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**NEXT-GENERATION IoT SOLUTIONS
FOR THE UNIVERSAL SUPPLY CHAIN**

**UC2: IMPROVE DRIVERS' SAFETY WITH MR AND HAPTIC
SOLUTIONS: PROGRESS AND FUTURE WORK**

WP2: Ecosystem

Leader: Nokia

meeting: 15th February 2023

Presenter: Jaime Ruiz Alonso

IMPROVED DRIVER'S SAFETY WITH MIXED REALITY (MR) AND HAPTIC SOLUTIONS

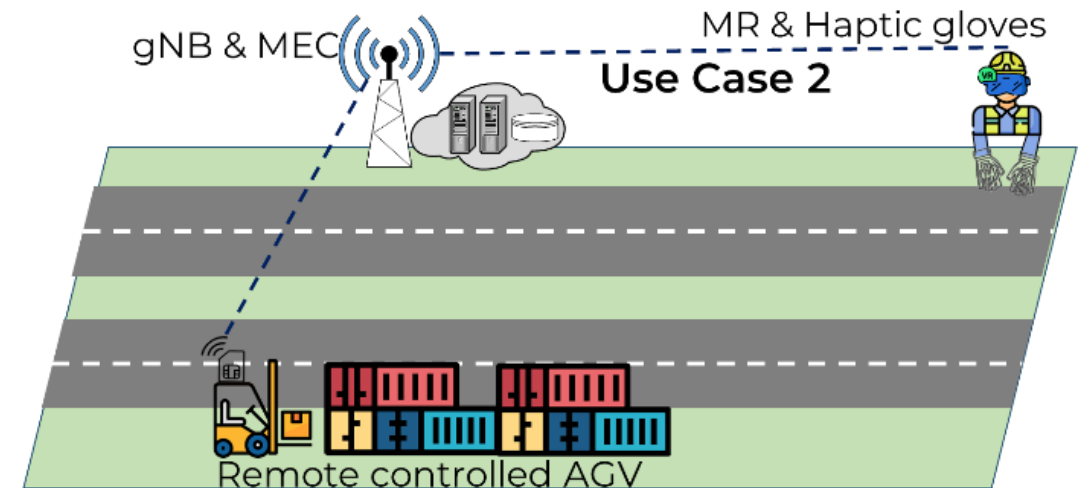
Description

To remotely control the transport of goods with Automated Guided Vehicles (AGVs) thanks to **tactile internet, edge computing and immersive enablers** (Mixed-Reality (MR) engines, haptic gloves).

Telepresence is supported by 360° low-latency video cameras installed in AGVs and road vehicles.

The interaction with the operator is implemented with haptic gloves to touch remotely sensors and getting real-time feedback.

Potential benefits include, automatic handling of assets, human-machine iteration by working remotely (e.g. indoor) in unexpected circumstances and scalability (e.g. working remotely in multiple sites governed by AGVs).



Next Generation NodeB (gNB) Multi-access Edge Computing (MEC)

UC2
champion

NOKIA



ASTI

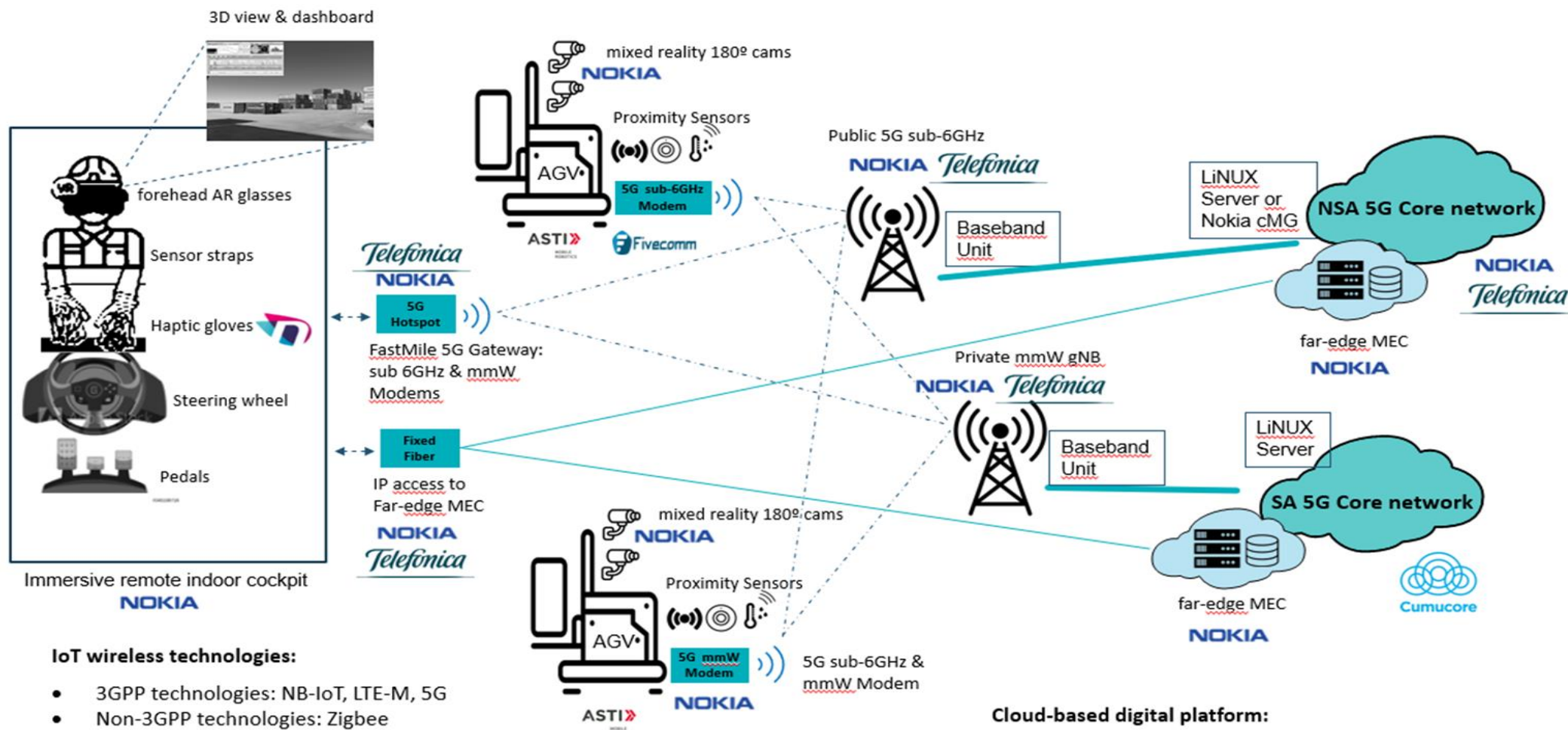


FUNDACIÓN
VALENCIAPORT



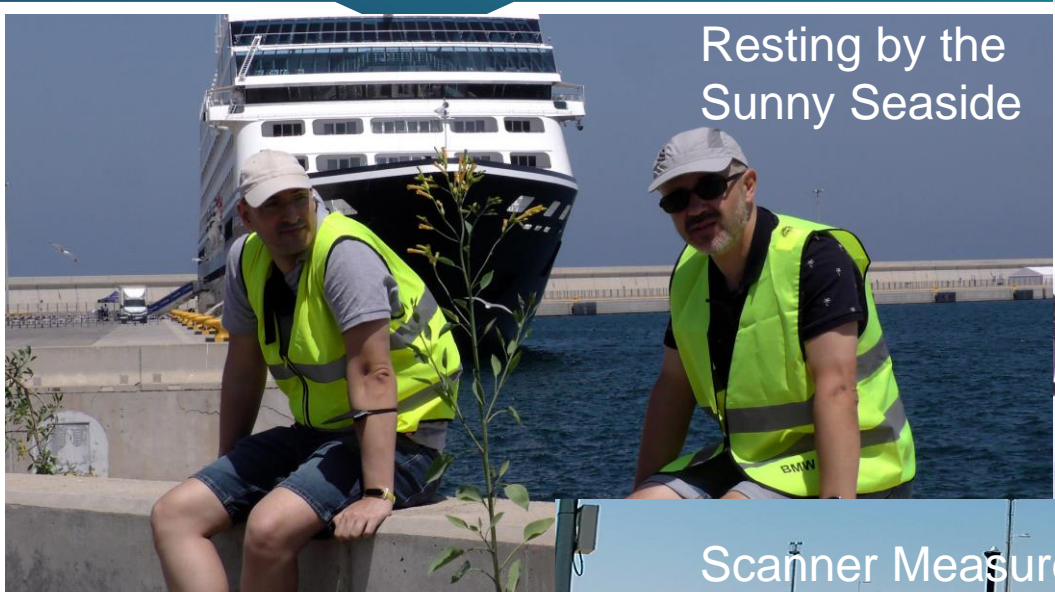
WHERE ARE WE: CONNECTIVITY

WIRELESS 5G/IOT



FIELD TESTS IN VALENCIA PORT

30/06/2022 TO 02/06/2022



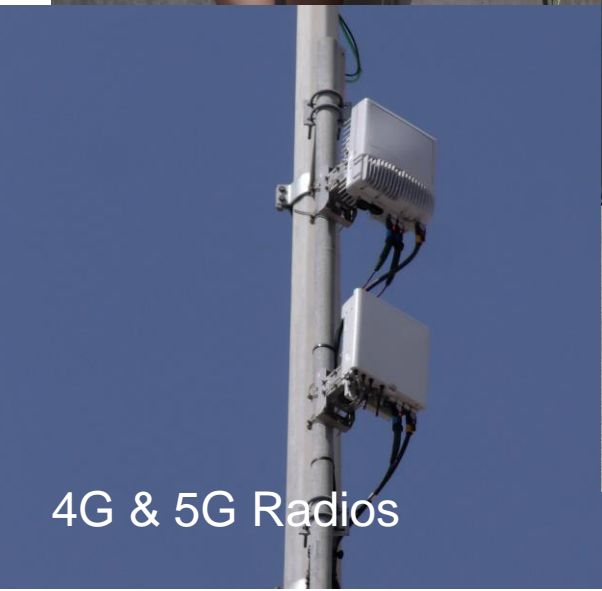
Resting by the Sunny Seaside



4G & 5G Baseband Radio Site



Scanner Measurements in 4G and in 5G



4G & 5G Radios



Measurement of Radioelectric Emission Levels

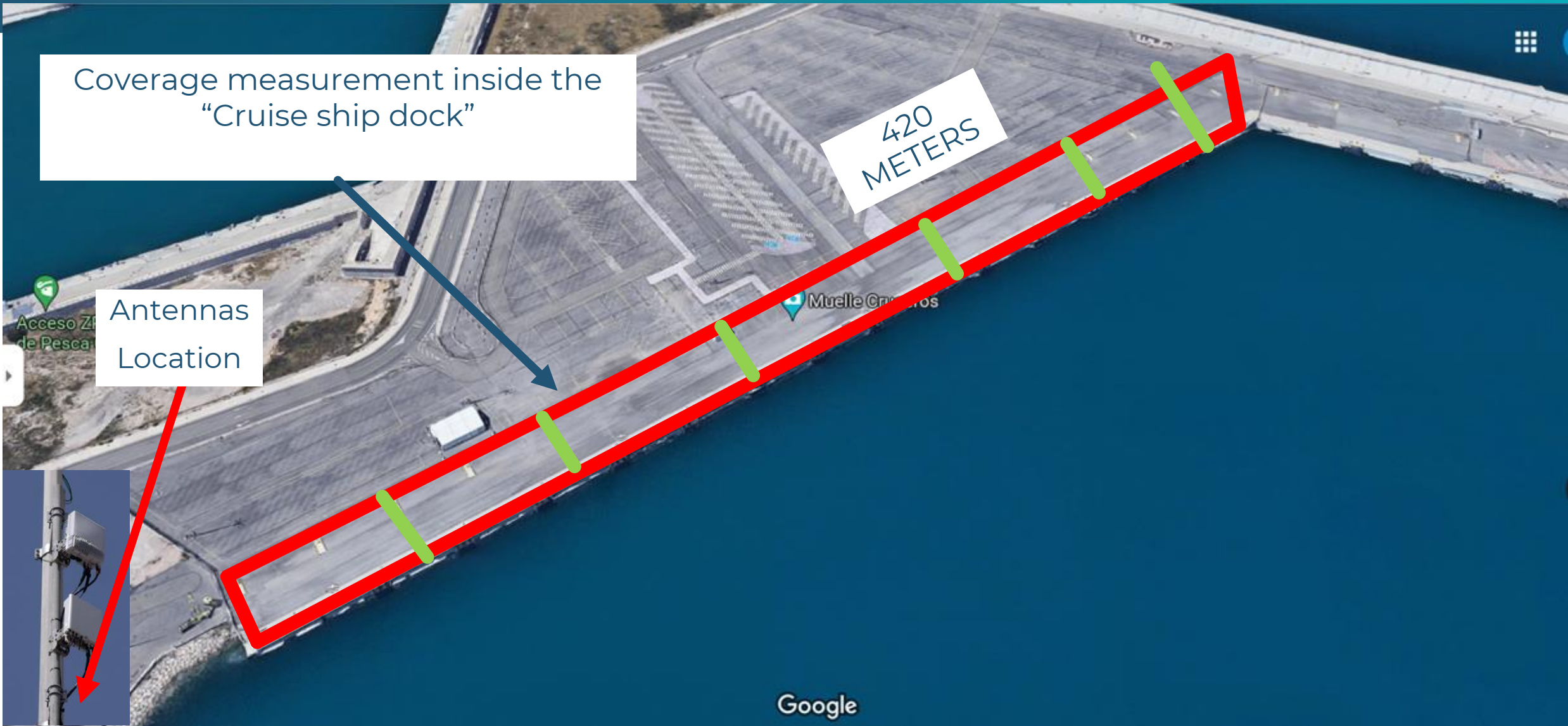
Summary

- Executed Smartphone coverage tests in 5G NSA mmW
- Good coverage at 420 meters of the antenna in Uplink
- Measured bandwidth, GPS
- Decided the final test scenario for moving AGVs: Passengers Dock



FIELD TESTS IN VALENCIA PORT

11/07/2022

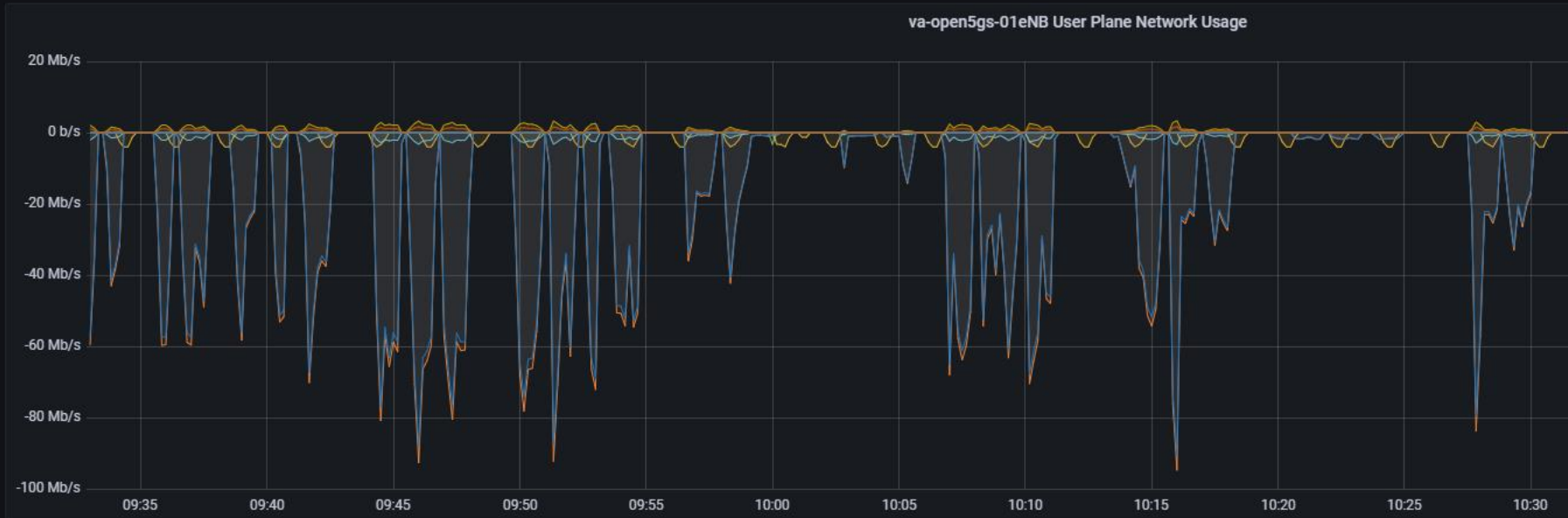
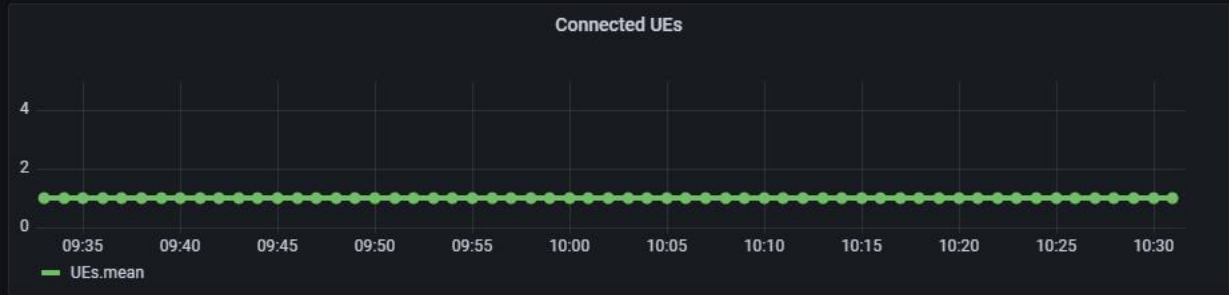
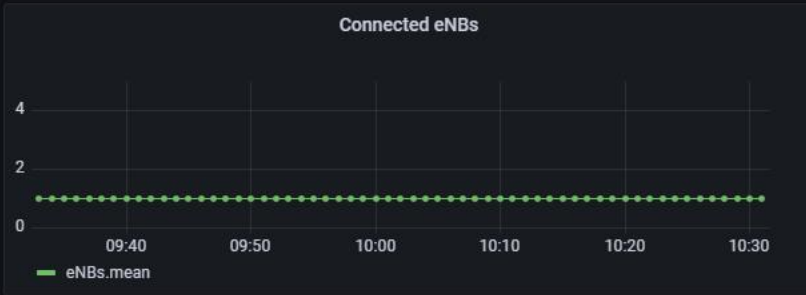


FIELD TESTS IN VALENCIA PORT UPLINK BENCHMARKS 11/07/2022

INGENIOUS / Valencia Core-Network Statistics

2022-07-11 09:32:51 to 2022-07-11 10:31:36

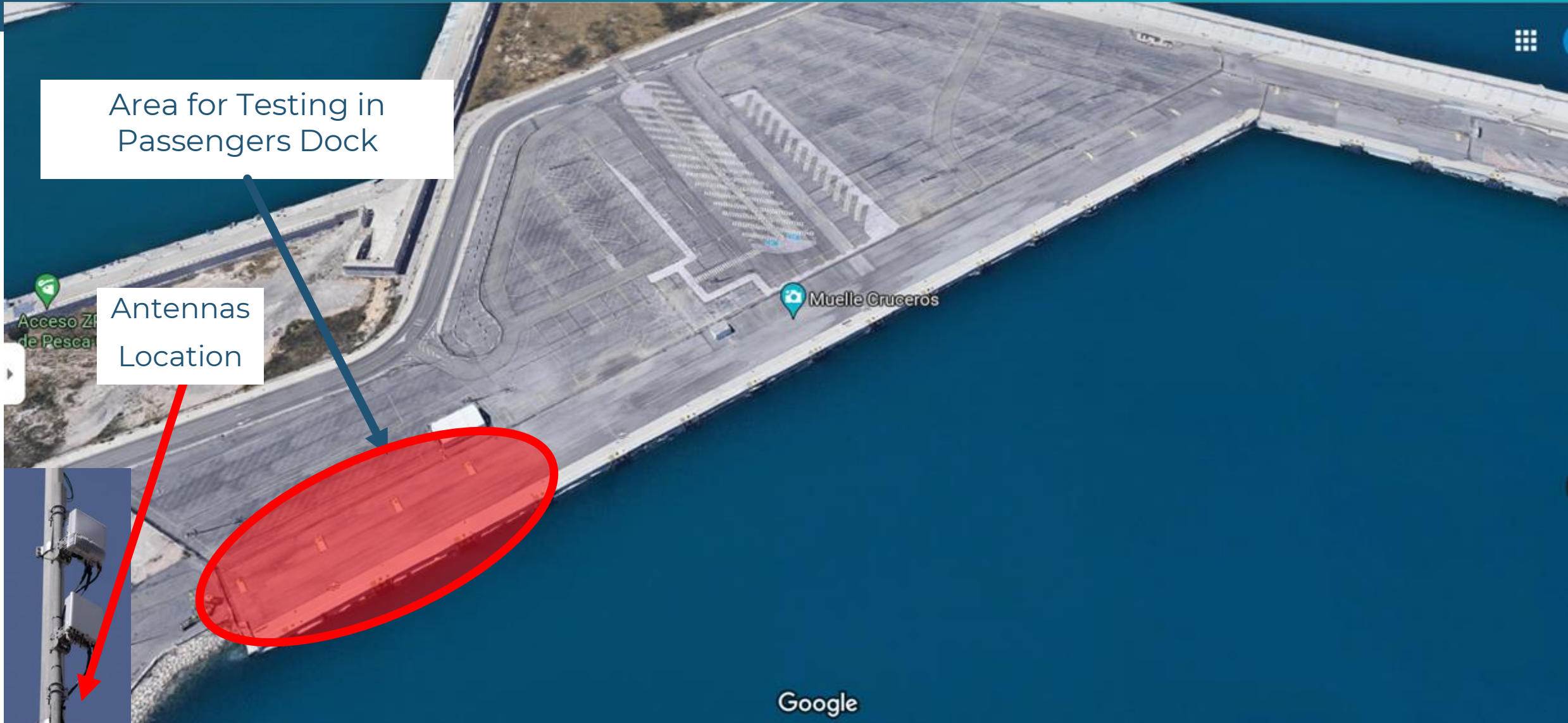
datasource InfluxDB Server open5gs interface All



	min	max	avg	current
va-open5gs-01: ens11: in	3.14 kb/s	3.34 Mb/s	15.3 kb/s	4.65 kb/s
va-open5gs-01: ens3: in	0 b/s	4.02 Mb/s	993 kb/s	89.6 b/s
va-open5gs-01: ens4: in	78.4 b/s	3.33 Mb/s	646 kb/s	1.47 kb/s
va-open5gs-01: ens5: in	78.4 b/s	94.8 Mb/s	17.8 Mb/s	1.49 kb/s
va-open5gs-01: ens6: in	0 b/s	7.87 kb/s	3.65 kb/s	784 b/s
va-open5gs-01: ogstun: in	0 b/s	90.8 Mb/s	17.1 Mb/s	754 b/s
va-open5gs-01: ens11: out	3.00 kb/s	128 kb/s	12.8 kb/s	14.7 kb/s
va-open5gs-01: ens3: out	0 b/s	53.5 kb/s	12.5 kb/s	0 b/s
va-open5gs-01: ens4: out	0 b/s	56 b/s	0.159 b/s	0 b/s
va-open5gs-01: ens5: out	78.4 b/s	3.33 Mb/s	646 kb/s	1.47 kb/s
va-open5gs-01: ens6: out	0 b/s	1.91 kb/s	325 b/s	627 b/s
va-open5gs-01: ogstun: out	0 b/s	1.71 Mb/s	334 kb/s	736 b/s



FIELD TESTS IN VALENCIA PORT: TEST AREA FOR FUNCTIONAL TESTS 11/07/2022



FINAL TESTS IN VALENCIA PORT

28/11/2022 WEEK 48



FINAL TESTS IN VALENCIA PORT

28/11/2022 WEEK 48

Summary

- Planned with real AGVs in Passengers Dock:
 - AGV-A ASTI
 - AGV-B NOKIA
 - AGV FIVECOMM



5G modems mmW provided by NOKIA:

- Smartphones for load tests during Use Cases:
 - Used to generate different levels of traffic during the execution of the Use Cases
- Smartphones for AGVs connectivity with Ethernet Interface.
 - Mounted in all the AGVs for the 5G mmW n258 connectivity



KPIs Infrastructure provided by NOKIA:

- KPIs Recording in the platform:
 - Ping latency to modem RTTs: Load Modem and AGV Modem
 - MEC, CORE – Throughput, Memory, CPU, GPU
- MEC Server for performance tests:
 - Iperf3 server available inside the network in MEC for benchmarking



FINAL TEST SCENARIO PROPOSAL: CONNECTIVITY

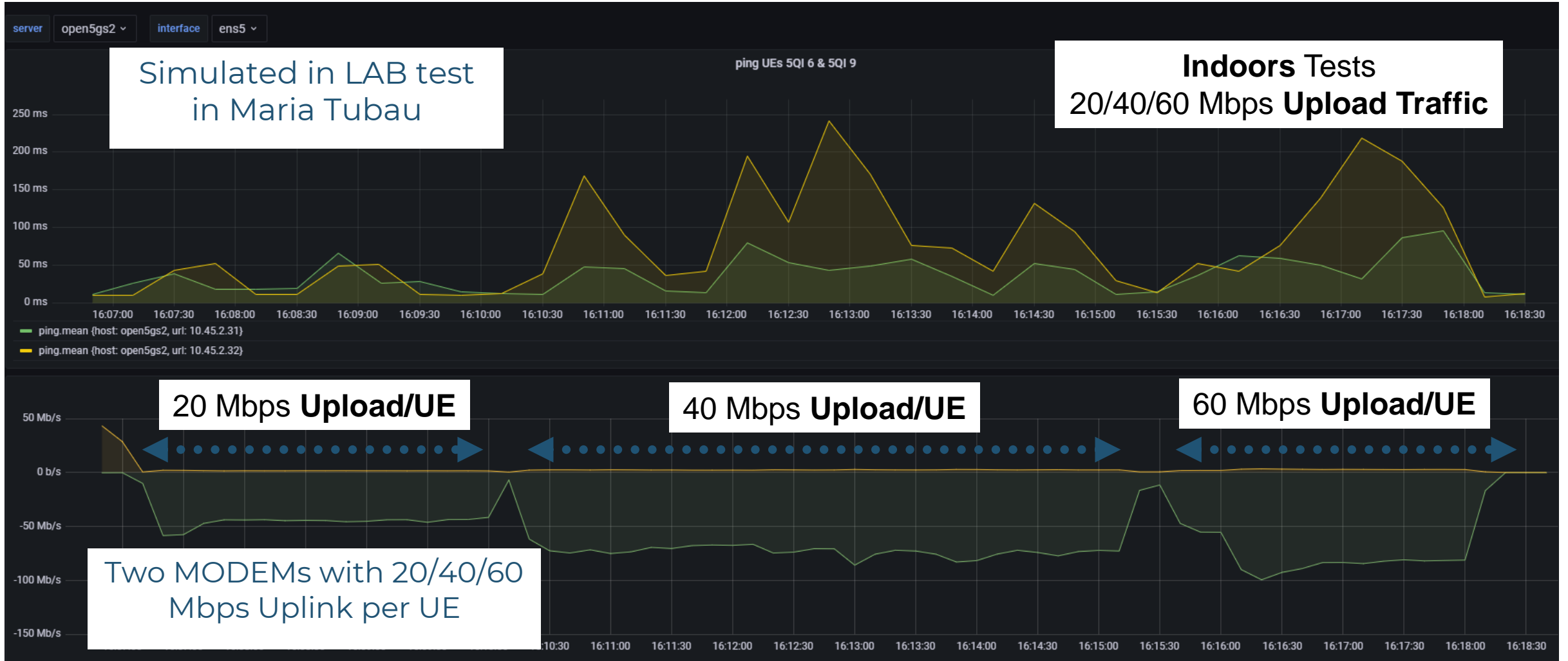
ASUS MOBILE PHONE FOR ENGINEERS

1. Model: ASUS Asus Smartphone for Snapdragon Insiders I007D. EXP21 Smartphone
2. Ethernet Connector: Tethering by USB-C Interface to Ethernet



Items	Maximum Radio-Frequency Output Power Table	
WCDMA	WCDMA Band I (1920-1980; 2110-2170MHz)	24 (dBm)
	WCDMA Band VIII (880-915; 925-960MHz)	24 (dBm)
LTE	LTE Band 1 (1920-1980; 2110-2170MHz)	24 (dBm)
	LTE Band 3 (1710-1785; 1805-1880MHz)	24 (dBm)
	LTE Band 7 (2500-2570; 2620-2690MHz)	24 (dBm)
	LTE Band 8 (880-915; 925-960MHz)	25 (dBm)
	LTE Band 20 (832-862; 791-821MHz)	25 (dBm)
	LTE Band 28 (703-748; 758-803MHz)	25 (dBm)
	LTE Band 34 (2010-2025MHz)	24 (dBm)
	LTE Band 38 (2570-2620MHz)	24 (dBm)
	LTE Band 40 (2300-2400MHz)	24 (dBm)
	LTE Band 42 (3400-3600MHz)	25 (dBm)
	LTE Band 43 (3600-3800MHz)	25 (dBm)
5G NR	NR n1 (1920-1980; 2110-2170MHz)	24 (dBm)
	NR n3 (1710-1785; 1805-1880MHz)	24 (dBm)
	NR n7 (2500-2570; 2620-2690MHz)	24 (dBm)
	NR n8 (880-915; 925-960MHz)	25 (dBm)
	NR n20 (832-862; 791-821MHz)	26 (dBm)
	NR n28 (703-748; 758-803MHz)	25 (dBm)
	NR n38 (2570-2620MHz)	24 (dBm)
	NR n40 (2300-2400MHz)	24 (dBm)
	NR n41 (2500-2690MHz)	26.5 (dBm)
	NR n77 (3300-4200MHz)	25 (dBm)
	NR n78 (3300-3800MHz)	26 (dBm)
	NR n257 (26500-29500MHz)	43 (EIRP)
	NR n258 (24250-27500MHz)	43 (EIRP)

KPIS FOR ALL PLATFORM TESTS



FINAL TESTS IN VALENCIA PORT

28/11/2022 WEEK 48

Modems, Servers, IPs for final tests

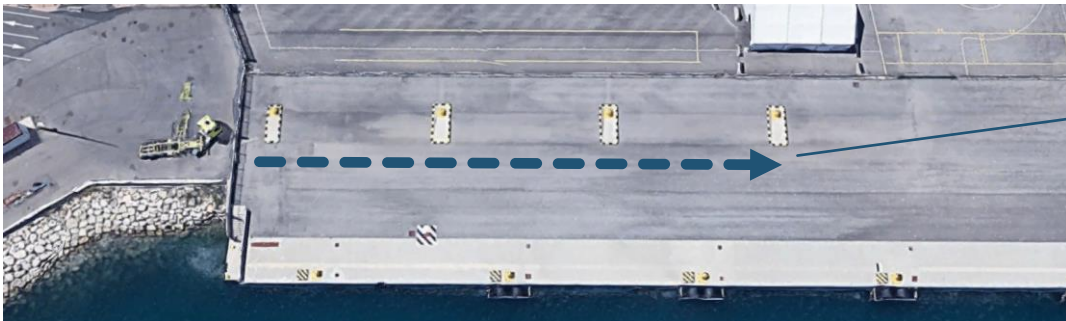
Tests Platform	AGV	IMSI friendly name	IMSI	Profile 5QI	IP	Comment	Modem Label
AGV-B	Fivecomm	AGV-13-NOK	214380000000013	9	10.45.100.13	Mounted in AGV	ASUS2
AGV-B	Nokia	AGV-14-NOK	214380000000014	6	10.45.100.14	Connected to Cockpit	ASUS3
AGV-A	ASTI	AGV-10-ASTI	214380000000010	6	10.45.100.10	Mounted in AGV	ASUS4
ALL	ALL	IMSI-P-1	214380000000006	9	10.45.100.6	KPIs Operations Center Connectivity	ASKEY-1
ALL	ALL	IMSI-P-2	214380000000009	9	10.45.100.9	Used for Load Test during Use Cases	ASUS1
ALL	ALL		iperf3 Server			Ports available: 5201	
ALL	ALL		KPIs Monitoring Platform			URL: https://192.168.1.200/	



FINAL TEST SCENARIO PROPOSAL: THREE DEVICES MOVING

AGVs moving from 30 to 130 meters from antenna

1. AGV-14-NOK – 5QI-6 – Prioritized User – SmartPhone - Moving from 50 to 130 meters
2. AGV-13-NOK – 5QI-9 – Normal User – SmartPhone – Load Test
3. AGV-10-ASTI – 5QI-9 – Normal User – SmartPhone – Load Test



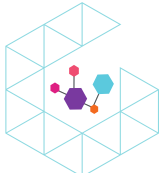
AGVs
Route





5G RADIO

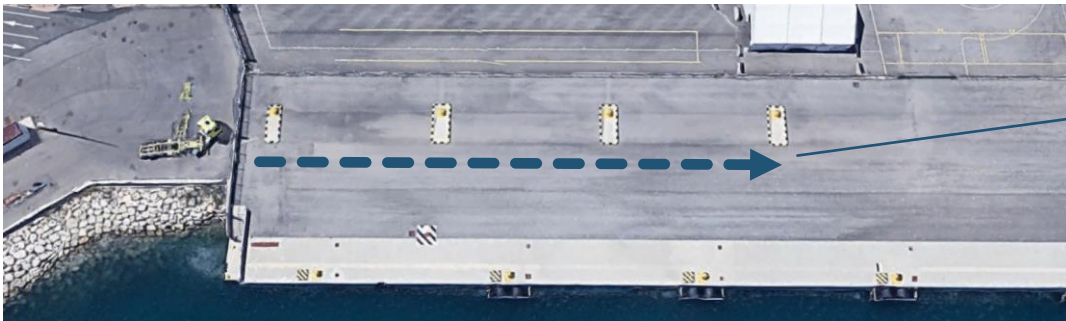
INGENIOUS AGV Tests Area



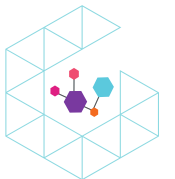
FINAL TEST SCENARIO PROPOSAL: DOWNLOAD STRESS TESTS TWO 100MHZ CARRIERS

AGVs moving from 30 to 130 meters from antenna

- 1. AGV-14-NOK – 5QI-6 – Prioritized User – SmartPhone - Moving from 50 to 130 meters**
- 2. AGV-13-NOK – 5QI-9 – Normal User – SmartPhone – Load Test**
- 3. AGV-10-ASTI – 5QI-9 – Normal User – SmartPhone – Load Test**
- 4. Another Terminal to load radio with data in uplink or downlink**

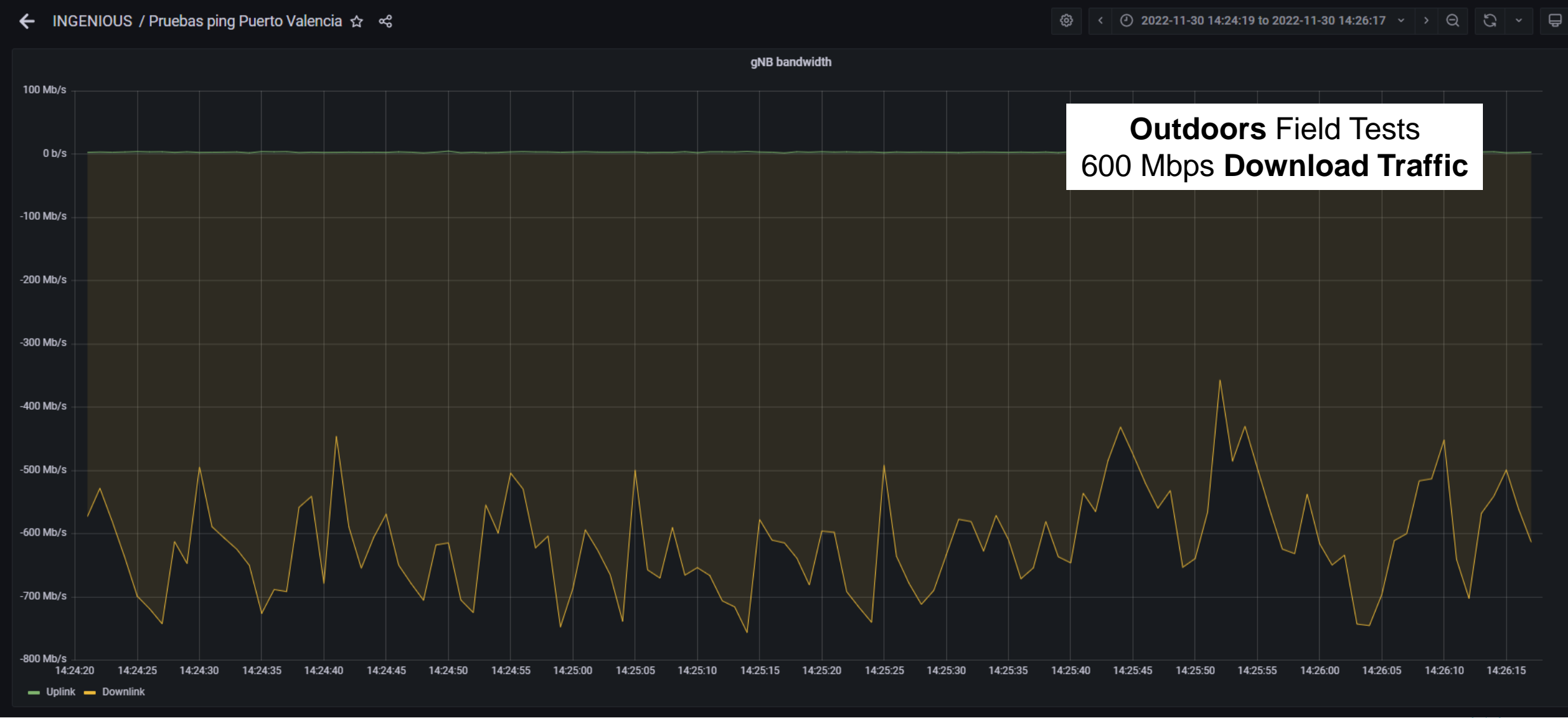


AGVs
Route

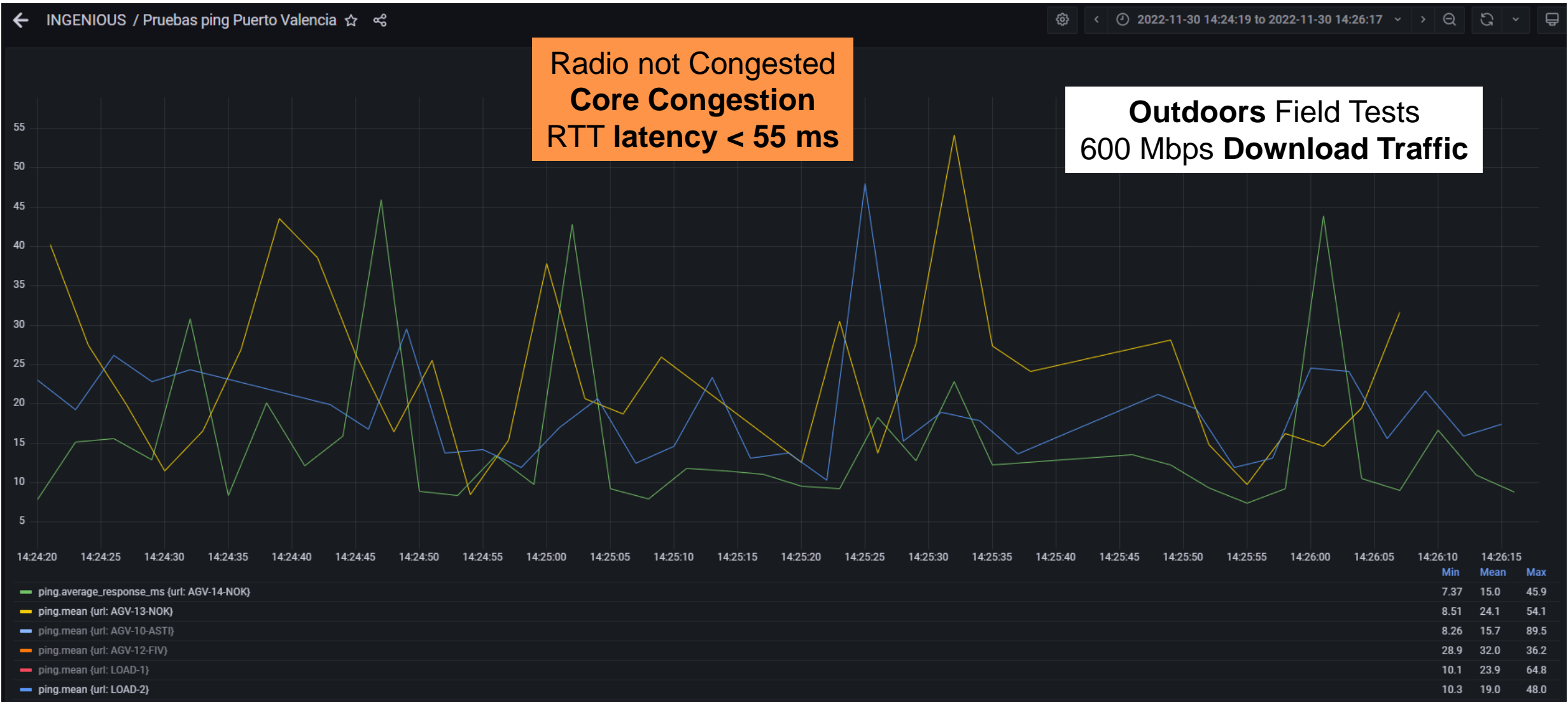


FINAL TEST SCENARIO PROPOSAL: DOWNLOAD STRESS TESTS

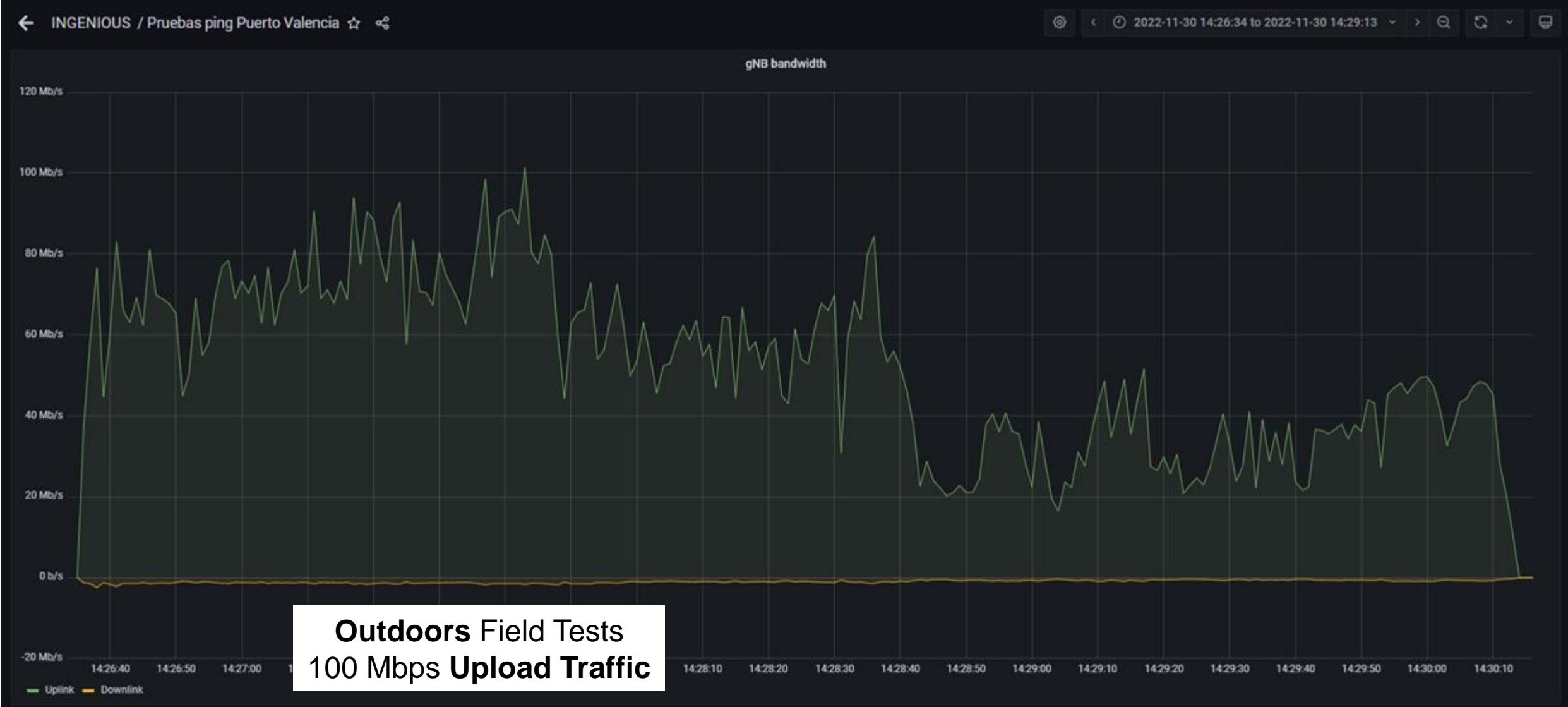
TWO 100MHZ CARRIERS: RADIO NOT CONGESTED (CORE LIMIT)



FINAL TEST SCENARIO PROPOSAL: DOWNLOAD STRESS TESTS 2X 100MHZ CARRIERS



FINAL TEST SCENARIO PROPOSAL: UPLOAD STRESS TESTS TWO 100MHZ CARRIERS (CONGESTED RADIO)

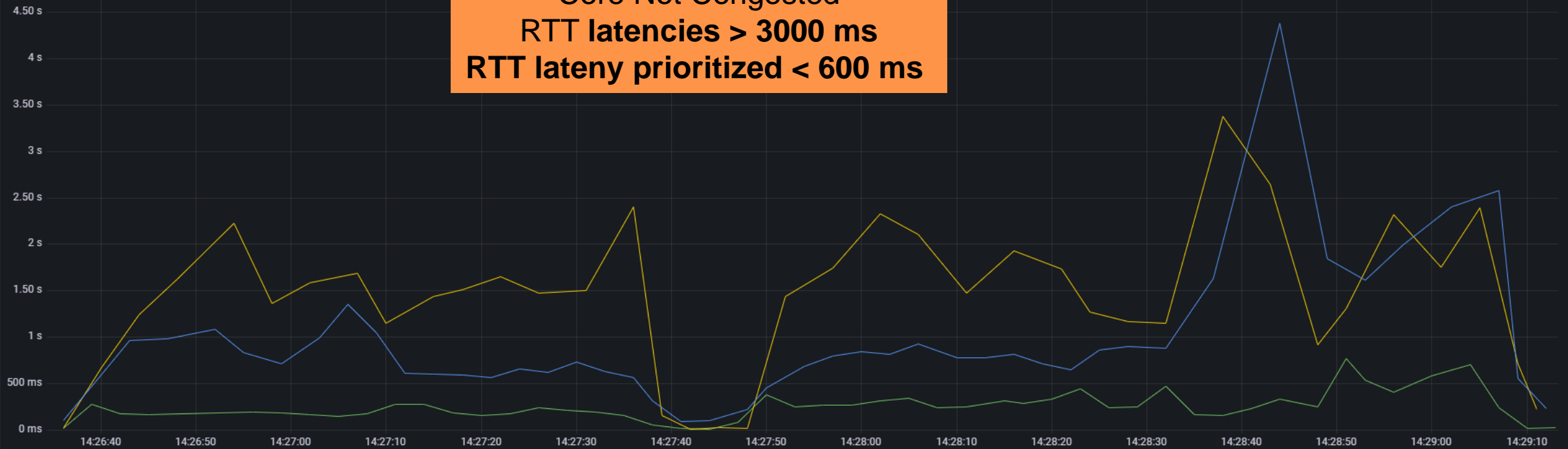


FINAL TEST SCENARIO PROPOSAL: UPLOAD STRESS TESTS TWO 100MHZ CARRIERS (CONGESTED RADIO)

← INGENIOUS / Pruebas ping Puerto Valencia ☆ 🔗

⚙️ < 🕒 2022-11-30 14:26:34 to 2022-11-30 14:29:13 > 🔍 ↻ 📄

Radio Congestion
Core Not Congested
RTT latencies > 3000 ms
RTT latency prioritized < 600 ms



- ping.average_response_ms (url: AGV-14-NOK)
- ping.mean (url: AGV-13-NOK)
- ping.mean (url: AGV-10-ASTI)
- ping.mean (url: AGV-12-FIV)
- ping.mean (url: LOAD-1)
- ping.mean (url: LOAD-2)

Outdoors Field Tests
100 Mbps Upload Traffic

	Min	Mean	Max
ping.average_response_ms (url: AGV-14-NOK)	9.41 ms	254 ms	771 ms
ping.mean (url: AGV-13-NOK)	10.5 ms	1.42 s	3.38 s
ping.mean (url: AGV-10-ASTI)	6.34 ms	15.9 ms	35.7 ms
ping.mean (url: AGV-12-FIV)	29.5 ms	31.8 ms	36.0 ms
ping.mean (url: LOAD-1)	5.41 ms	22.3 ms	208 ms
ping.mean (url: LOAD-2)	89.2 ms	938 ms	4.38 s

APPLICATION KPIS AND FUNCTIONAL TESTS

1. Application KPIS

1. AGV

1. Speed, GPS
2. Battery, Angular Speed

2. COCKPIT

1. FPS, CAM RTT
2. Throughput

2. Network/Platform KPIS

1. Ping latency to modem RTTs:

1. IMSI-AGV-B-1
2. IMSI-AGV-B-2
3. IMSI-P-2

2. MEC, CORE, AGV, COCKPIT – Throughput, Memory, CPU, GPU



APPLICATION KPIS AND FUNCTIONAL TESTS



Remote Driving RTT (Round Trip Time) in milliseconds is monitored during the use case execution. RTT should be under 100ms. The speed and the steering of the AGV are also monitored during the tests so that it is verified the AGV is moving and being remotely driven.



Encoded and decoded video frames which are transmitted over the network and need to be kept under 25-30 FPS limit so that the final cockpit immersive application provides the end user with a smooth experience.



**STAY UPDATE
AND GET INVOLVED!**



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**THANKS FOR
YOUR ATTENTION**

ANY QUESTIONS?

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