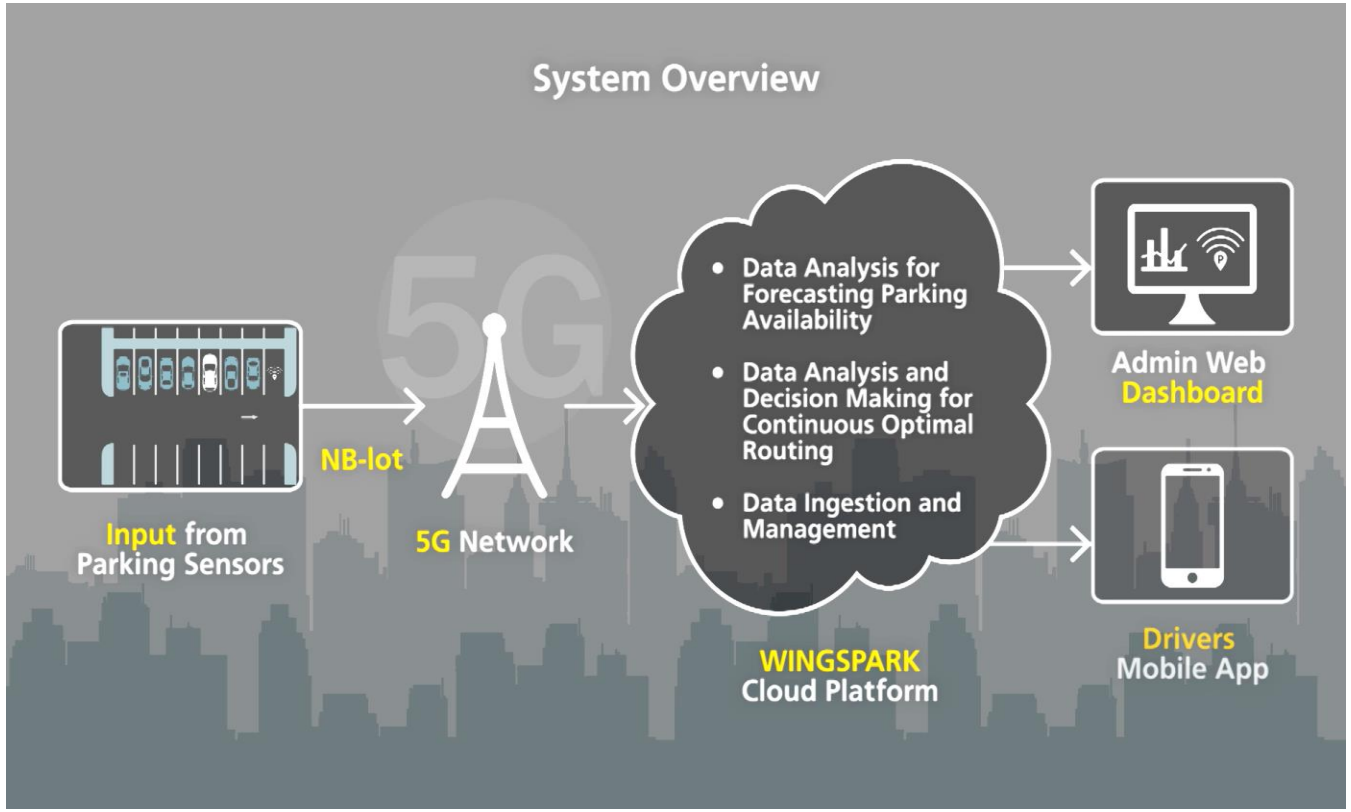
Virtual CPE/ Software Probe hardware

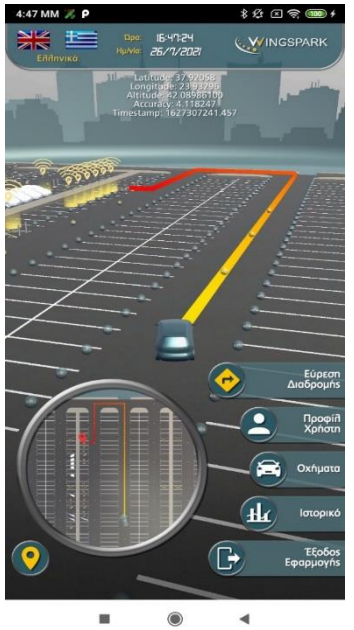
A **TWAMP/VIAVI** software for real-time KPI measurements 24x7.

The Network KPIs measured and calculated for the 5G TOURS UCs, are:

- **Throughput** – real time (mainly relevant for the BW demanding UCs)
- **Max Sustainable Throughput** (Attainable Bitrates TCP)
- **Latency end-to-end** (1-min-Average)
- **RAN latency** (calculated approximately through deduction of metrics between e2e and backhauling segments)
- **Jitter** (1-min-Average)
- **Packet Loss** (1-min-Average)
- **Availability** (calculated as the percentage of Network layer packets successfully delivered out of all Network layer packets sent)
- **Reliability** (calculated as the percentage of Network layer packets successfully delivered within the predefined Network layer KPI limits, e.g. latency)

UC10 - Smart parking management system overview





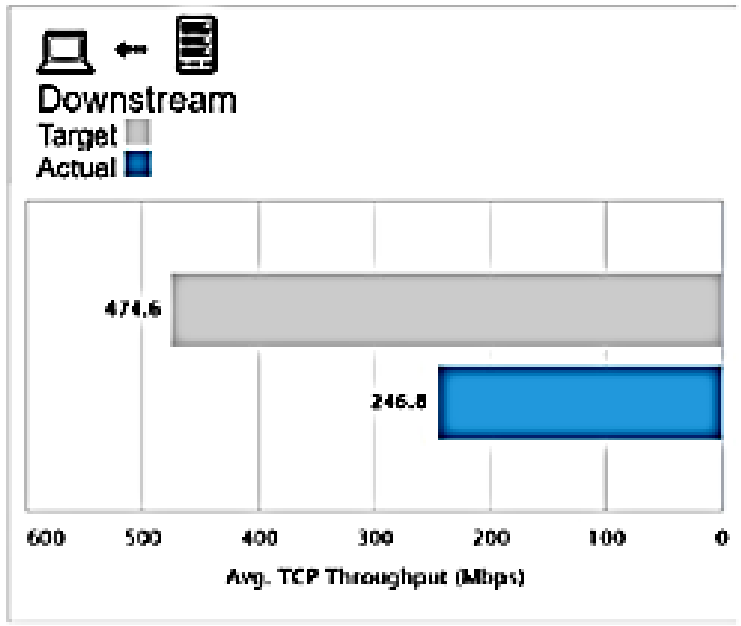
- **2 Apps (Dashboard, Mobile app)**
- **50 parking spots** (4 Sequans + 46 Quectel BG96 chipsets)
- **1 x cloud platform**

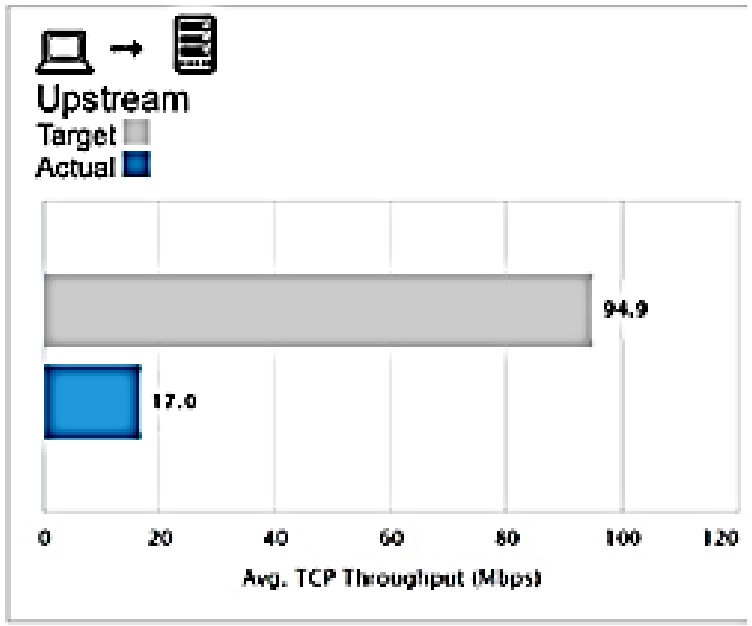
UC10 - Final Network KPIs Validation Results

The data shown reflect the real life KPIs for UC 10 trial performed in B17 parking area, on April 12, 2022, afternoon. Overall, the network KPIs were measured as follows:

- **TCP Throughput** (Download) **250 Mbps** – (Upload) **17 Mbps**
- **Latency** below **0,9ms** for the transport segment (local switches in OTE labs and AIA), **and 17 ms for the e2e path**
- **Availability 99,9998%** (100% for the transport part)
- **Reliability 99,9998%** (100% for the transport part)

√ The overall conclusion is that the Max sustainable L4 TCP Throughput as well as the L2/L3 Network KPIs of Latency, Availability and Reliability **comply with the targets set in WP2**.



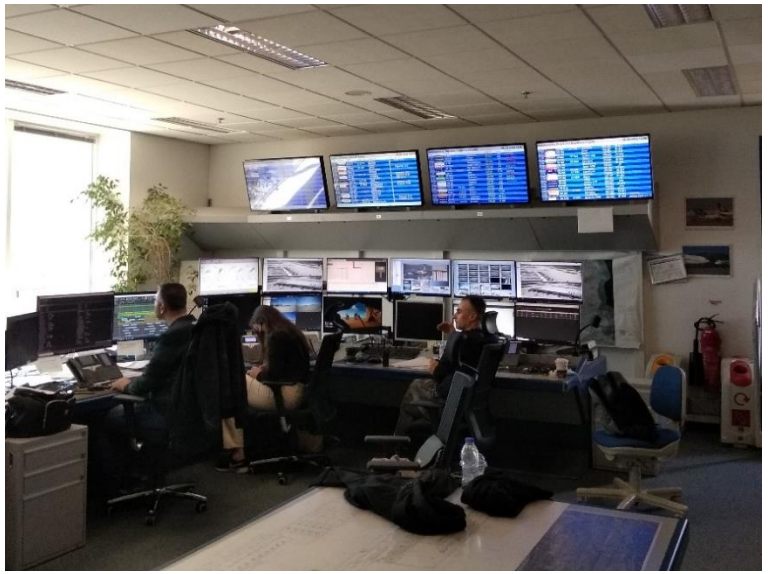


UC10 Max Throughput Measurement results with S20 mobile device

UC11 – Video enhanced Ground moving vehicles

Installation of high definition cameras on the follow-me vehicles, which will feed live video feeds to the **ASOC** (**Airport Security Operation Center**) as well as to other concerned third parties and stakeholders (emergency resource personnel – Police, Ambulance Services, Fire Brigade) in efficiently responding to emergencies, in order to prevent or quickly respond to incidents that may impact airport operations.

- **3 Vans, 3 cameras, 3 5G peplink routers, 1 app, 1 x Media server**



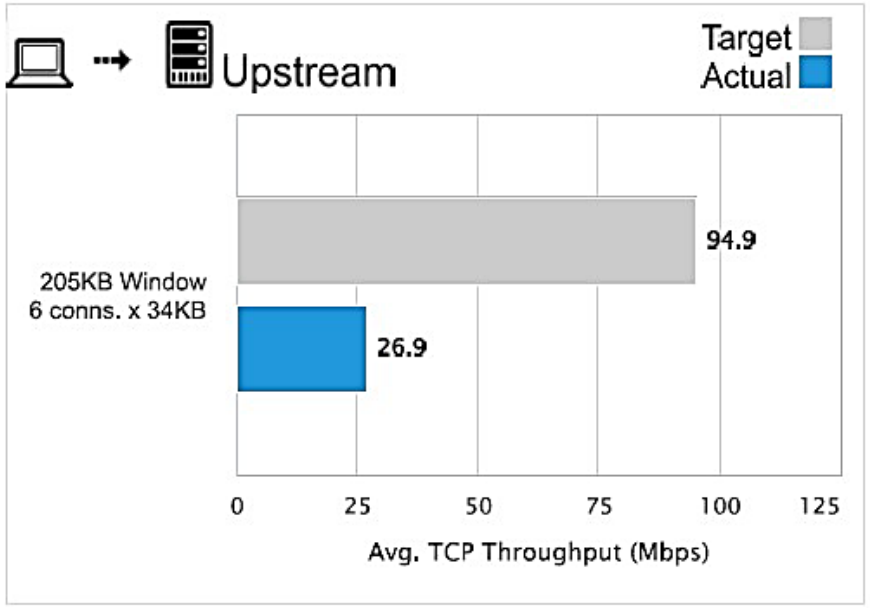
UC11 - Final Network KPIs Validation Results

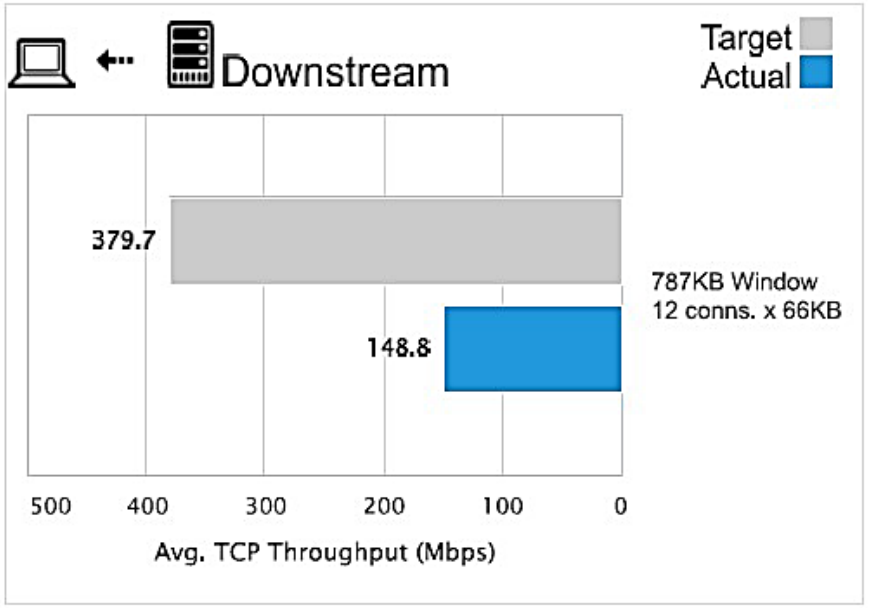
The data shown reflect the real life KPIs for UC 11 trial performed in AIA Apron area, on April 08, 2022. Overall, the network KPIs were measured as follows:

- **TCP Throughput** (Download) **150 Mbps** – (Upload) **26 Mbps**
- **Latency** below **0,8ms** for the transport segment (local switches in OTE labs and AIA), and **22 ms for the e2e path**
- **Availability 99,9999%**
- **Reliability 99,9999%**

√ The overall conclusion is that the L2/L3 Network KPIs of Latency, Availability and Reliability **comply with the targets set in WP2**.

As for the Max sustainable L4 TCP Throughput, one must factor in the **50MHz bandwidth limitation**, which was imposed by the interference conditions at the airport.





UC11 Max Throughput Measurement results with Peplink 5G routers

UC12 – Emergency airport evacuation

This use case focuses on the evacuation of the airport in a quick and organized fashion in case of an emergency, providing automated guidance of emergency routes from the affected area up to the muster areas. This use case focuses on the location accuracy part of 5G technology and the guidance of a user to the nearest exit.

- **3 indoor antennas**
- **1 app**
- **LBS Algorithm**
- **Optimal route to the nearest exit**
- **Balance of evacuees to different exits**
- **3D model and simulator with Unity s/w**
- **20 volunteers**

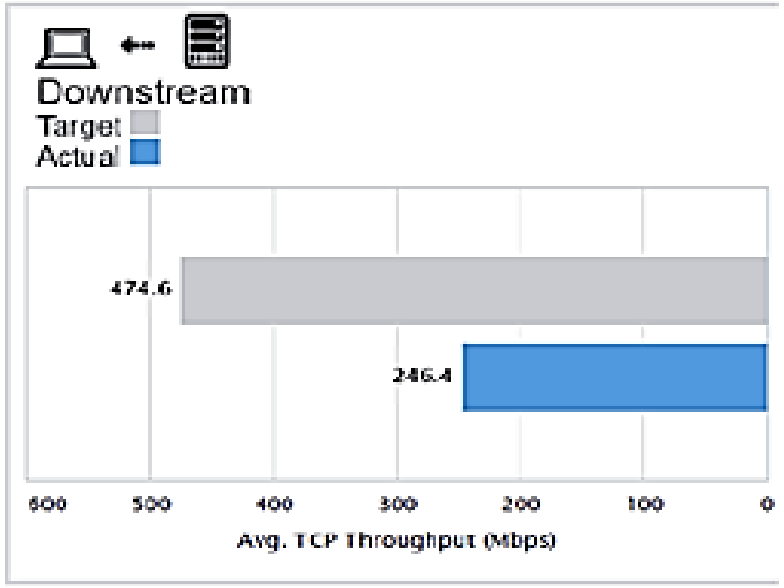
UC12 - Final Network KPIs Validation Results

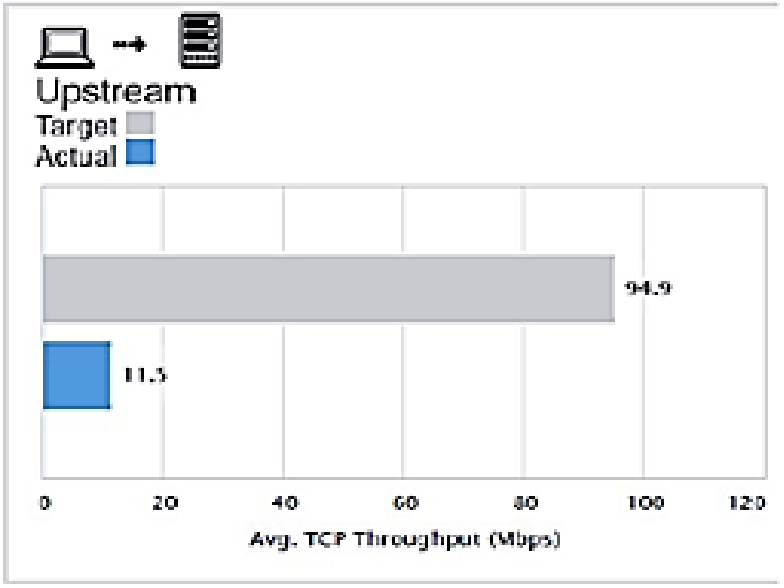
The data shown reflect the real life KPIs for UC 12 trial performed in AIA Satellite Building, on April 12, 2022, morning. Overall:

- **TCP Throughput** (Download) **250 Mbps** – (Upload) **11-27* Mbps**
- **Latency** below **2 ms** for the transport segment and **25 ms for the e2e path**
- **Availability 99,9997%**
- **Reliability 99,9997%**

√ This shows that the L2/L3 Network KPIs of Latency, Availability and Reliability **comply with the targets set in WP2.**

As for the limitations in the Max sustainable L4 TCP Throughput, one must factor in the **50MHz bandwidth limitation**, which was imposed by the interference commercial 5G transitions at the airport.



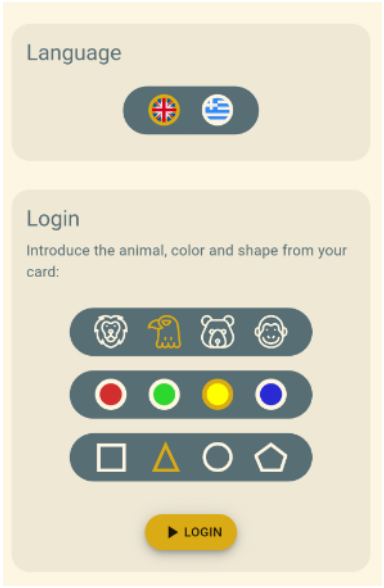


UC12 Max Throughput Measurement results with S20 mobile device

* When FastMile router was used for, not shown in the above diagram

UC13 – AR/VR student bus excursion

- The main objective of this UC is to demonstrate the need of 5G for groups of **people travelling on a bus** to visit a site of interest
- The UC will Focus on **school students** on an excursion to a destination of educational interest (the theme of interest is **Myrtis**, **a young Athenian 11- year girl, who died** by typhoid fever in 430 BC, during the Peloponnesian War. Her's face has been reconstructed by Prof. Papagrigorakis' team, University of Athens.
- In the **trials**, 24 students participated from the school of EA on a school bus visiting an exhibit hosted in AIA
- **2 x AR applications 1 x VR Application, 24 students, 3 scenarios (1 indoor, 1 outdoor)**

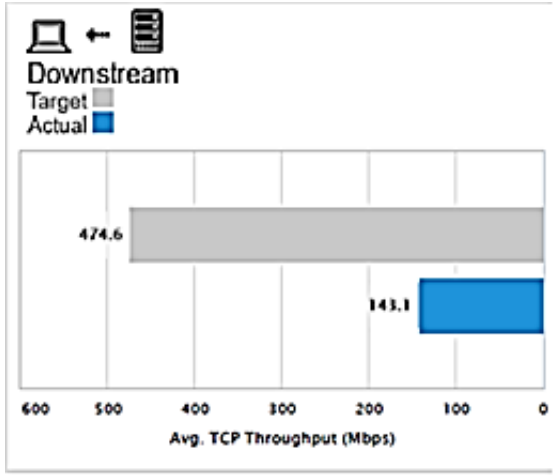


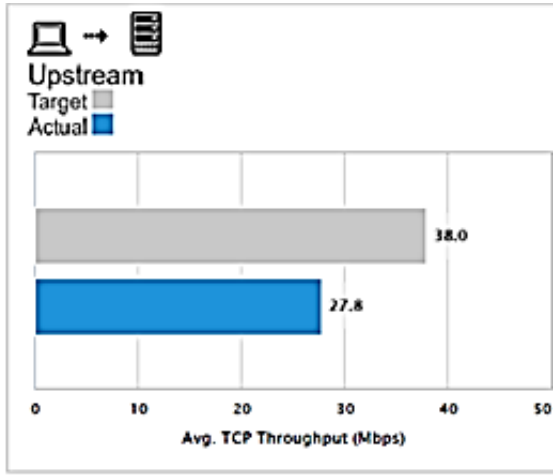
UC13 - Final Network KPIs Validation Results

The data shown reflect the real life KPIs for UC 13 trial performed on March 31, 2022.

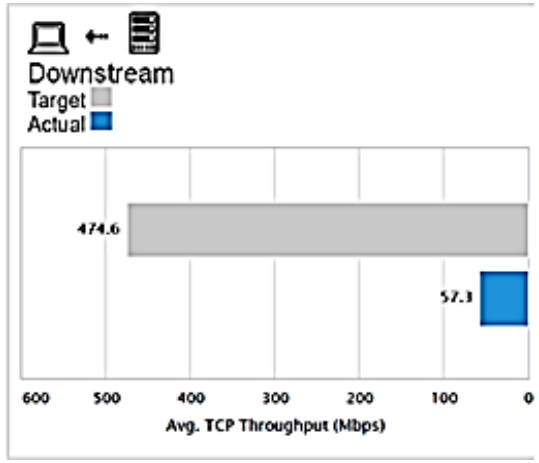
- **TCP Throughput** (Download) **150 Mbps** – (Upload) **27 Mbps (AR indoor scenario)**
- **TCP Throughput** (Download) **60 Mbps** – (Upload) **32* Mbps (VR outdoor scenario)**
- **Latency** below **1 ms** for the transport segment **but for the e2e path varying between 20 ms in the 13bAR subcase and 100 ms in the 13aVR** subcase (with momentary peaks of up to 3s)
- **Availability 99,9994%**
- **Reliability 99,9994%** - lower value in the 13aVR subcase for a few minutes when the latency rises to 1-3s because of traffic congestion, caused by students accessing almost simultaneously the VR app in their S20s inside the bus.

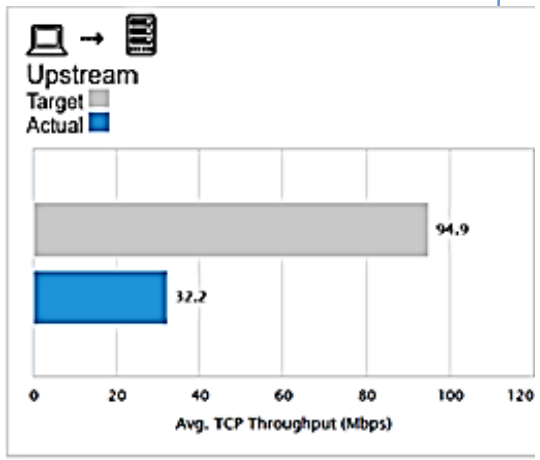
√ Overall, the L2/L3 Network KPIs of Latency, Availability and Reliability **comply with the targets set in WP2.**





UC13b AR Myrtis exhibition Max Throughput Measurement results





UC13a VR Bus excursion Max Throughput Measurement results

- *Less throughput to the outdoor scenario. The download metric varies from 150 to 60 Mbps due to week signal strength, the longer distance from the antenna installed on roof of B11 Building to the VR parking trial area, interference, 50MHz bandwidth limitation.*

OTE Group of Companies

www.ote.gr

http://5gtours.eu/

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