

Dealing with App validation, in practice

5GPPP-TB eWorkshop

2020-12-10

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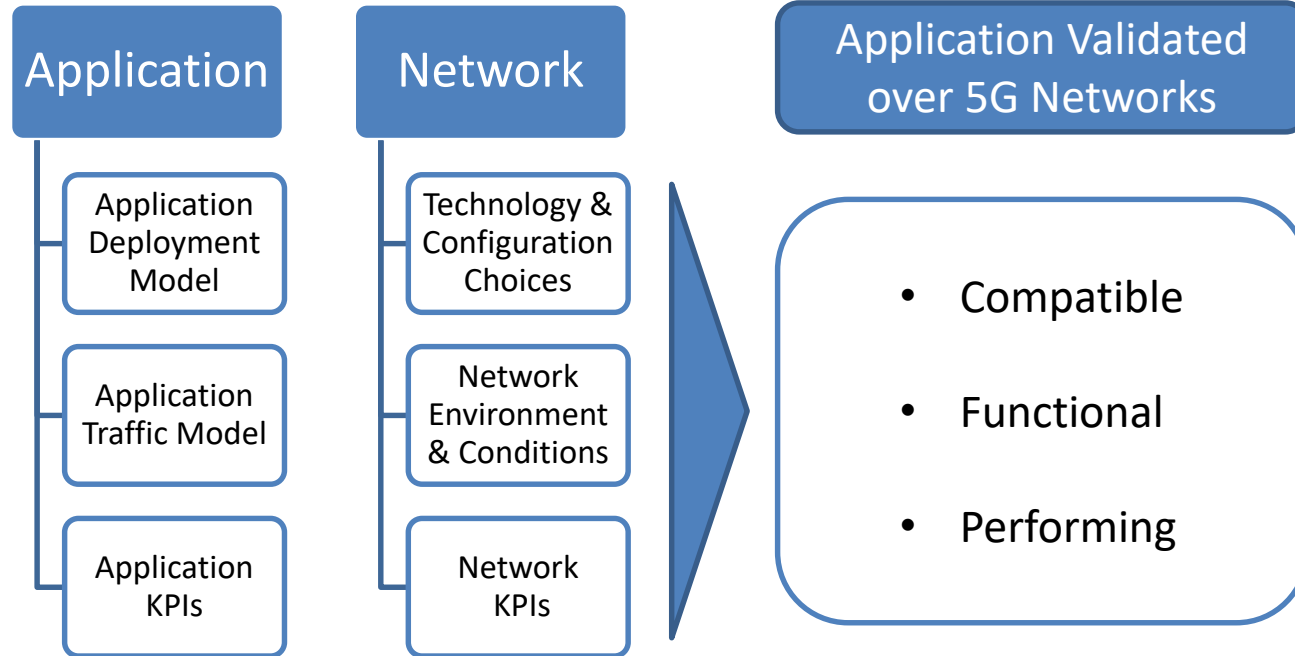


5G EVE



- The Challenge
- Reference Framework for KPI Modelling & Validation
- KPI Validation ++: an iterative process
- Experimentation Cases
- Approach of 5G EVE (ICT-17) + 5GROWTH (ICT-19)
- Key Take Aways

The Challenge



How to validate vertical-specific KPIs over a 5G validation platform

- Understanding the relative influence of 5G network performance indicators
- Collecting and processing performance data collected in the actual experimentation
- Iterating the validation process towards the optimization of both application and network performance

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Definitions

Vertical KPIs

- Targeted values for a vertical-specific KPI. Normally influenced –although normally not only– by one or several 5G service KPIs.
- Specific to the UC, in value and sometimes in nature.
- Measured by the application.
- It's NOT part of the SLA between the vertical and the CSP. It's only meaningful in the specific vertical domain
- Ex: Device to Controller synchronization = 99% of device-controller time-outs do not expire for a 1h-long traffic session

5G Core KPIs

5G Network KPIs:

- Network Performance
- Measured in the Network (with network testing tools)
- Use case independent.
- Part of the SLA between the 5G CSP and the 5G technology/solution vendor
- Ex: For instance U/L Latency OWD = 4 ms (avg), measured with standard network monitoring tools (active probe)

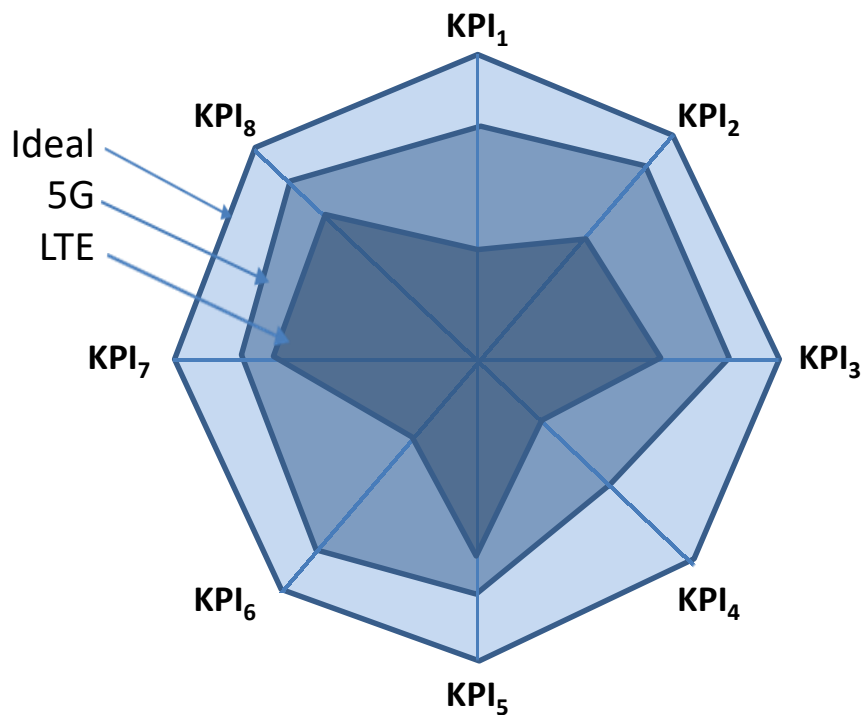
5G Service KPIs:

- Perceived/experienced Network performance.
- Measured by the vertical (itself or by trusted platform).
- Values are specific to UCs (i.e may vary from UC to UC)
- Part of the SLA between the Vertical and the 5G CSP
- Note: Let's consider, just for a while, only the type of 5G service KPIs related directly to a single reference 5G network KPI (for simplicity)
- Ex: U/L Latency for the actual application TCP traffic = 8 ms (avg), measured by trusted ICT17 (with passive probe)

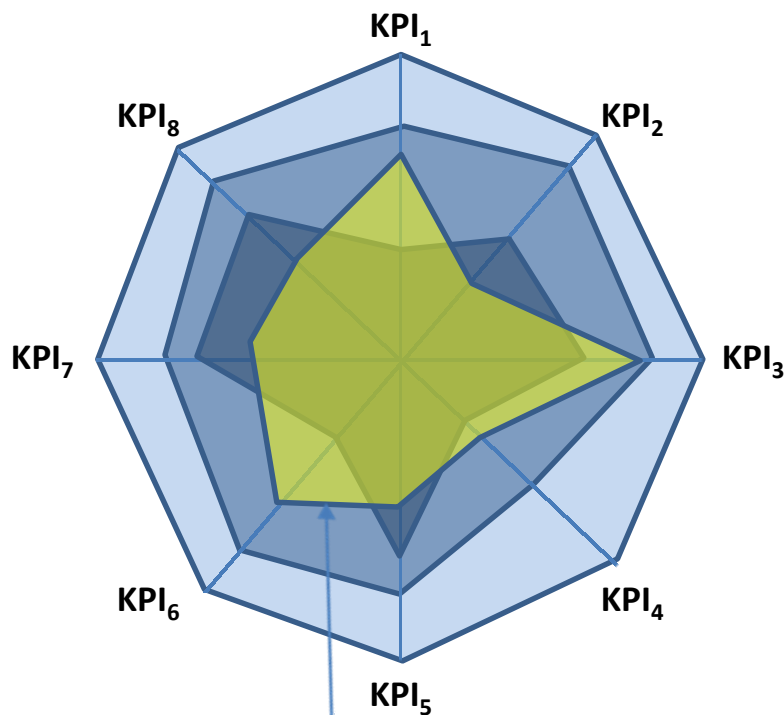
Relevant Clarification

5G NETWORK KPI	NETWORK PERFORMANCE (PRECONDITION)	EXPER. PERFORMANCE (POST-CONDITION)	5G SERVICE KPI
E2E LATENCY	YES	Not likely	-
RTT LATENCY	YES	YES	MAXIMUM EXPECTED RTT LATENCY
USER DATA RATE (D/L or U/L)	YES	YES	MINIMUM EXPECTED USER DATA RATE (D/L or U/L)
PEAK DATA RATE (D/L or U/L)	YES	Not Applicable	-
RELIABILITY	YES	YES	MINIMUM EXPECTED RELIABILITY FOR A SELECTED MAX RTT LATENCY VALUE
AVAILABILITY (NETWORK)	YES	Not Applicable	-
AVAILABILITY (SERVICE)	Not Applicable	YES	MINIMUM EXPECTED AVAILABILITY (SERVICE)
NETWORK PERFORMANCE DIMENSION		SERVICE EXPERIENCE DIMENSION	








Reference Framework (by 2018)



Expected Network Performance levels per Technology







5G KPIs demanded by the Vertical App / Use Case

VERTICAL APPLICATION	5G Core KPI-1	5G Core KPI-2	5G Core KPI-3	...
UC-1			-	
UC-2	-			
UC-3				
...				





1. Vertical Application is broken down into a set of Use Cases
2. Each Use Case poses quantitative requirements on 5G Core KPIs
3. Validation activities focus on the set of 5G Core KPIs

Note: The performance of the Application itself is neither formally modelled nor monitored

USE CASE	5G Core KPI-1	5G Core KPI-2	5G Core KPI-3	...
Composite KPI-A		-	-	
Composite KPI-B	-		-	
Composite KPI-C		-		
...				

1. Vertical Application is broken down into a set of Use Cases
2. For each Use Case a set of Composite KPIs are modelled over component 5G Core KPIs, and quantitative requirements are posed on the 5G Core KPIs
3. Validation activities focus on the set of component 5G Core KPIs

Note: Modelling & Monitoring of composite KPIs is a major step towards formal app validation

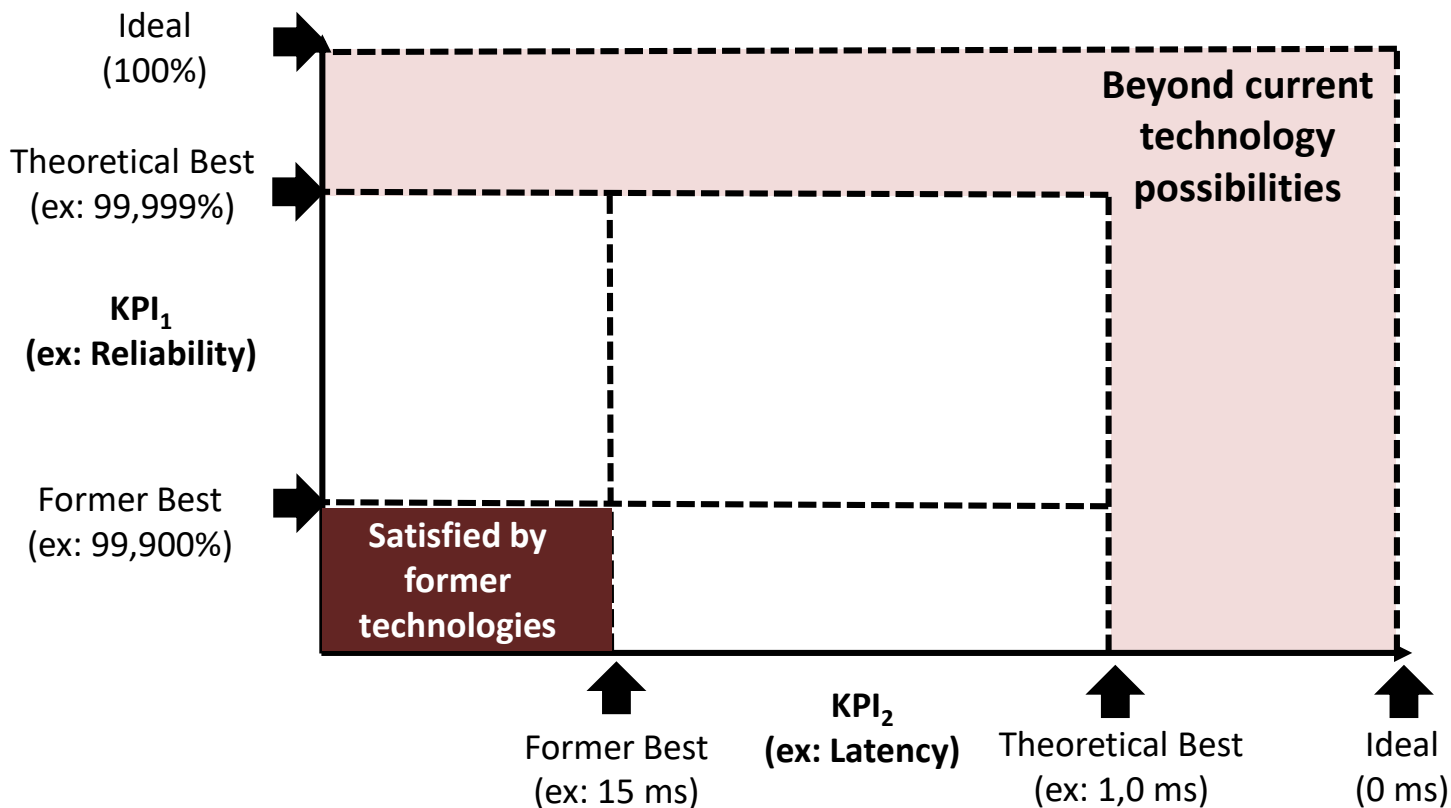
VERTICAL APPLICATION KPI	5G SERVICE KPI-1	5G SERVICE KPI-2	5G SERVICE KPI-3	...
V.KPI-A = <Value>			-	
V.KPI-B = <Value>		-		
V.KPI-C = <Value>	-	-	-	
...				

1. Vertical Application performance is modelled, in its own domain, in meaningful, quantifiable and monitorable Vertical KPIs
2. For each V-KPI a set of -a priori- influencing 5G Core KPIs are postulated
3. Validation activities focus on BOTH V-KPI validation and 5G Core KPI Validation
4. Post-validation data analysis can bring new insight on the actual V.KPI-vs-C.KPI model

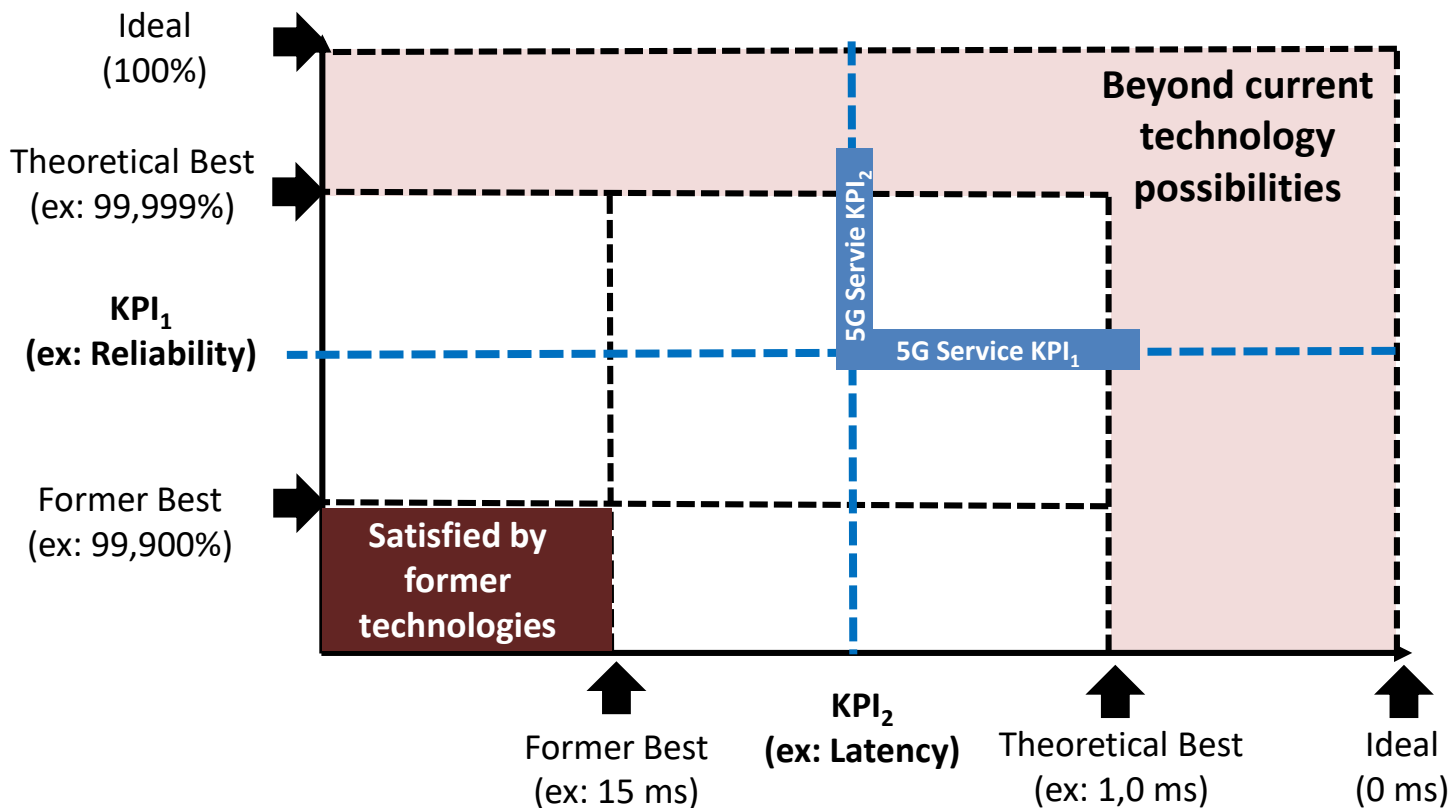
Visualizing the model ...

- For simplicity, let's limit now to 2 just dimensions per V-KPI

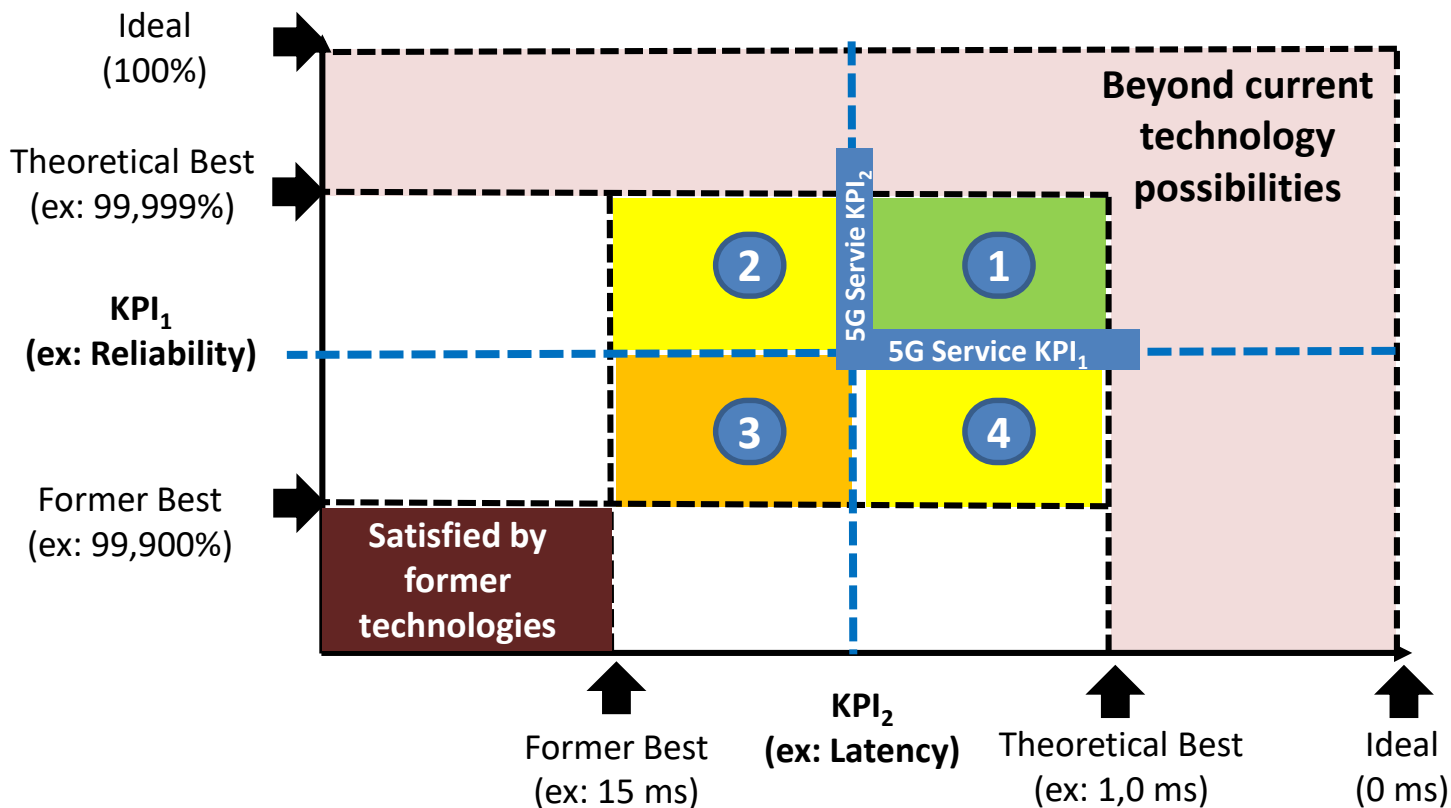
Technology & Limits



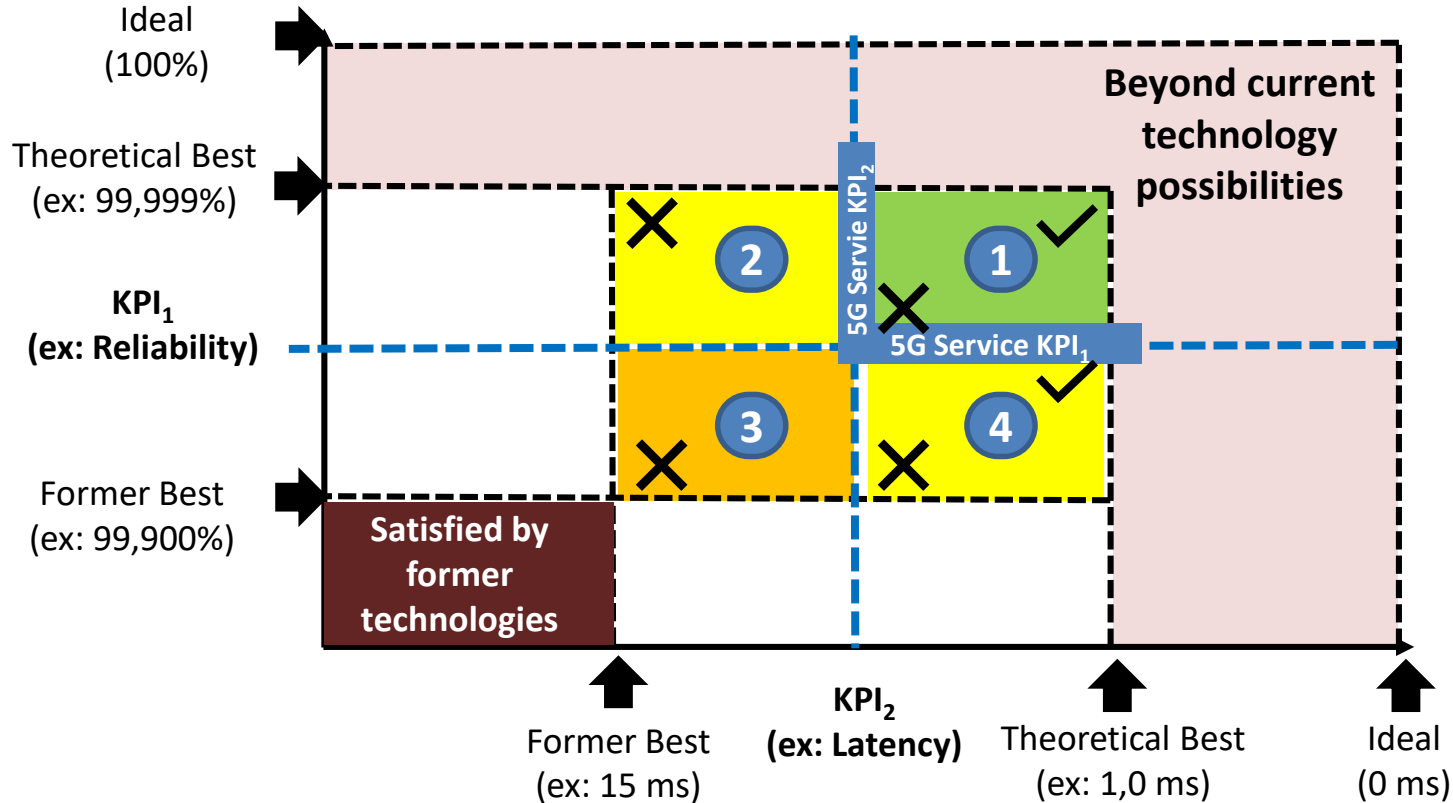
This is an a priori V.KPI model



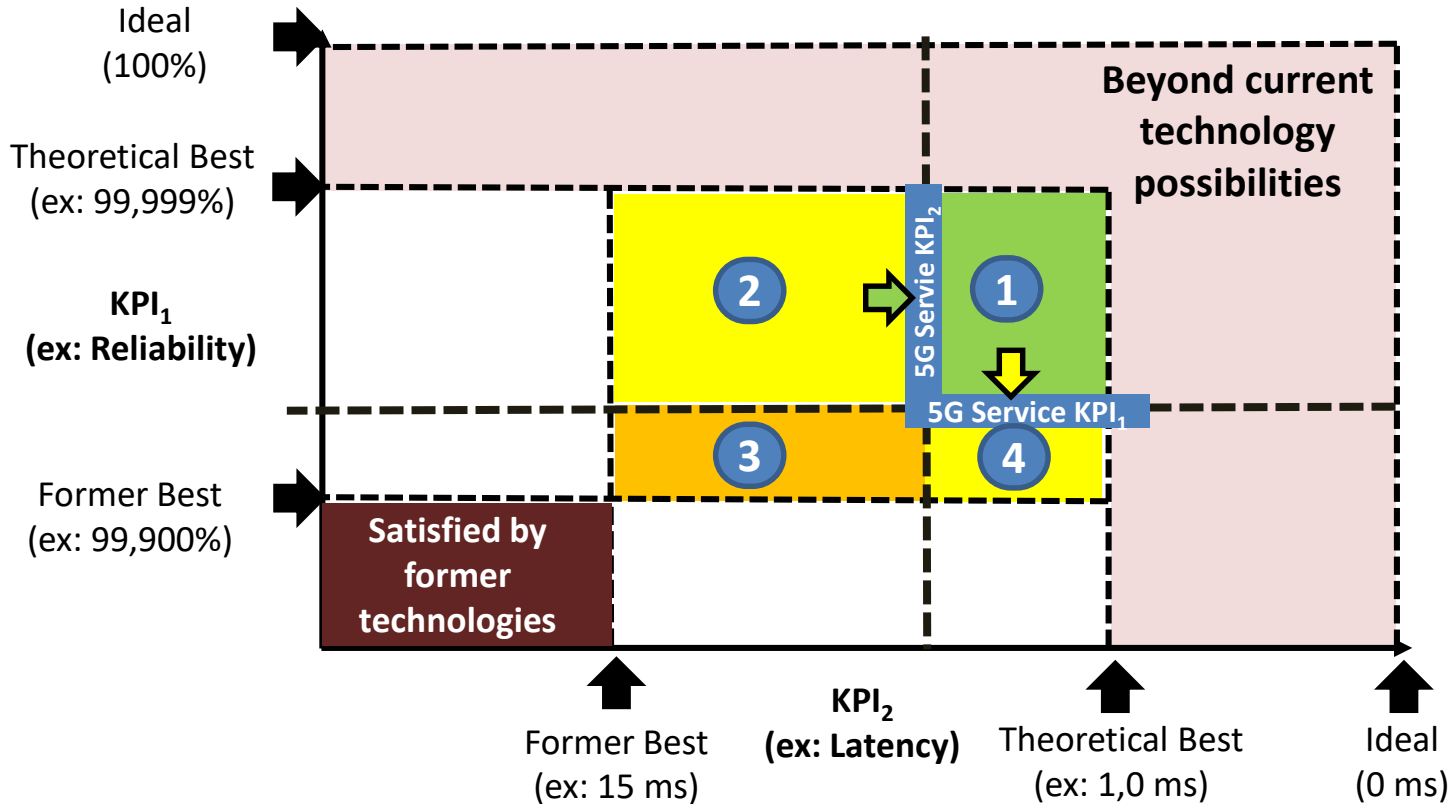
Data Collection Scenarios



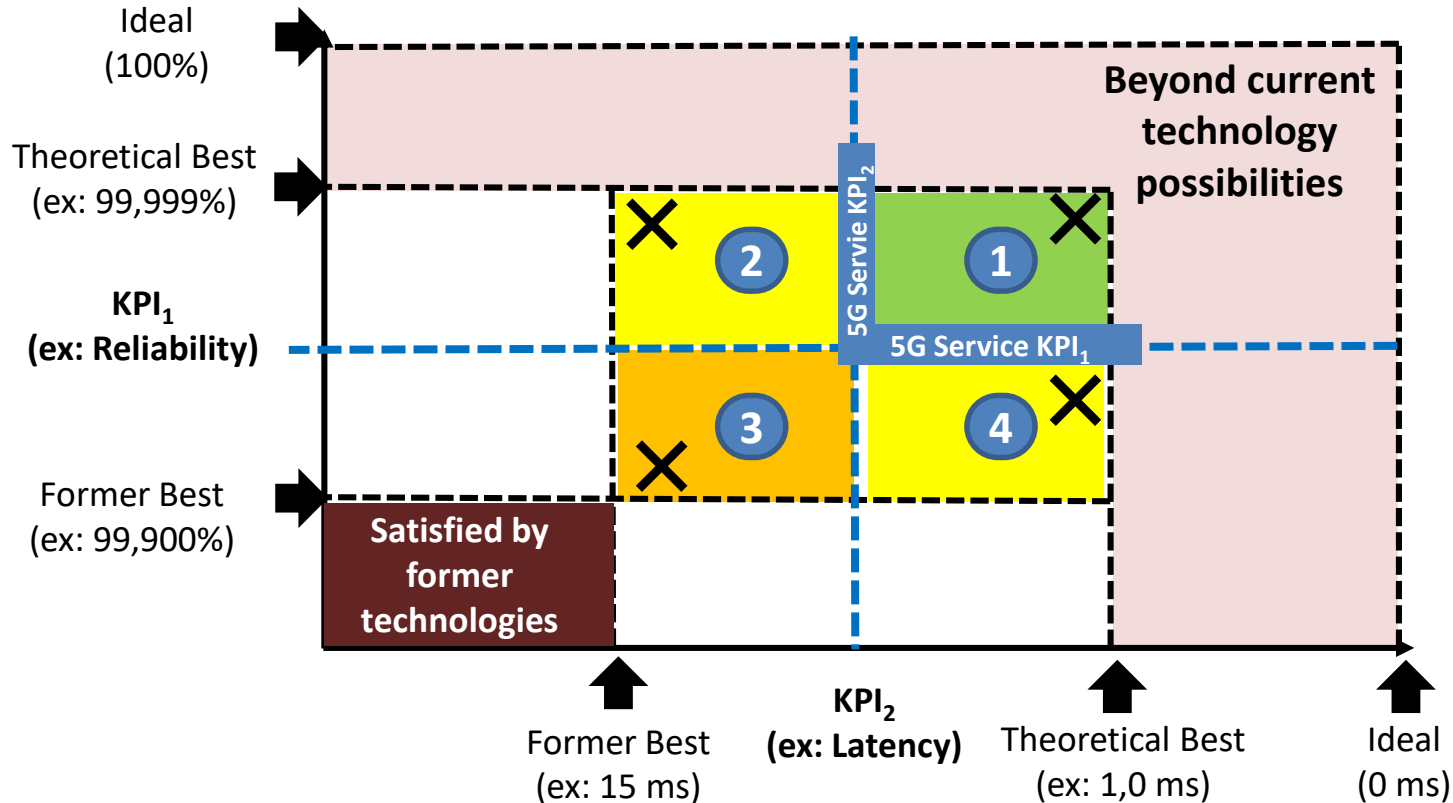
By collecting vertical KPI data ...



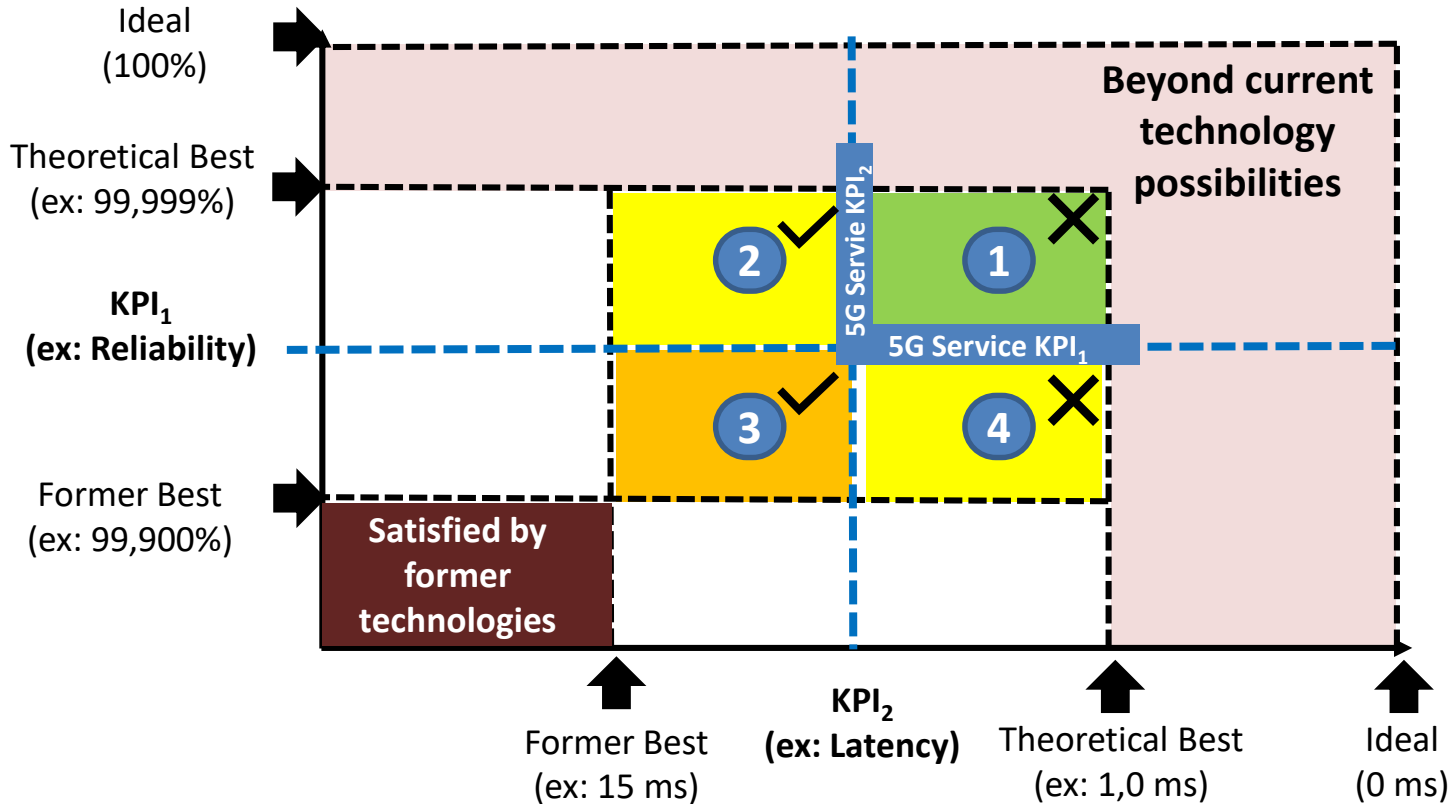
.. we can tune our a priori model







Buit it could be worse!



It could even be inconsistent!



VERTICAL APPLICATION KPI	5G SERVICE KPI-1	5G SERVICE KPI-2	5G SERVICE KPI-3	...
V.KPI-A = <Value>			-	
V.KPI-B = <Value>		-		
V.KPI-C = <Value>	-	-	-	
...				

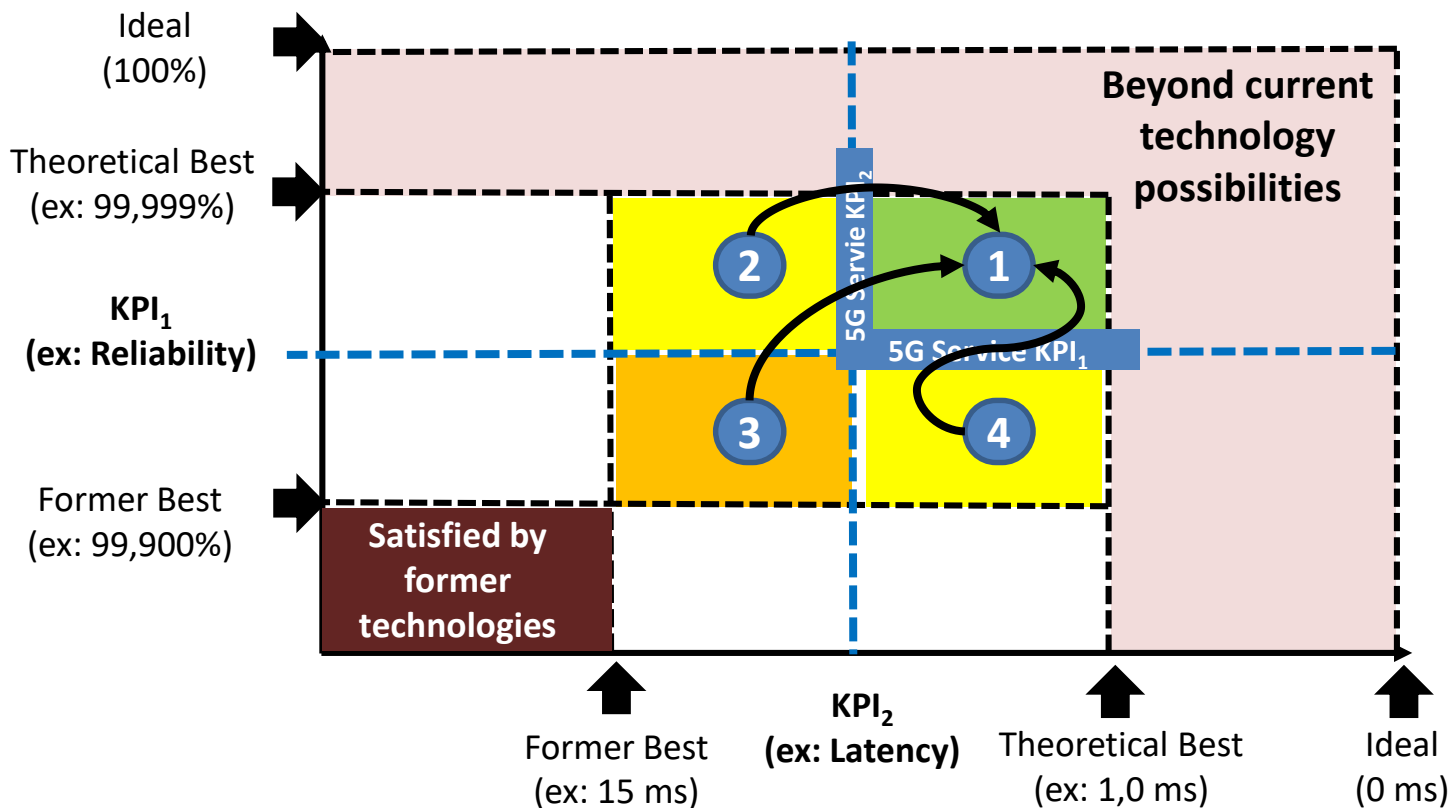
- It's all about data analysis mixing Both V-KPIs and C.KPIs involved in the experimentation
- The actual V.KPI-vs-C.KPI model is an OUTPUT of the validation process (rather than an input)
- The range of 5G Core KPIs supporting the V-KPI expected levels allows to select the 5G network technology and configurations enabling it.

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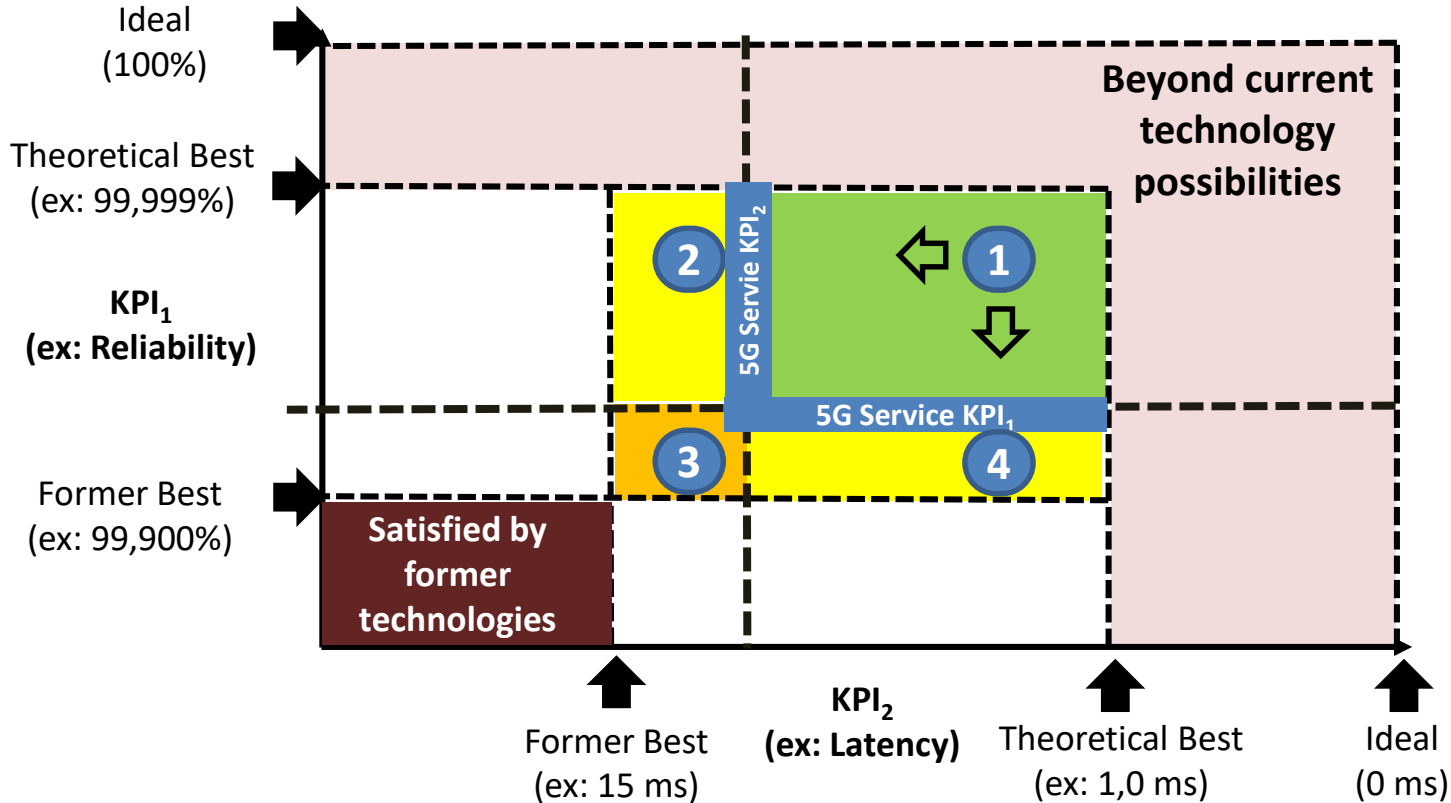
Anything else?

- Yes,
 - Additionally we could tune, if deemed necessary towards further eventual tests,
 - Mobile Network
 - Technology
 - Configurations
 - Vertical SW application
 - Design
 - Deployment model
 - and re-start the cycle

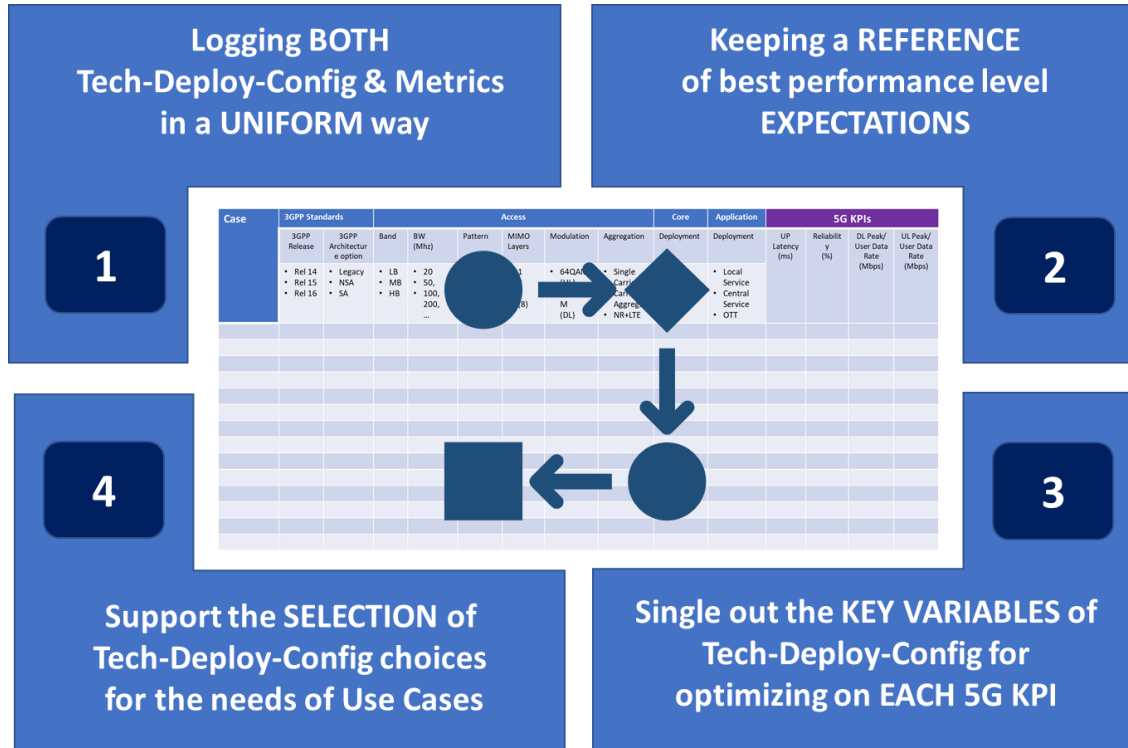
Tuning of NW configuration



Tuning of Vertical application



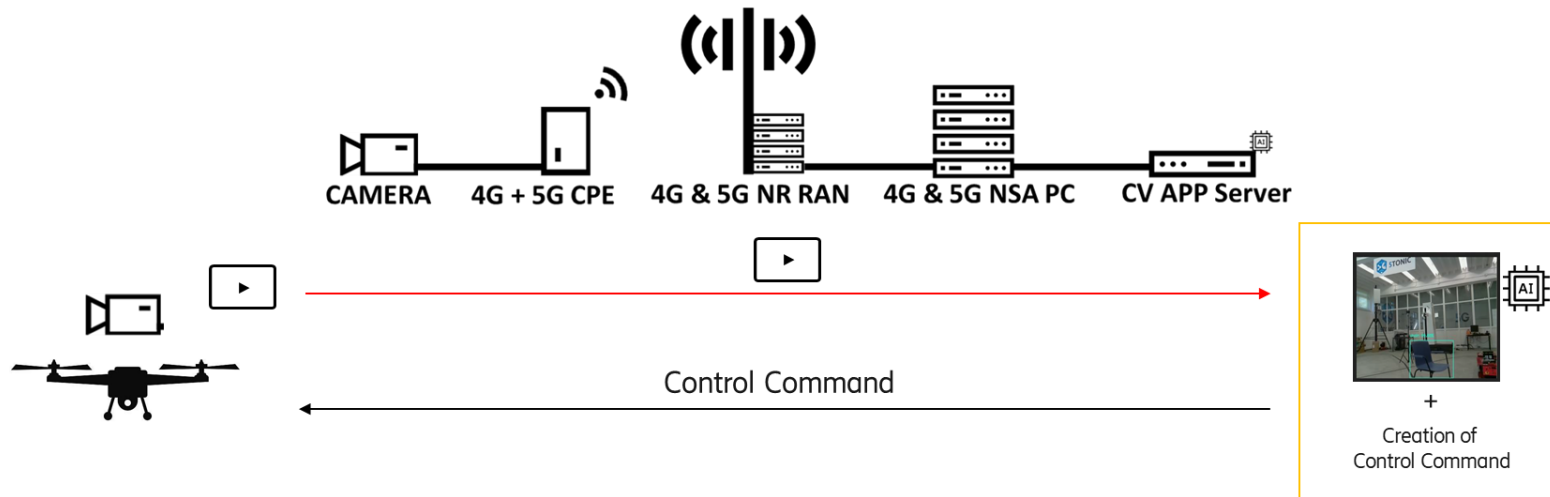
What does it take?



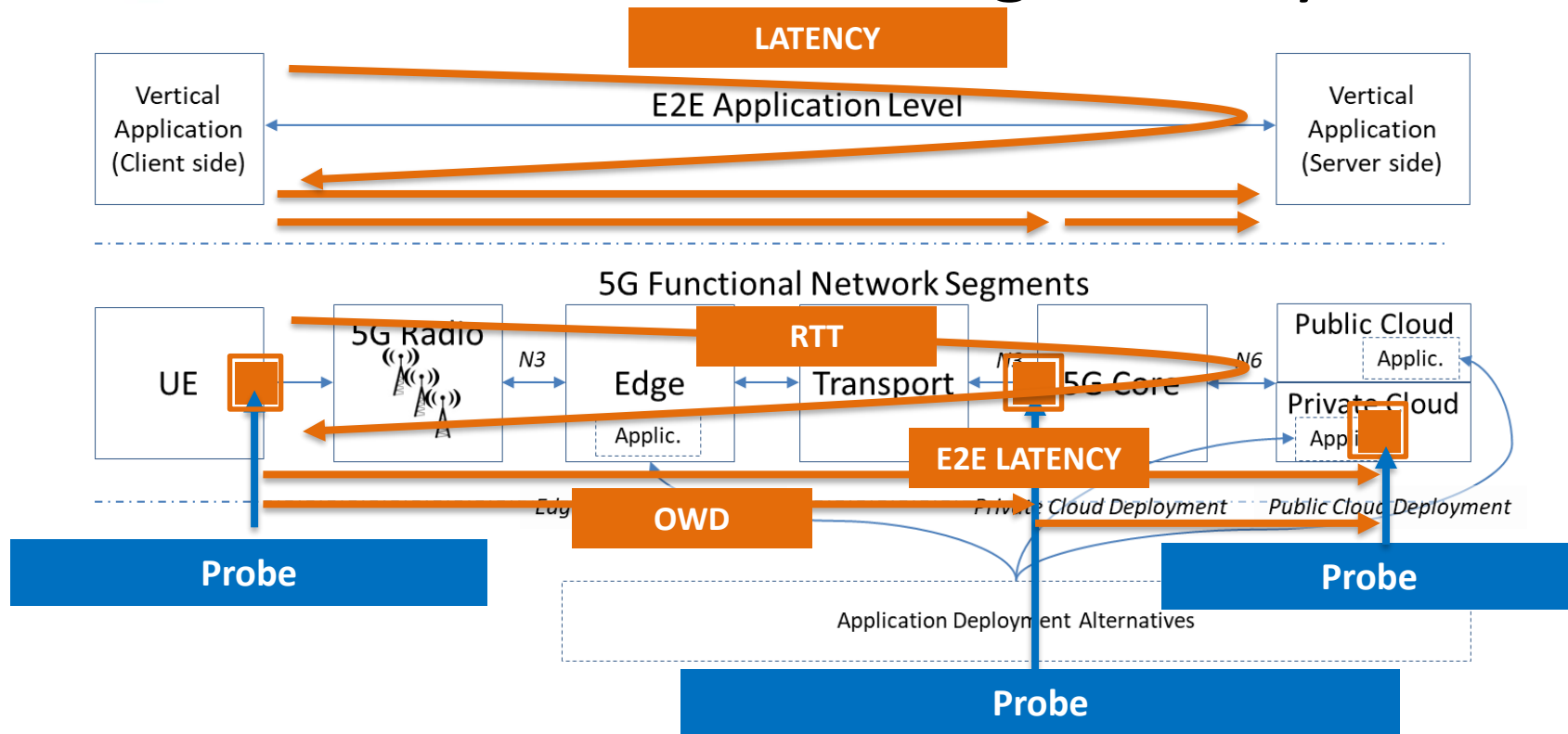
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Application Case – 5G EVE

- Evaluate the feasibility of Computer Vision with image recognition UCs in 5G.
 - Comparison with 4G & possible scenarios

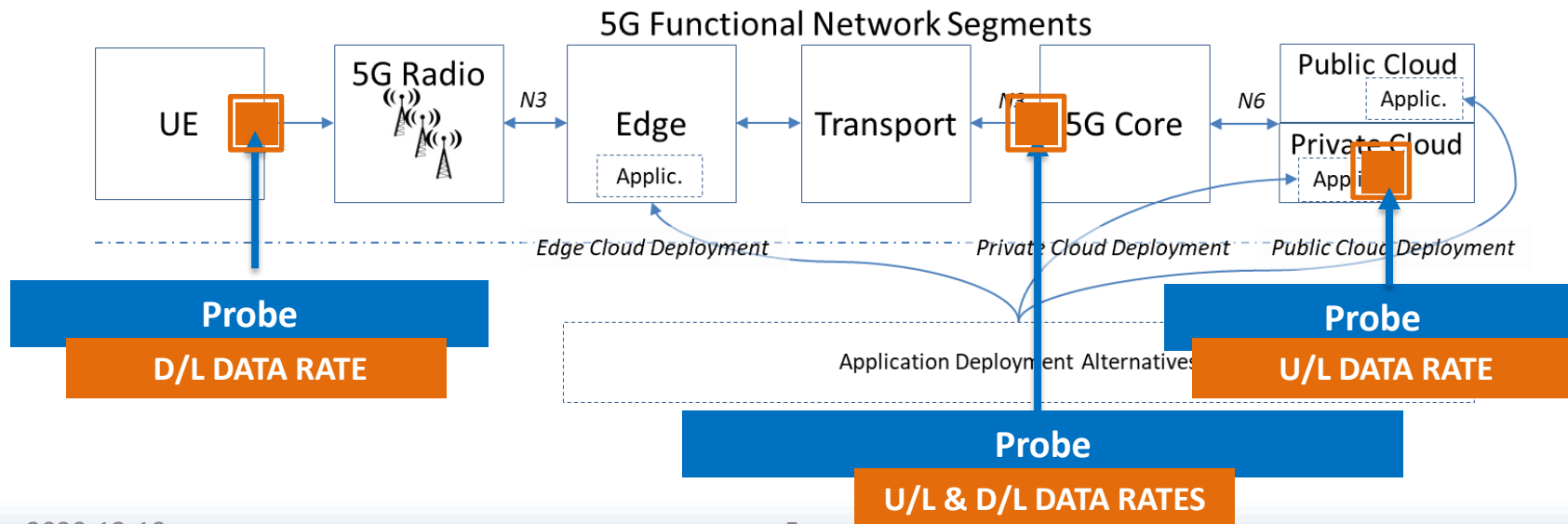
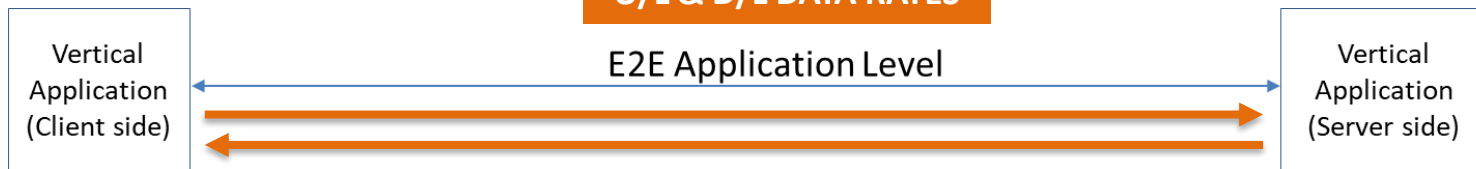


Monitoring Latency



Monitoring Data Rate

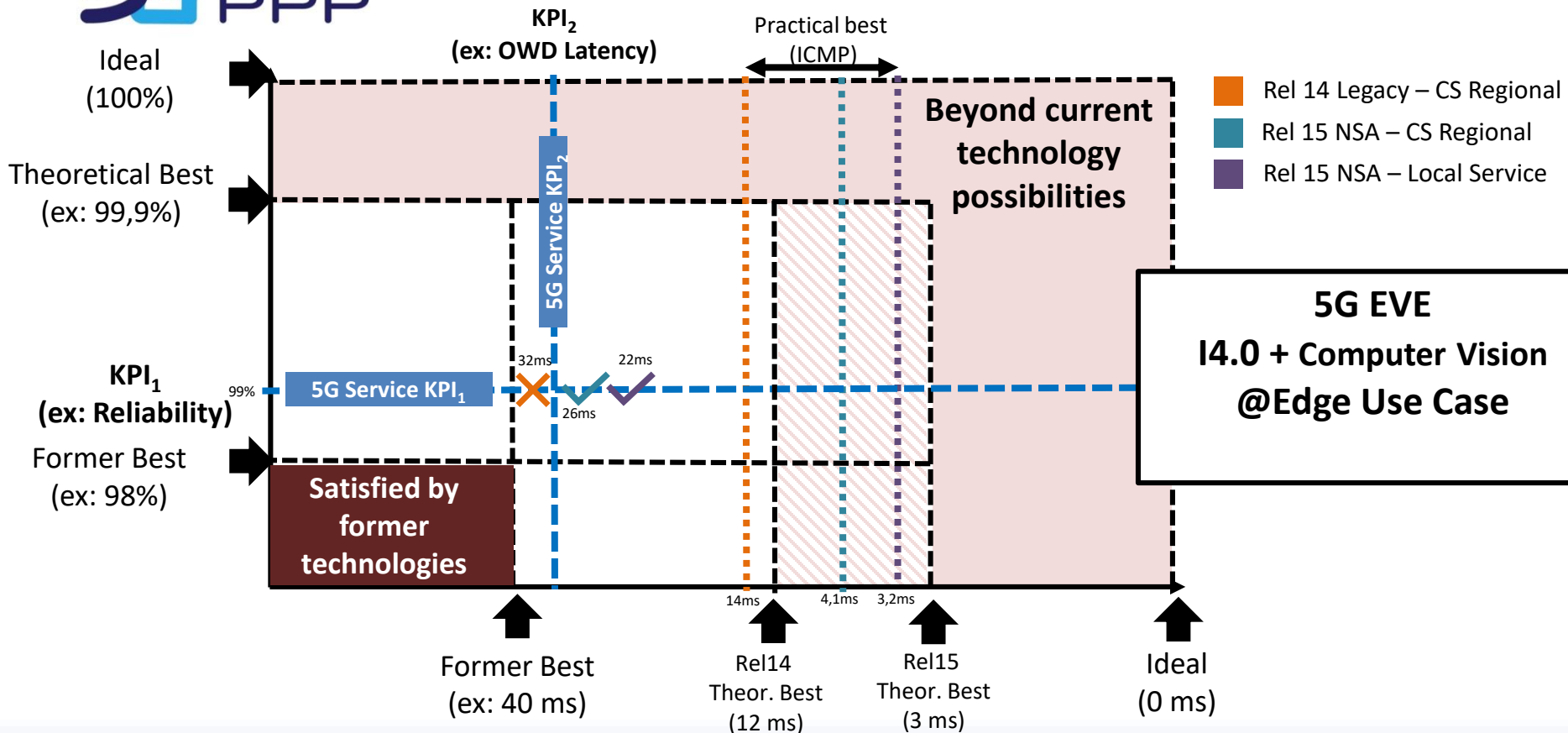
U/L & D/L DATA RATES

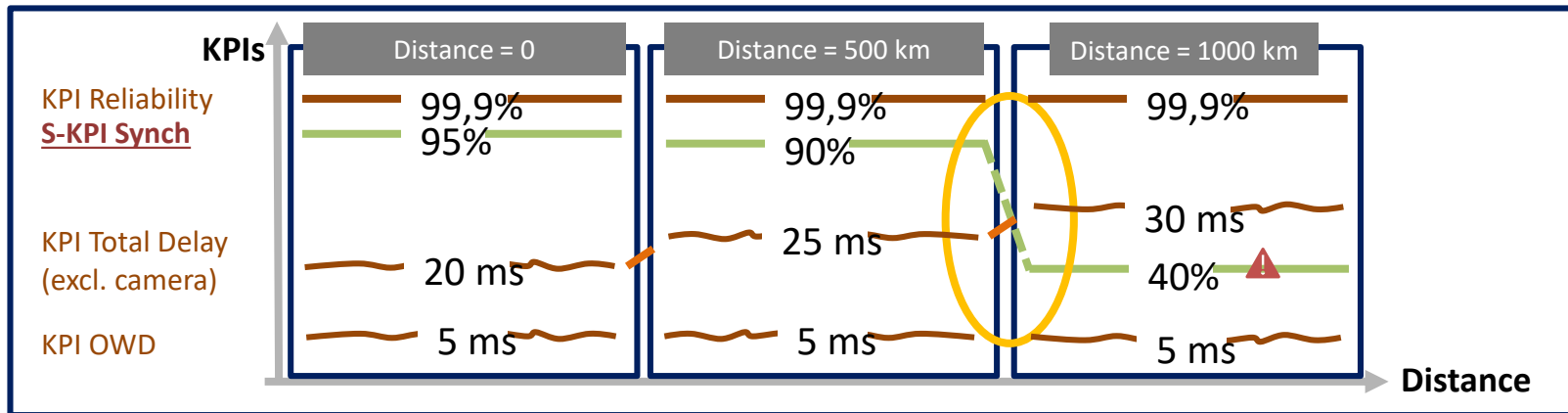
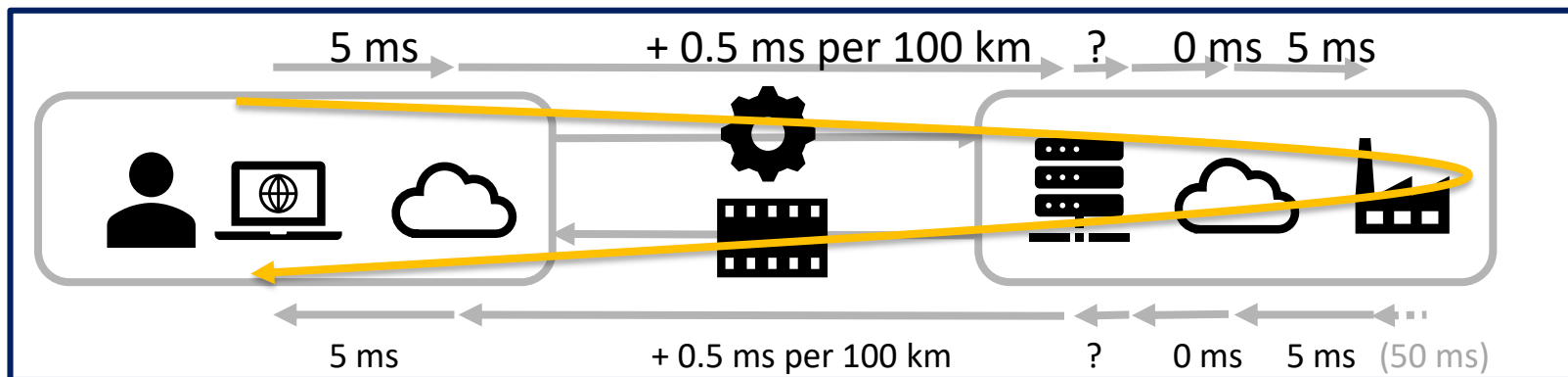


Case	3GPP Standards		Access						Core	Application	5G KPIs			
5G EVE I4.0 + Computer Vision @Edge Use Case	3GPP Release	3GPP Architecture option	Band	BW (MHz)	Pattern	MIMO Layers	Modulation	Aggregation	Deployment	Deployment	UP Latency (ms)	Reliability (%)	UL Peak/ User Data Rate (Mbps)	
	• Rel 14	• Legacy	• LB	• 20	• FDD	• 1	• 256QAM (DL)	• Single Carrier	• Edge	• Local Service				
	• Rel 15	• NSA	• M	• 50,	• 4:1	• 2	• 64QAM (UL)	• Carrier Aggreg.	• Central	• Central Service				
	• Rel 16	• SA	• B	• 100, 200, ...	• 7:3	• 4		• NR+LTE		• OTT				
Exp#1: 2020-09-21 UC-1	Rel 15	NSA	MB	50MHz	• 7:3	4 DL / 1 UL	256QAM DL / 64QAM UL	Single Carrier	Edge	Local Service (Edge)	• 3.8ms OWD E2E ICMP	99% (RTT=9ms)		
Exp#1: 2020-09-21 UC-1	Rel 15	NSA	MB	50MHz	• 7:3	4 DL / 1 UL	256QAM DL / 64QAM UL	Single Carrier	Edge	Central Service	• 4.1ms OWD ICMP	99% • RTT=10.5ms		
Exp#2: 2020-10-05 UC-1	Rel 15	NSA	MB	50MHz	• 7:3	4 DL / 1 UL	256QAM DL / 64QAM UL	Single Carrier	Edge	Local Service (Edge)	• 22ms E2E OWD TCP User Traffic	99% (RTT=32ms)	• 40Mbps TCP HD video streaming	
Exp#2: 2020-10-05 UC-1	Rel 15	NSA	MB	50MHz	• 7:3	4 DL / 1 UL	256QAM DL / 64QAM UL	Single Carrier	Edge	Central Service	• 26ms E2E OWD TCP User Traffic	99% • RTT=34ms		
Exp#3: 2020-10-05 UC-1	Rel 15	NSA	MB	50MHz	• 7:3	4 DL / 1 UL	256QAM DL / 64QAM UL	Single Carrier	Edge	Local Service (Edge -> Application)			• 54Mbps Iperf3 UDP	

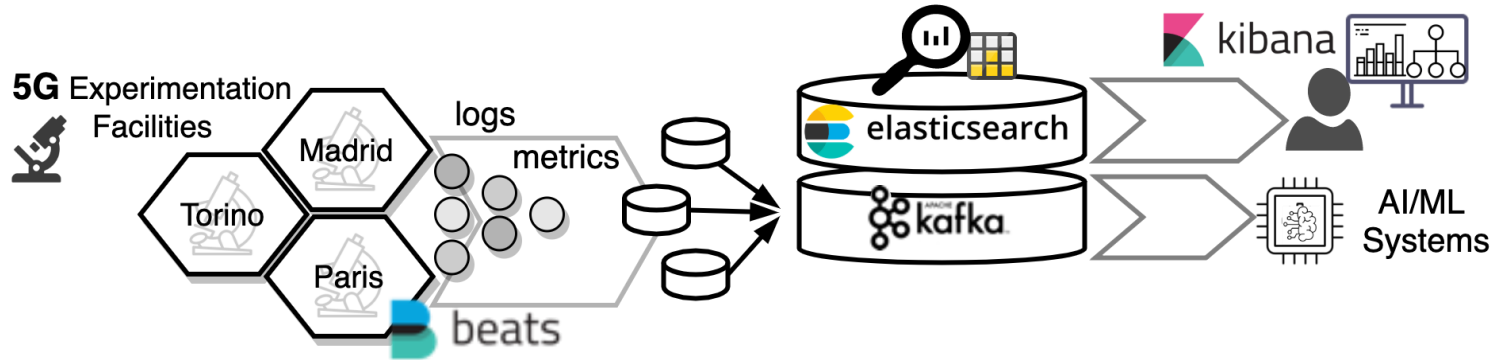
Case	3GPP Standards		Access						Core	Application	5G KPIs		
	3GPP Release	3GPP Architecture option	Band	BW (MHz)	Pattern	MIMO Layers	Modulation	Aggregation	Deployment	Deployment	UP Latency (ms) E2E	DL Peak/ User Data Rate (Mbps)	UL Peak/ User Data Rate (Mbps)
	• Rel 14 • Rel 15 • Rel 16	• Legacy • NSA • SA	• LB • MB • HB	• 20 • 50, • 100, • 200, • ...	• FDD • 4:1 • 7:3	• 1 • 2 • 4 • (8)	• 256QAM (DL) • 64QAM (UL)	• Single Carrier • Carrier Aggreg. • NR+LTE	• Edge • Central	• Local Service • Central Service • OTT			
MAX THEORETICAL KPI VALUES	Rel 14	Legacy	MB	20MHz	• FDD	2 DL / 1 UL	256QAM DL / 64QAM UL	Single Carrier	Edge	Local	• 12ms • 12ms	• 195 Mbps TCP	• 75 Mbps TCP
	Rel 15	NSA	MB	50MHz	• 4:1 • 7:3	4 DL / 1 UL	256QAM DL / 64QAM UL	Single Carrier	Edge	Local	• 6ms • 5ms	• 776 Mbps • 660 Mbps TCP	• 41 Mbps • 63 Mbps TCP
	Rel 15	NSA	MB	100MHz	• 4:1 • 7:3	4 DL / 1 UL	256QAM DL / 64QAM UL	Single Carrier	Edge	Local	• 6ms • 5ms	• 1600 Mbps • 1350 Mbps TCP	• 86 Mbps • 130 Mbps TCP
	Rel 15	NSA	MB	50MHz	• 4:1 • 7:3	4 DL / 1 UL	256QAM DL / 64QAM UL	Downlink NR (50MHz) + LTE (20MHz)	Edge	Local	• 12ms • 11ms	• 950 Mbps • 810 Mbps TCP	• 41 Mbps • 63 Mbps TCP
	Rel 15	NSA	MB	50MHz	• 4:1 • 7:3	4 DL / 1 UL	256QAM DL / 64QAM UL	Uplink NR (50MHz) + LTE (20MHz)	Edge	Local	• 12ms • 11ms	• 776 Mbps • 660 Mbps TCP	• 100Mbps • 120Mbps TCP
	Rel 15	NSA	MB	50MHz	• 4:1 • 7:3	4 DL / 1 UL	256QAM DL / 64QAM UL	Downl Carrier Aggregation (50MHz + 20MHz)	Edge	Local	• 7ms • 6ms	• 1050 Mbps • 860 Mbps TCP	• 41 Mbps • 63 Mbps TCP
	Rel 15	NSA	HB	100MHz	• 4:1 • 7:3	4 DL / 1 UL	256QAM DL / 64QAM UL	Single Carrier	Edge	Local	• 3ms	• 1470 Mbps • 1160 Mbps TCP	• 50 Mbps • 82 Mbps TCP
	Rel 15	NSA	HB	400MHz	• 4:1 • 7:3	4 DL / 1 UL	256QAM DL / 64QAM UL	Single Carrier	Edge	Local	• 3ms	• 5900 Mbps • 4630 Mbps TCP	• 200Mbps • 330Mbps TCP
	Rel 15	NSA	HB	100MHz	• 4:1 • 7:3	4 DL / 1 UL	256QAM DL / 64QAM UL	Downl Carrier Aggregation (100MHz + 100MHz + 100MHz + 100MHz)	Edge	Local	• 3ms	• 5800 Mbps • 4560 Mbps TCP	• 180Mbps • 300Mbps TCP

Real deployment results





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- Common platform to ship, collect, store and visualize the data generated from the experiments.
- Data can be collected at any domain, even inside the vertical applications.
- Seamlessly adapting to the KPI validation framework defined.

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Key Take-Aways

- KPI models are instrumental for proper and formal application validation procedures
- Vertical KPIs can bring objectivity to the validation and support data-driven analysis and decisions
- Iterating KPI models, network technology and configuration choices, and application design and deployment model can prove a fruitful approach

Thank you!

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