5G-MOBIX

Webinar: 5G-MOBIX evaluation results and recommendations
Technical Evaluation

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5GMOBIX

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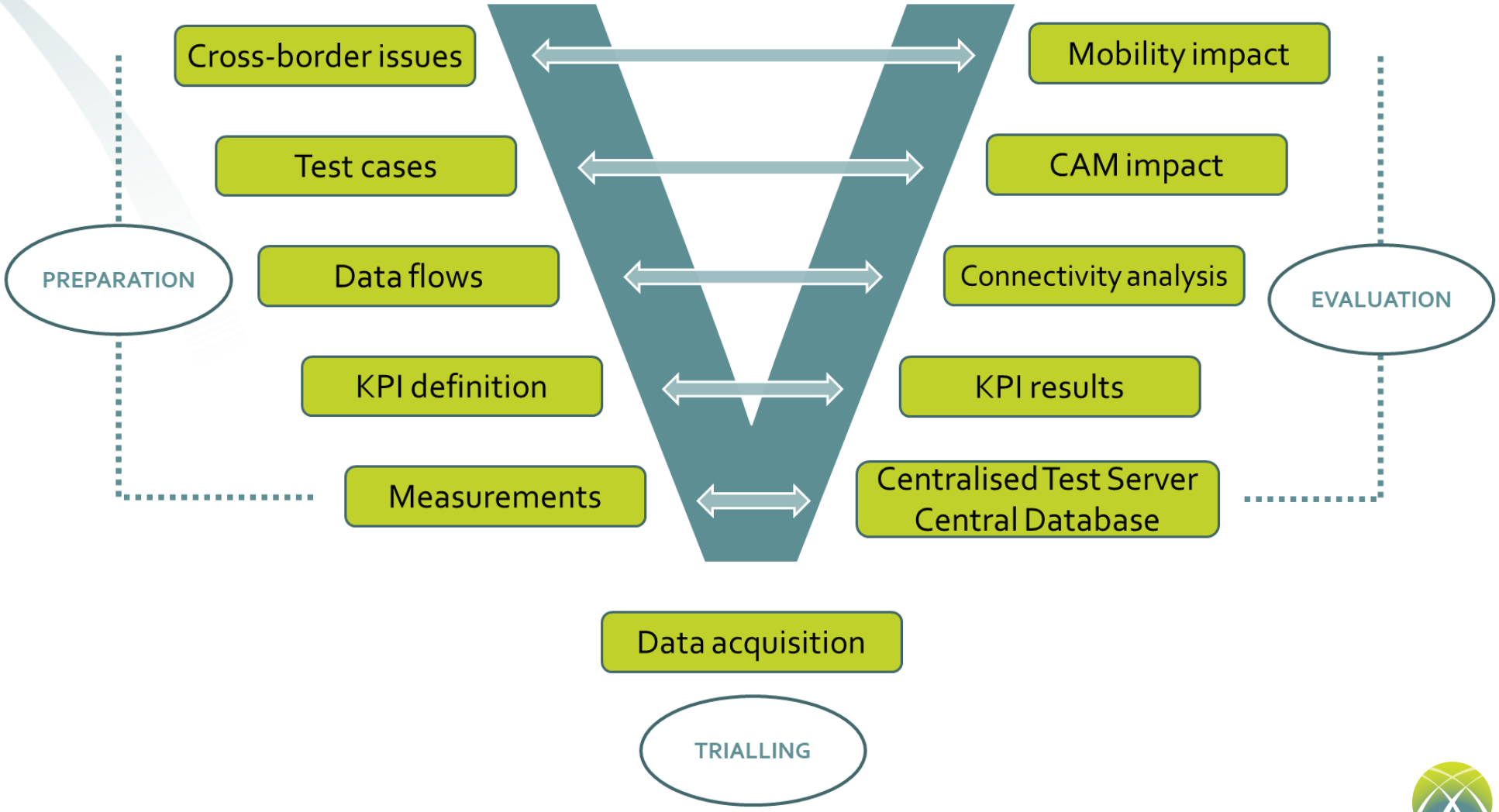
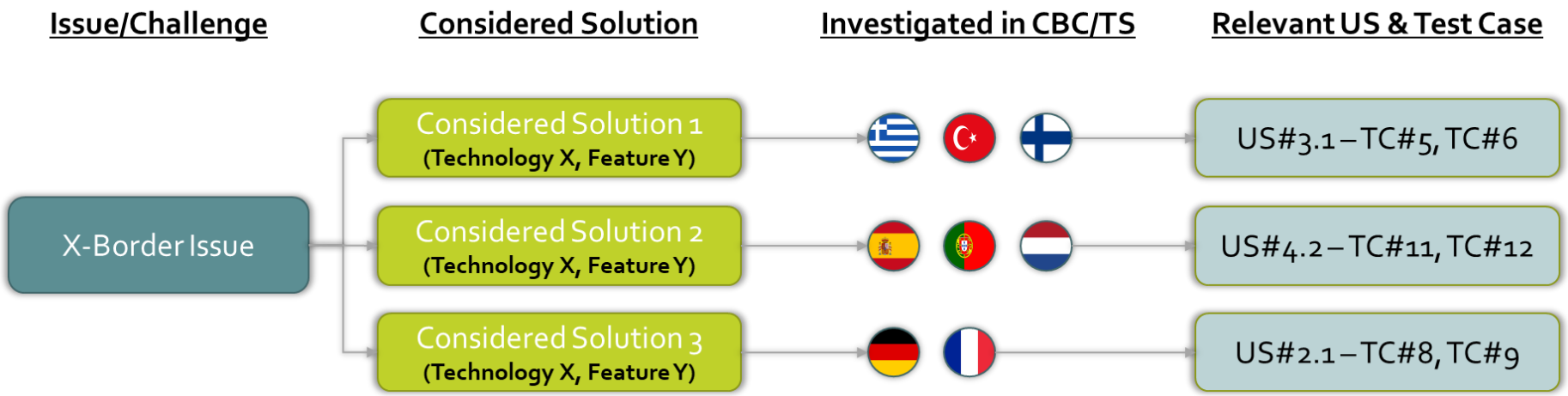
Technical Evaluation

Methodology



Cross-Border Issues (XBIs) & Considered Solutions (CSs)

- **Cross-Border Issues (XBIs):** identify set of technical challenges towards seamless cross-border CAM functionality over 5G → **11 XBIs** identified in 5G-MOBIX
- **Considered Solutions (CS):** identify set of the most promising technical approaches to address the identified XBIs → **26 CSs** identified in 5G-MOBIX
  - Can be alternative solutions to the same XBI
  - Can be analysed by different CBC/TS



Cross-border issues and considered solutions (1/2)

XBI		Associated CS	
ID	Name	ID	Name
XBI_0	Baseline	CS_0	Feature OFF
XBI_1	NSA Roaming interruption	CS_1	S1 handover with S10 interface using an NSA network
		CS_2	Release and redirect using an NSA network
		CS_3	Release and redirect with S10 interface using an NSA network
XBI_2	SA Roaming interruption	CS_6	Release and redirect using an SA network
XBI_3	Inter-PLMN interconnection latency	CS_7	Internet-based Interconnection
		CS_8	Direct Interconnection
XBI_4	Low coverage Areas	CS_4	Multi-modem / multi-SIM connectivity - Passive Mode
		CS_9	Satellite connectivity
XBI_5	Session & Service Continuity	CS_4	Multi-modem / multi-SIM connectivity - Passive Mode
		CS_5	Multi-modem / multi-SIM connectivity-Link Aggregation
		CS_6	Release and redirect using an SA network
		CS_10	MEC service discovery and migration using enhanced DNS support
		CS_11	Imminent HO detection & Proactive IP change alert
		CS_12	Inter-PLMN HO, AF make-before-break, SA
		CS_13	Double MQTT client
		CS_14	Inter-MEC exchange of data
		CS_15	Inter-server exchange of data

Cross-border issues and considered solutions (2/2)

XBI		Associated CS	
ID	Name	ID	Name
XBI_6	Data routing	CS_16	LBO NSA
		CS_17	HR NSA
		CS_18	LBO SA
		CS_19	HR SA
XBI_7	Insufficient Accuracy of GPS Positioning	CS_20	Compressed sensing positioning
XBI_8	Dynamic QoS Continuity	CS_21	Adaptive Video Streaming
		CS_22	Predictive QoS
		CS_26	Network slicing
XBI_9	Geo-Constrained Information Dissemination	CS_23	Uu geobroadcast
		CS_24	PC5 geobroacast
		CS_25	mmWave 5G
XBI_10	mmWave applicability	CS_25	mmWave 5G
XBI_11	Network slicing applicability	CS_26	Network slicing

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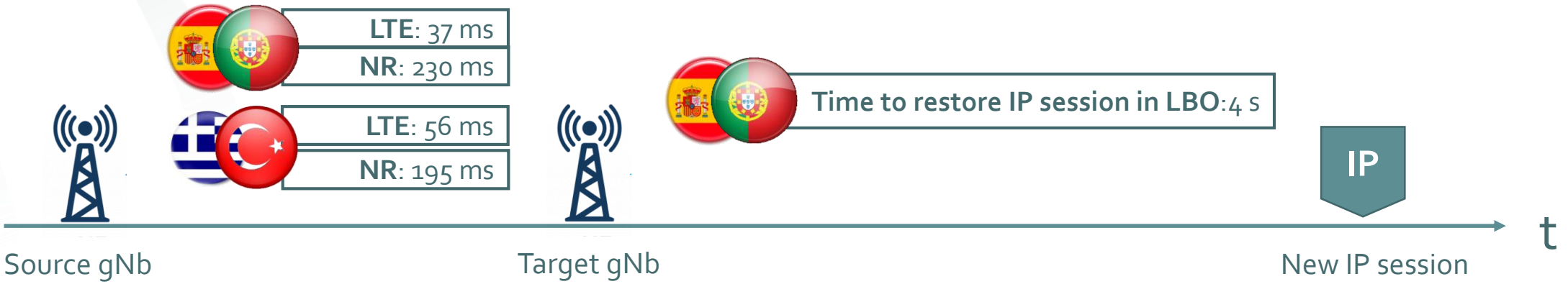
Mobility interruption time in NSA networks

Release and redirect with S10 interface using an NSA network

The UE attaches to the target gNB in idle mode and has to transition to connected mode.
Context information is exchanged between the source and destination core through the S10 interface.



☑ Handover achieved between NSA networks in HR and LBO

☑ Reproducibility, comparable results in both CBC.

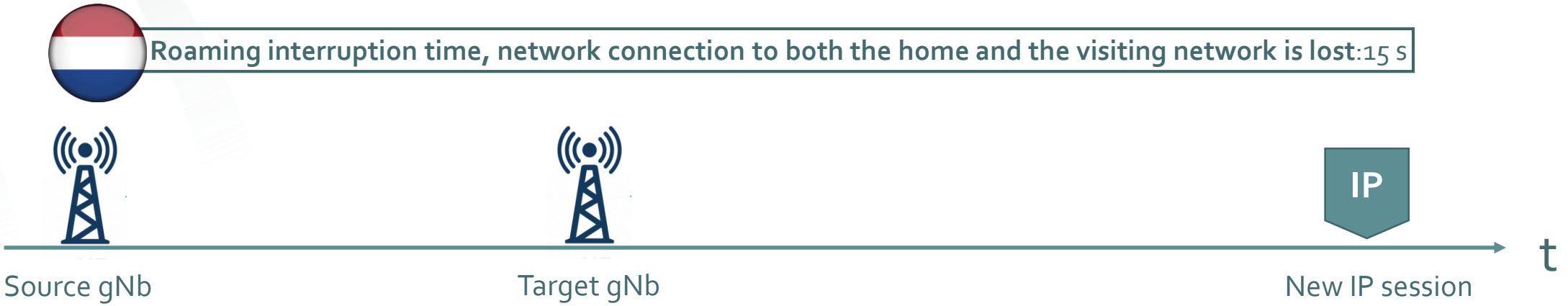
☑ Interruption times in HR are compatible with most CAM functions.

☒ The way to restore the IP network connection in LBO is a non-standarized process triggered by the UE (and not the network) that increase the interruption time to seconds, no valid for autonomous driving.

Mobility interruption time in SA networks

Release and redirect using an SA network

The UE attaches to the target gNB, has to authenticate and setup a new bearer session



- ☑ Handover achieved between SA networks in LBO
- ☑ 100% roaming handover success rate
- ☒ Technology not yet ready for the dynamic reléase, tests were done by pre-configuring the SIM cards
- ☒ Interruption time below the requirements of CAM applications.

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Inter-PLMN interconnection latency

Internet based interconnection vs direct interconnection

E2E Latency - Public Internet – See-what-I-See

SAMPLES	Mean	Median	Std. Deviation
480	113.6 ms	112.4 ms	21.56 ms
Max	**Min**	**CI 95%**	**Percentile 95%**
120.13 ms	109.33 ms	2.52 ms – 3.78 ms	3.678 ms

E2E Latency - Direct Interconnection – See-what-I-See

SAMPLES	Mean	Median	Std. Deviation
480	45.6 ms	45.54 ms	14.43 ms
Max	**Min**	**CI 95%**	**Percentile 95%**
161.29 ms	19.619 ms	1.68 - 1.82 ms	1.702 ms

☑ Direct interconnection reduces significantly the E2E latency, compared to public internet

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Session and service continuity

Multi-modem / multi-SIM connectivity

Passive Mode (best or high priority connection) vs Link Aggregation (multiple connections)

Highest performance in link aggregation (compared to single-SIM and passive mode):
- E2E latency of 25 ms with passive mode and 20 ms with link aggregation
- 0.4% of packet loss with passive mode and no packet los with link aggregation

Highest performance in link aggregation (compared to single-SIM and passive mode):
- Less packet loss rate
- E2E latency of 68 ms (76 ms with single-SIM)

Service interruption time with passive mode:
- 50 – 300 ms in ping tests
- 1 – 3 s in tests against a MQTT

E2E latency of 34 ms in link aggregation
10% of packet loss with passive mode and no packet loss with link aggregation

☑ Latency and reliability benefits from link aggregation, compared to passive mode.

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Data Routing

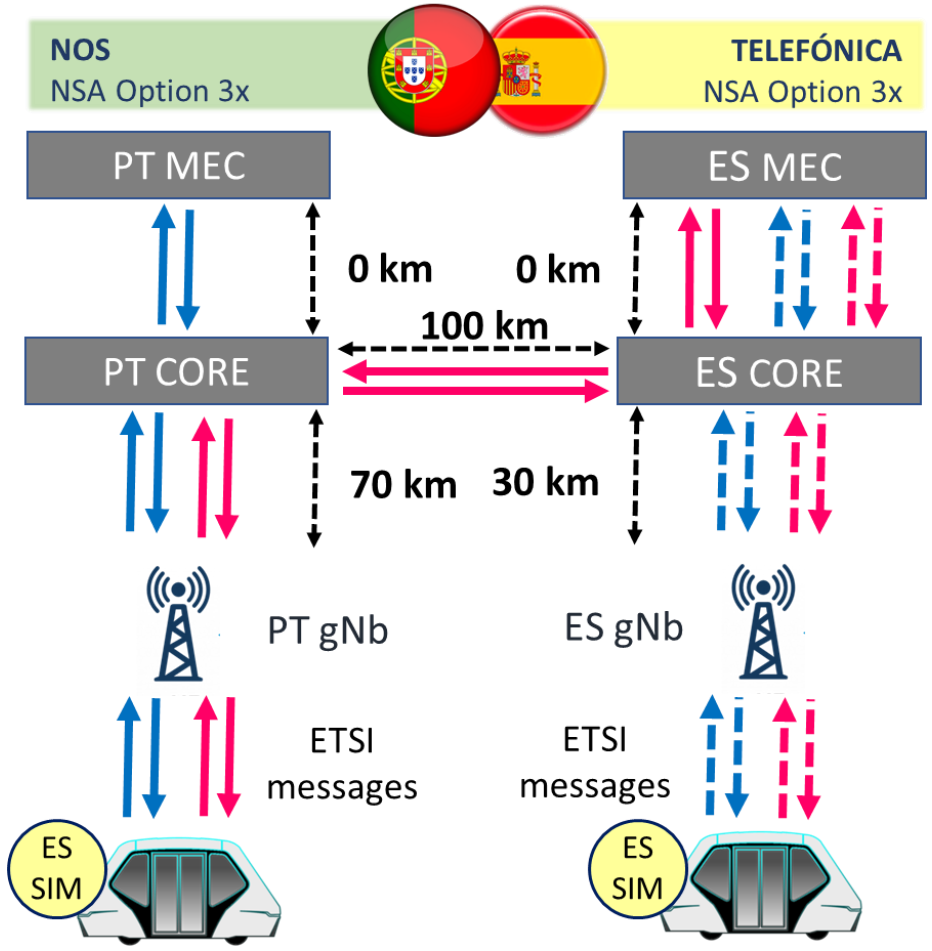
HR NSA vs LBO NSA

UE is served by the H-PLMN vs UE is served by the V-PLMN

Roaming Configuration	E2E latency
Home Routed	60 ms
Local Breakout	40 ms

☑ LBO provides shorter latencies when driving in the visited network, compared to HR

☑ HR and LBO latencies are compatible with most CAM functions



Home Routed vs Local Breakout

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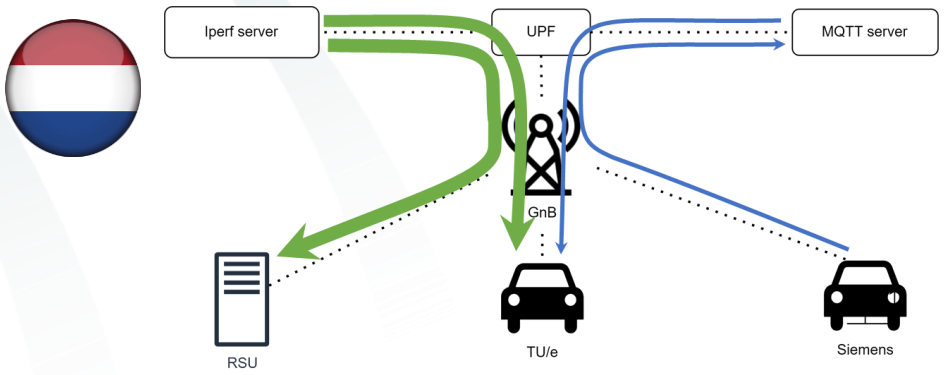
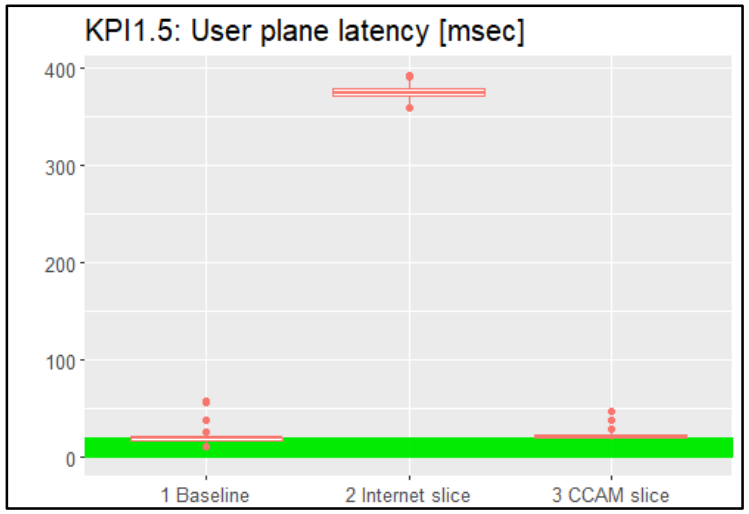
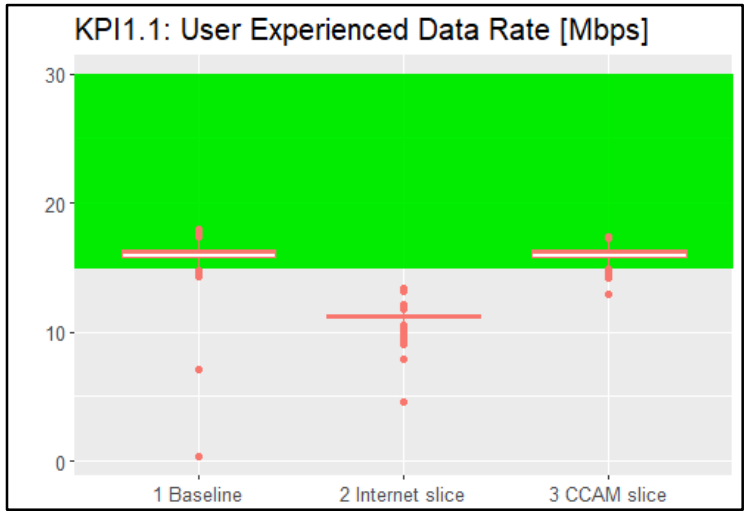
Network slicing in SA

Partitioning of data and services in different slices to guarantee service performance



Test Case	High priority CAM slice	Low priority internet slice
Baseline		CAM traffic
Internet slice		CAM + background traffic
CAM slice	CAM traffic	background traffic





☑ Network slicing can fulfil the QoS requirements

☒ CAM slice should not be polluted with background traffic because the scheduler at the gNB can not differentiate high and low priority data.

Technical Evaluation

Contributions of the trial sites to the cross-border corridors

Edge Dynamic Map -enabled extended sensors with surround view generation
-> increase the reliability in 25%

Edge Discovery service protocol
-> DNS migration of data session of 1 s

Multi-SIM on-board units
-> reduction of interruption times compared with the single-SIM

Edge Computing for cooperative messages
-> cooperative messages between vehicles travel with a delay of 60 ms

LEVIS (Live strEaming VehIcle System)
-> deployment in a cross-border scenario with comparable results to the FI ones

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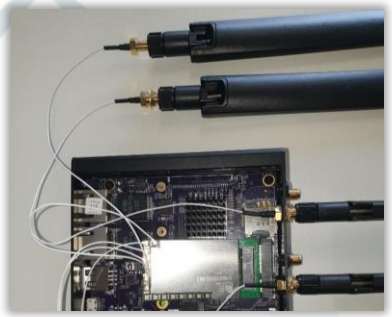
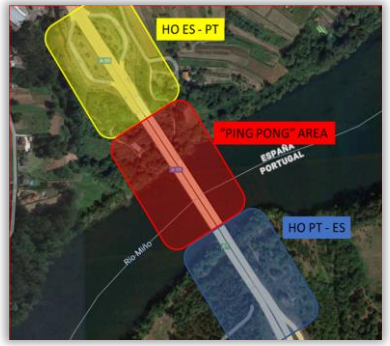
Lessons Learned



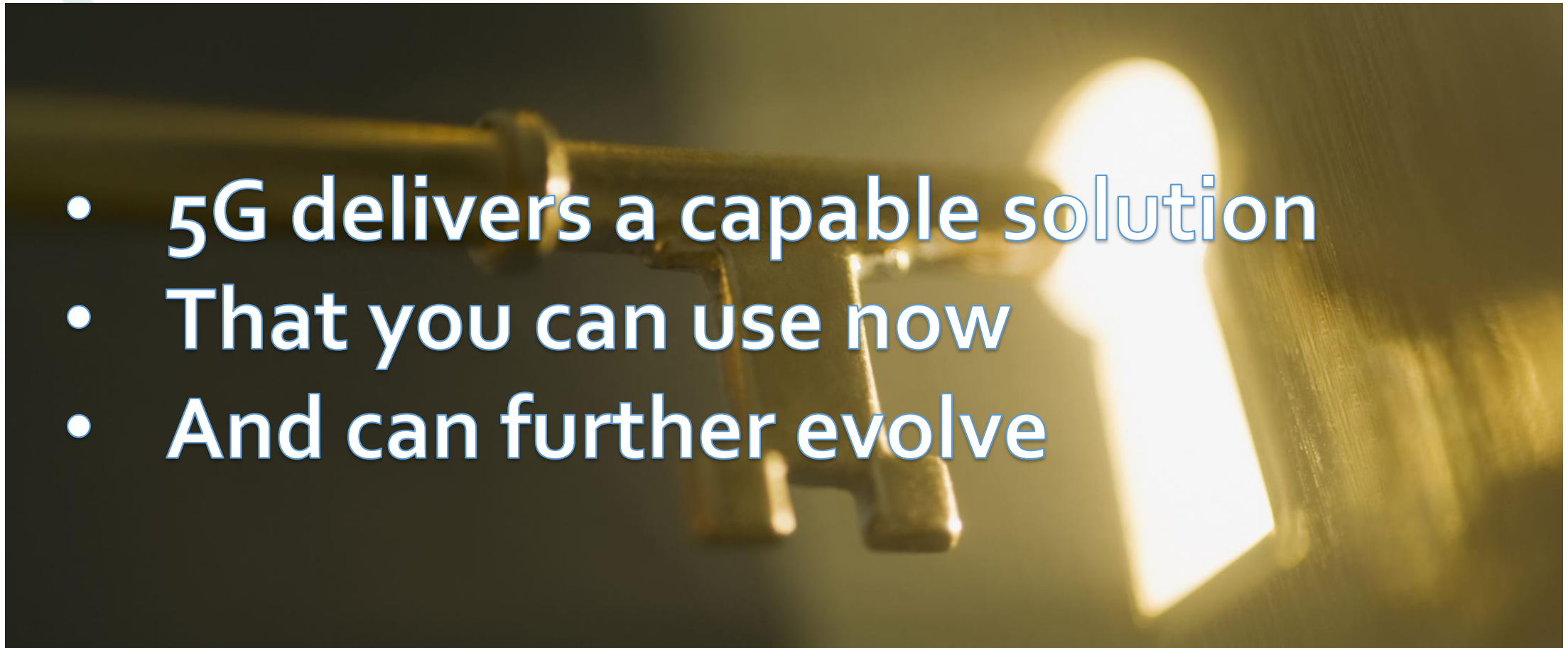
The performance of the different **5G devices** is still unstable and sometimes subject to the regional settings, this was especially critical during the handover processes.

5G behaviour is affected by **interference of objects** in the line of sight of the antennas (buildings, metallic road signalling, mountains, bridges or foliage) and the weather conditions.



Road conditions and exact test scenario timings have an important effect on the observed performance, in particular in what concerns the effect on impact of network behaviour on CAM service. Regarding the latter aspect, evaluation is further complicated by the need to configure **a deterministic location for handover/roaming events**, so as to coordinate with CAM level scenario timings.

Conclusions



Conclusions

- **5G delivers a capable solution**
  - Almost seamless cross-border mobility is feasible
  - CAM performance with 5G is significantly better
  - Scalable allowing for more users and more services
- **That can use now**
  - A large set of CAM services can be supported today
  - Services with higher needs can be adapted to the network status
  - Needs tailor with the collaboration between telecom network and service providers
- **And can further evolve**
  - Incentivizing solutions for universal support of services
  - Understanding the power of current 5G capabilities within the services
  - Finding synergies among all the stakeholders

Thank you!

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