Hexa-X

5GPPP TMV WG workshop

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Hexa-X 6G KPIs

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Hexa-X

hexa-x.eu

Hexa-X overview

- Hexa-X is the European flagship research initiative to develop the foundation and contribute to industry consensus leading to 6G

- The focus is on structuring, framing, and developing technology for connectivity needs in the 2030 timeframe

- 25 partners
  - NW vendors
  - Operators
  - Industry
  - Academia
  - SMEs

- Nokia is overall leader

- Ericsson is technical manager

Needed capabilities
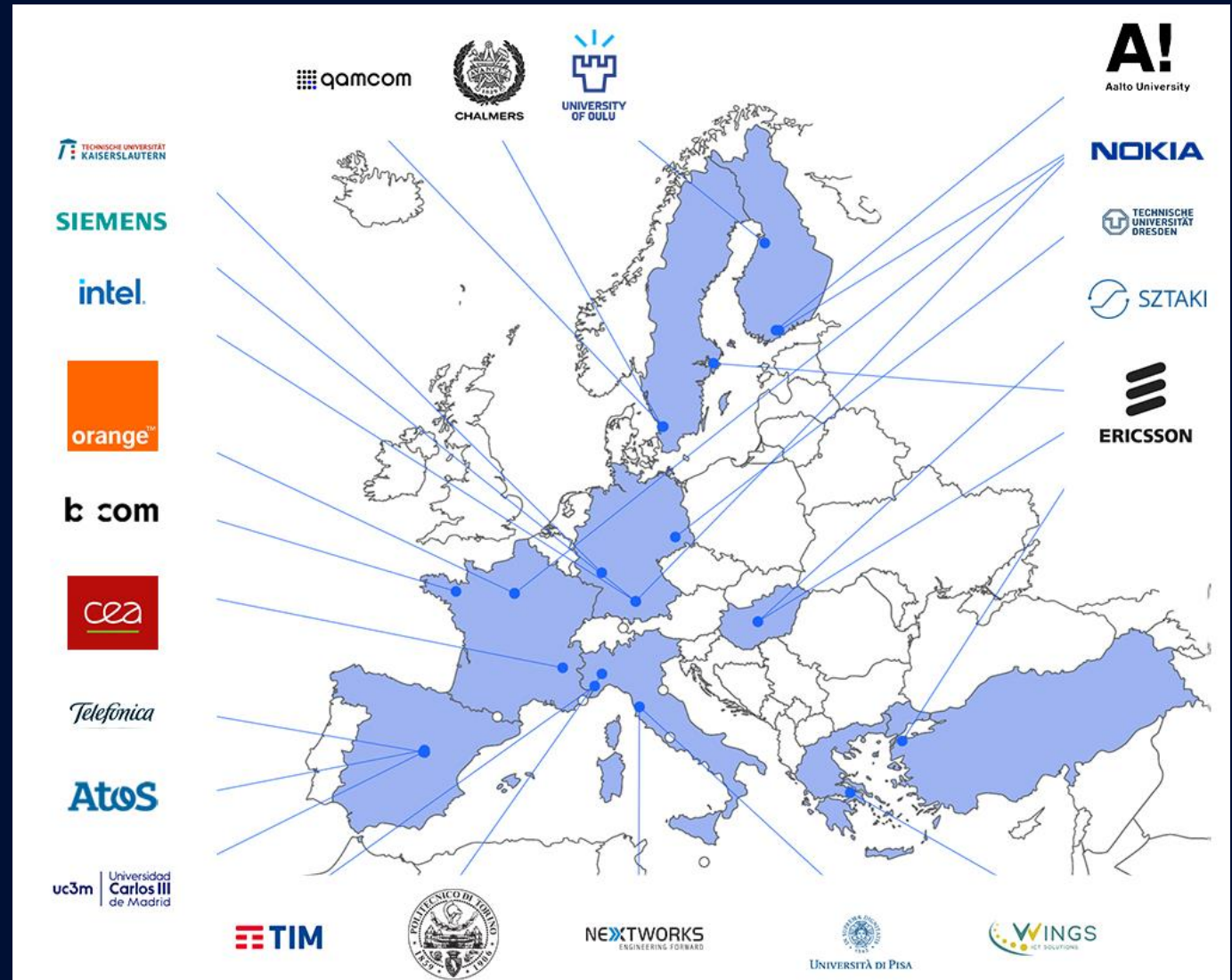
KPIs
extreme evolution
of capabilities

Extended KPIs
- Bit rates
- Connection density
- Traffic capacity
- Location accuracy

Needed capabilities

KPIs
extreme evolution
of capabilities

KPIs
revolution of new
E2E measures

E2E KPIs
- NW energy efficiency
- Dependability
- Coverage
- Service availability

Needed capabilities

KPIs
extreme evolution
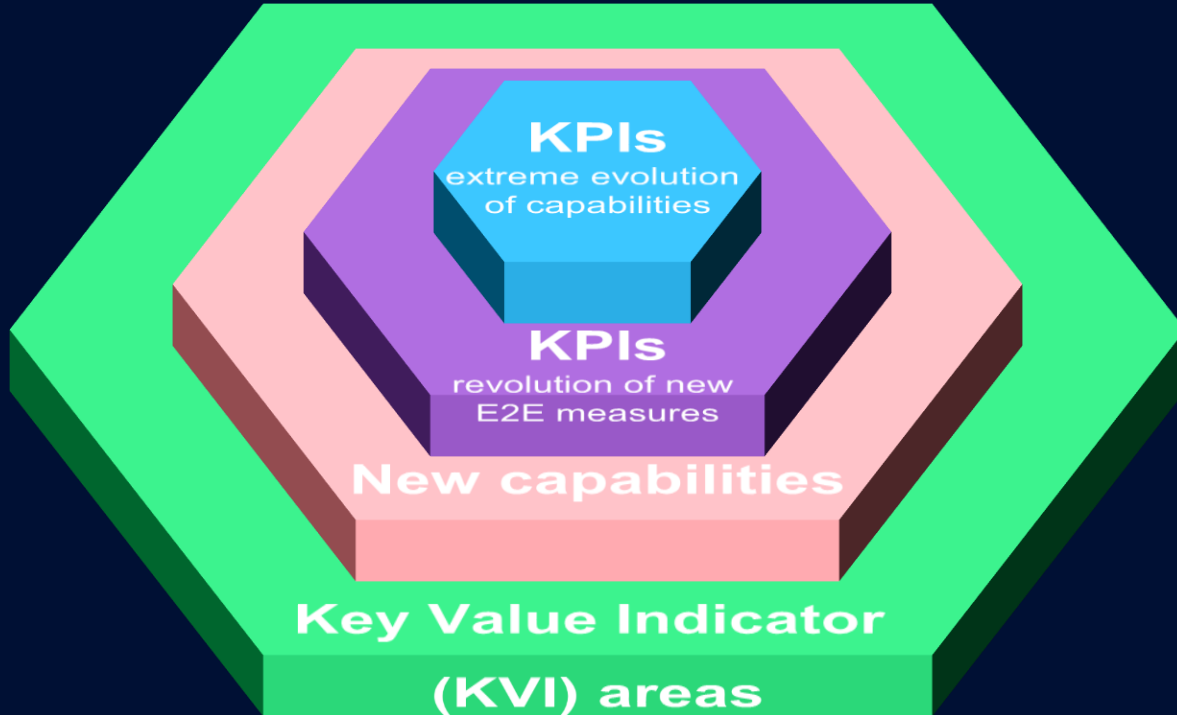of capabilities

KPIs
revolution of new
E2E measures

New capabilities

New capabilities
- Integrated sensing
- Local compute
- Ubiquitous AI
- Embedded devices

Needed capabilities

KVIs:
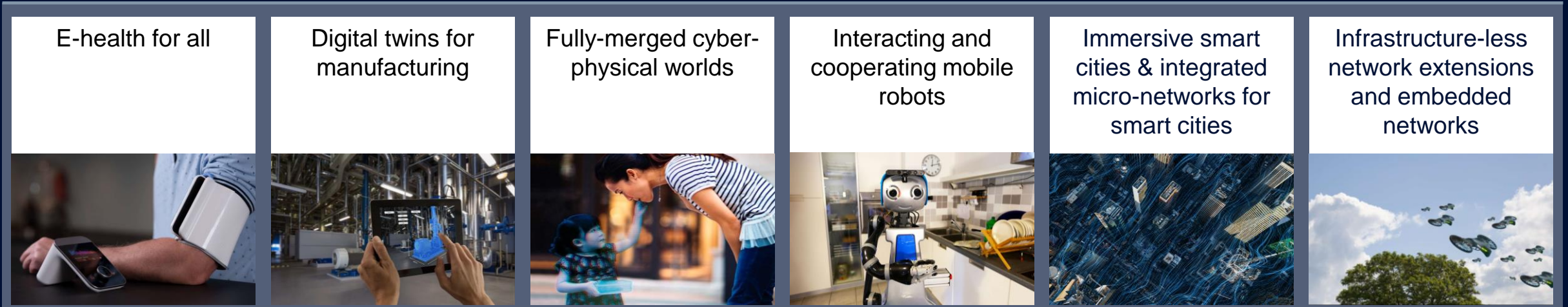- Sustainable 6G
- 6G for sustainability
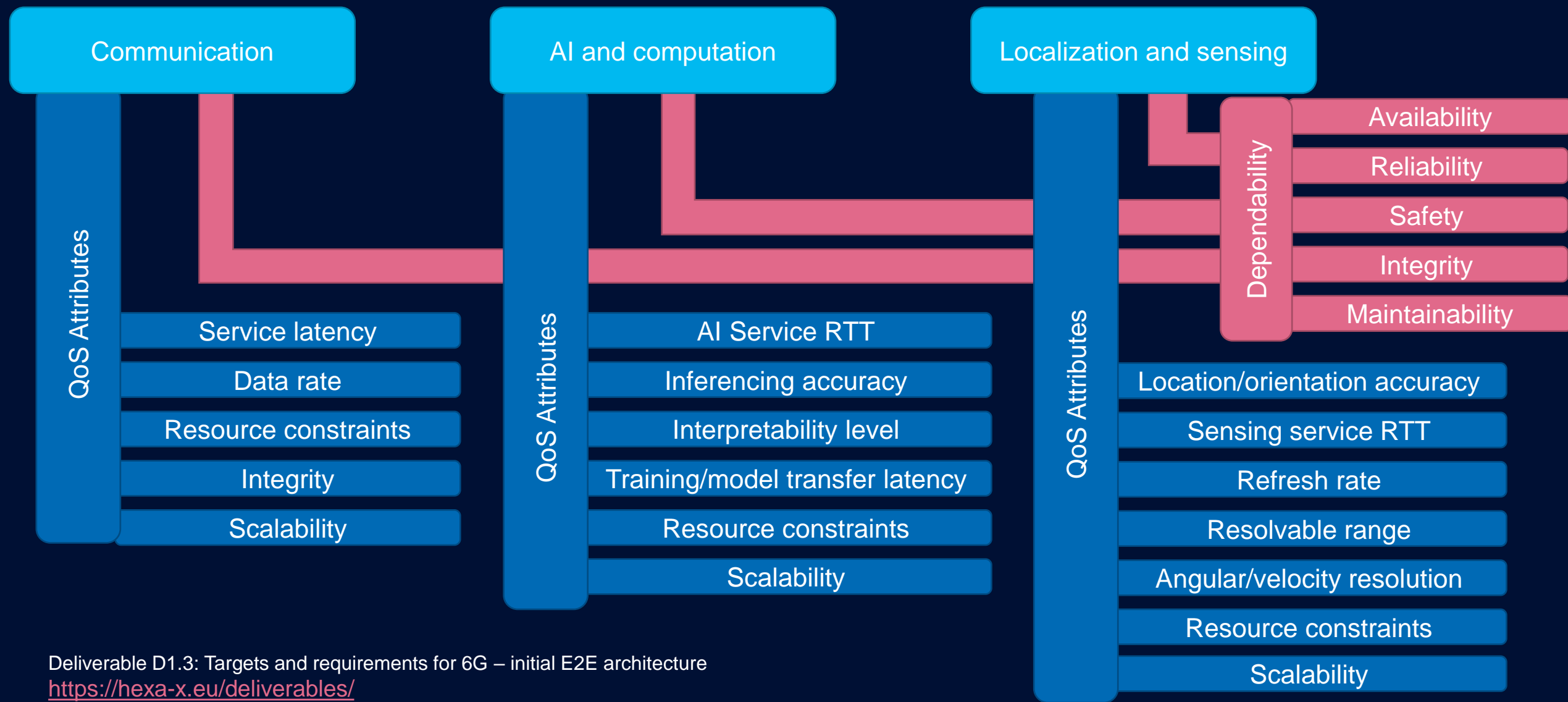- Trustworthiness
- Digital inclusion

Use cases

6G use case families

Enabling Sustainability	Massive twinning	Telepresence	Robots to cobots	Trusted embedded networks	Hyperconnected resilient network infrastructure

Representative use cases

E-health for all	Digital twins for manufacturing	Fully-merged cyber-physical worlds	Interacting and cooperating mobile robots	Immersive smart cities & integrated micro-networks for smart cities	Infrastructure-less network extensions and embedded networks

KPI structure

Communication

AI and computation

Localization and sensing

Dependability
- Availability
- Reliability
- Safety
- Integrity
- Maintainability

QoS Attributes (Communication)
- Service latency
- Data rate
- Resource constraints
- Integrity
- Scalability

QoS Attributes (AI and computation)
- AI Service RTT
- Inferencing accuracy
- Interpretability level
- Training/model transfer latency
- Resource constraints
- Scalability

QoS Attributes (Localization and sensing)
- Location/orientation accuracy
- Sensing service RTT
- Refresh rate
- Resolvable range
- Angular/velocity resolution
- Resource constraints
- Scalability

Deliverable D1.3: Targets and requirements for 6G – initial E2E architecture
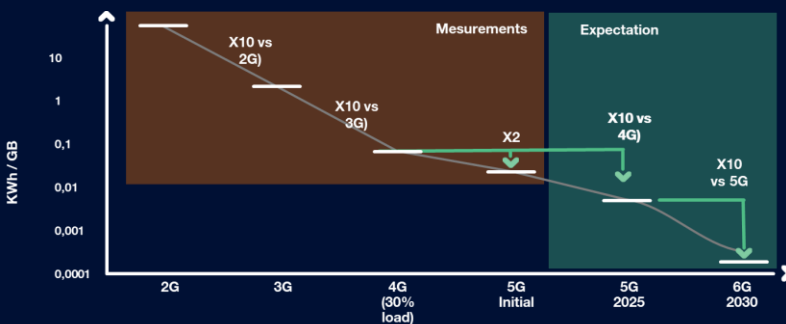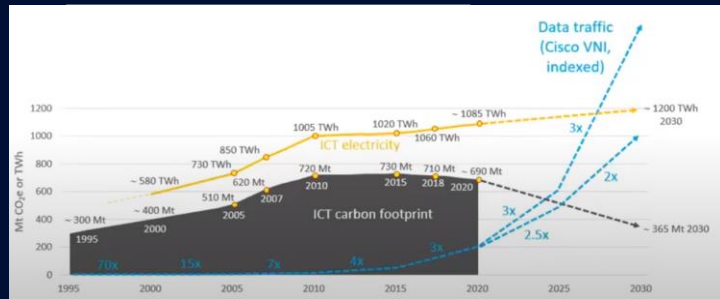https://hexa-x.eu/deliverables/

Hexa-X

Sustainability targets

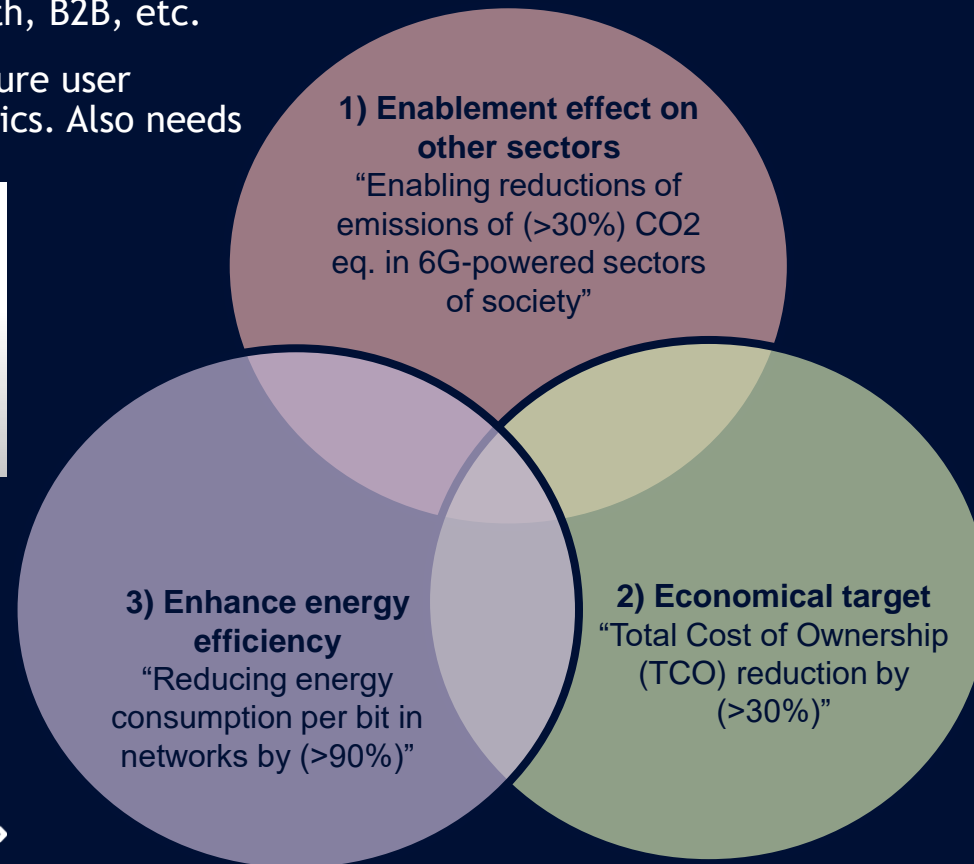Baseline will be a scenario without 6G applied

Define use cases with opportunities for decarbonization improvements in e.g., transportation, health, B2B, etc.

Difficulties lies in defining a reasonable future user scenario and define proper evaluation metrics. Also needs to consider rebound effects
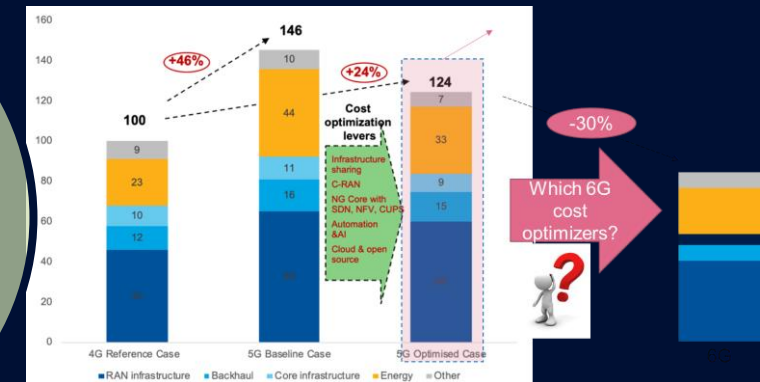
Baseline will be 5G NR SA with 5GC

Consider methodology from GSMA work on 5G TCO with:

- Cost drivers (traffic growth, spectrum, …)

- Cost accelerators (Densification, energy consumption …)

- Cost optimizers (SBA, automation, AI, cloud)

1) Enablement effect on other sectors
"Enabling reductions of emissions of (>30%) CO_2 eq. in 6G-powered sectors of society"

2) Economical target
"Total Cost of Ownership (TCO) reduction by (>30%)"

3) Enhance energy efficiency
"Reducing energy consumption per bit in networks by (>90%)"

Baseline will be 5G NR SA with 5GC

Evaluate current energy models considering future technologies, e.g., employing novel hardware and technologies

Radio targets

Initial estimations of latencies
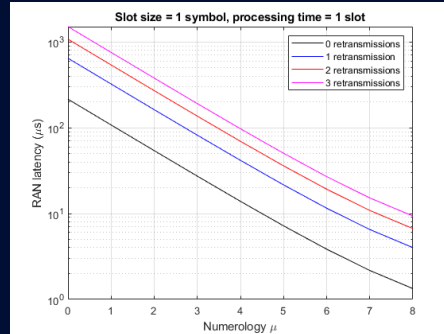
SCS>480 kHz, Maximum BW 1.96 GHz
→ <0.1 ms RAN latency

Deployment specific
e.g., edge-deployed cloud CN in factory setting

(<0.1 ms) RAN latency

(>0.1 Tbps) achievable rate for access

(<1 ms) bounded E2E latency;
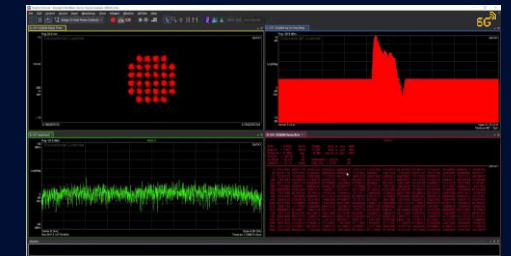
(<1 cm) positioning precision
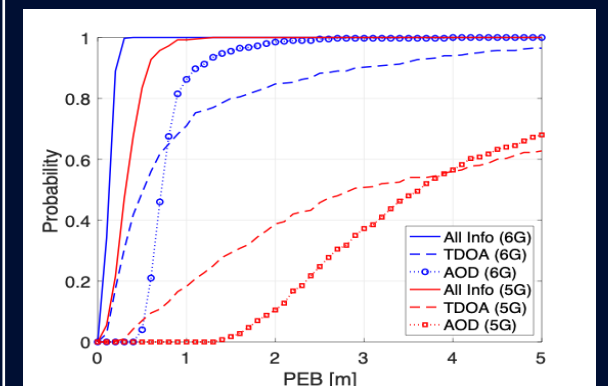
Required bandwidth
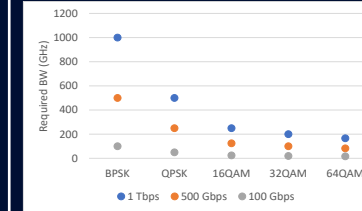
Power consumption model:

Initial demo results

## Localization in outdoor Urban micro cell

Flexible networks targets

Access links supporting simultaneous high rate and low E2E latency (>0.1 Tbps @ <1 ms E2E).

X μs   Y μs   Z μs   1μs   40 μs   A μs

Radio: 100 μs   Fiber: 166 μs + OEO: 31μs

UE   RU   DU   CU   Eth Switch   UPF   Server

Simultaneous bit rate and E2E latency

Global service coverage

Abounding connected devices

MEA$_s$ = 30, MEA$_f$ = 20, h = 600 km

MEA$_s$ = 30, MEA$_f$ = 20, h = 600 km, 1 hops above 400 km
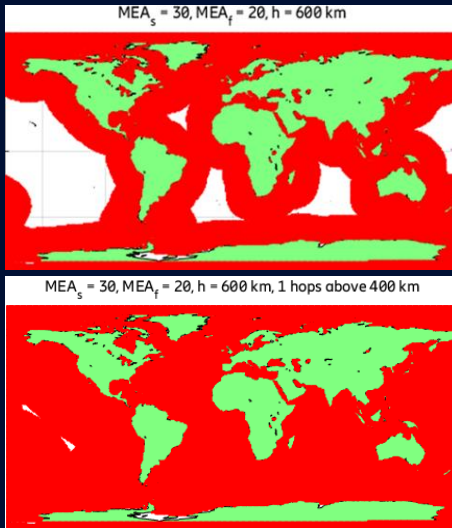
(>99%) of global population reached with (>1 Mbps) data rates at sustainable cost levels; Full coverage (100%) of world area

Ad-hoc NW control

Node discovery

Enforcement

Data ingestion

NTN

MiniPCs as edge servers

Data Centers

D2D/Mesh

Edge

Small cell (indoor-outdoor)

Macro cells

USRPs as BSs

Core

No cell (computations)
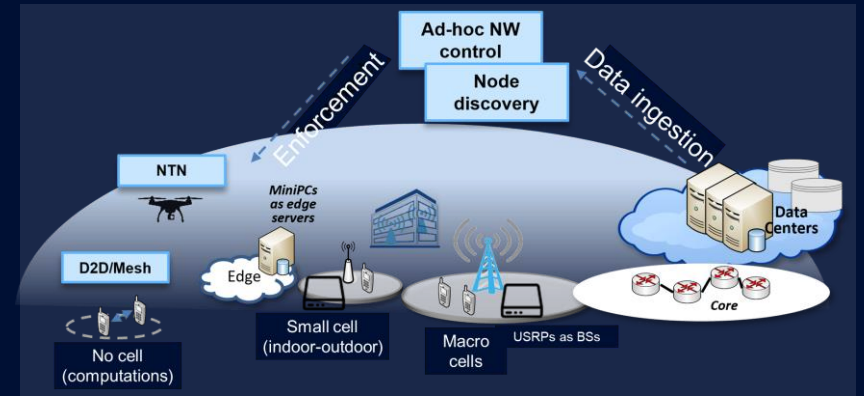
Supporting (>100 bn) connected devices in the network

AI for PHY targets

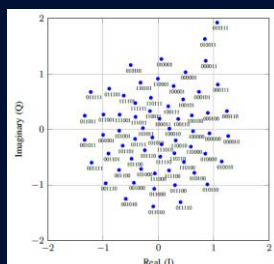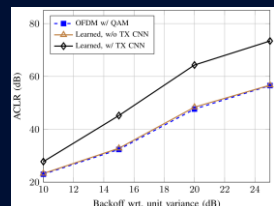Increased AI algorithm robustness to system parameter volatility, lower complexity and significant Bit Error Rate (BER)/ BLock-Error Rate (BLER) gain, as compared to classical approaches
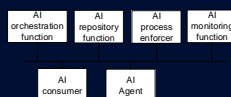
AI PHY level robustness

Constellation shaping

ML based reduction of out-of-bound emission

Predictive orchestration

AIaaS

Large scale distributed AI

Resilient communication and compute network services for distributed AI applications in large scales (e.g., applications with >1000 collaborating AI components

The accuracy of an XAI model within (<10%) of "black box" solutions (e.g., Deep Neural Networks - DNNs)

XAI model accuracy

FED-XAI demo
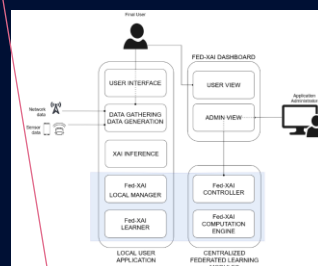
CaaS

Semantic communication
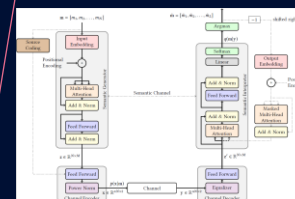
Energy reduction

Energy reduction of a factor of (>10) at the infrastructure level and a factor of (>100) at the user devices' side, as a result of (network & application) workload offloading and learning/inferencing task delegation.

Increased AI algorithm robustness to system parameter volatility, lower complexity and efficient resource utilization and rate gain as compared to classical approaches.

AI RRM robustness

Location based beamforming
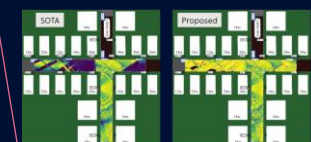
Differentially private FL
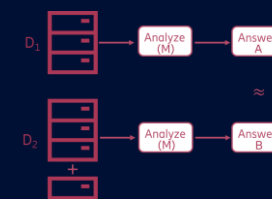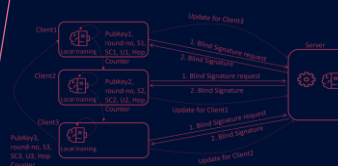
Trustworthy AI

Increased trustworthiness of AI through privacy and security enhancing technologies; using differential privacy to evaluate privacy versus communication utility trade-off

Intelligent orchestration targets

Network reconfiguration (creation, composition and scaling times) is performed by (>10%) of the prediction horizon

Network reconfiguration

Demonstrator #5 "Data-driven device-edge-cloud continuum management" started in M16
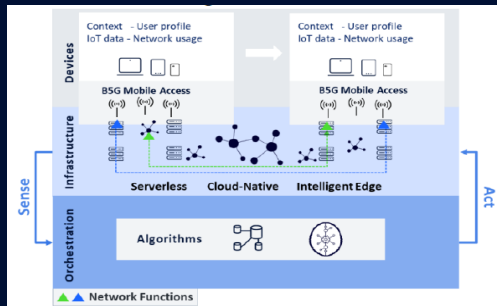
Scenario dependent
- Only instantiation
- Configuration + deletion

Resource onboarding

Improvement by (>90%) in time to onboard new resources from other domains and manage the addition/removal elements from the network

Increase the service continuity by reducing the downtime by (>80%)

Service continuity

Consideration of Mean-time-to-recovery (MTTR) and Availability (x-nines) using 5G as baseline Improvements based on integrating intelligence and improving flexibiltiy
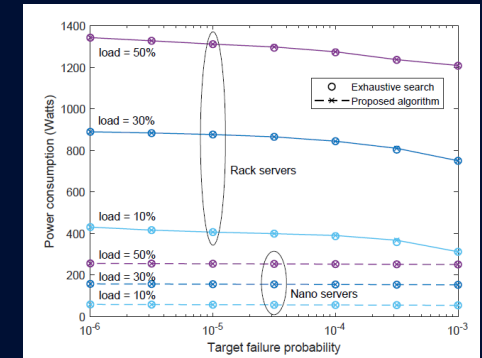
Predicting servers' usage demand allowing servers to be shut off when not needed

Network energy efficiency

Increase network energy efficiency by (>50%) applying predictive orchestration.

Thank you!

HEXA-X.EU

E-health for all

		KPI	Target value	Reasoning / References
Communication	Dependability Attributes	Availability [%]	99.99 – 99.9999	High or ultra-high Emergency The key issue is that the user should expect to have a ubiquitous network access anywhere [ETS20a].
		Reliability [%]	99.999 – 99.999999	High or ultra-high Surgery, Imaging, Emergency
		Safety		Industry-specific regulations apply for human-machine interaction.
		Integrity		Integrity protection and protection against 3rd party usage/modification of data.
		Maintainability		No use-case-specific requirements are known.
	QoS Attributes	Service latency [ms]	0.1 - 100	Depending on the service. Lower latency is required in indoor, robotic-assisted surgery operations. More relaxed requirements in rural, outdoor connections.
		Data rate (minimum expected, desired, maximum) [Mbit/s]	100 kbit/s – 25 Mbit/s	From 100 kbps (sensor data) to 25 Mbit/s (4K video) expected bit rates. Peak bit rates can be much higher for specific applications, e.g., XR remote diagnostics.
		Resource constraints		refer to deployment characteristics (prev. section)
		Scalability		refer to deployment characteristics (prev. section)
AI and computation	Dependability Attributes	Agent availability [%]	N/A	No use-case-specific requirements are known. The expectation is: same as for a communication service. AI services can be provided offline to ease requirements on availability and reliability.
		Agent reliability [%]	99.9999	Expectation. Target value depends on the use of AI in the use case.
		Safety	high	Expectation. Target value depends on the use of AI in the use case.
		Integrity	high	Expectation. Target value depends on the use of AI in the use case.
		Maintainability	high	Expectation. Target value depends on the use of AI in the use case.
	QoS Attributes	AI service RTT [ms]	NA	AI services can be provided offline, utilizing big data analytics. RTT is not an issue. For real-time assistance, latency requirements and additional regulations would apply.
		Inferencing accuracy [%]	99.999	Health-related decisions do not tolerate faults. Requirements might be more stringent for real-time decision-making and assistance functions.
		Interpretability level	high	Increased demands due to liability.
		Training/model transfer latency [ms]	N/A	Training can occur offline, no requirements in the use case.
		Resource constraints		refer to deployment characteristics (prev. section)
		Scalability		refer to deployment characteristics (prev. section)
Localisation and Sensing	Dependability Attributes	Service availability [%]	99	Depends on the application at hand. For global coverage aspects, availability might be lower than for remote surgery applications.
		Service reliability [%]	99.999	Health data is highly sensitive, and its reliability requirements are very high
		Safety		SAR limits
		Integrity	99.999	Highly sensitive health data needs to be protected and secured against modification.
		Maintainability	N/A	No use-case-specific requirements are known.
	QoS Attributes	Location accuracy [m]	0.001 - 1	Global coverage option is not prone to high accuracy requirements. On the other hand, assisted surgery requires better than sub-mm accuracy.
		L/S service RTT [ms]		Depends on the application. Rural deployment of basic healthcare service provision has looser requirements than in in-hospital or surgery applications.
		Orientation accuracy [°]		High accuracy requirements might apply for, e.g., assisted surgery. No specific requirements in other aspects of the use case.
		Refresh rate [1/s]		Depends on the application. Basic vital sign measurement does not need a high refresh rate. However, surgical robots require higher rates.
		Minimum and maximum resolvable range [m]	0.0001 - 1000	Depends on the application and service.
		Angular resolution [°]		Depends on the application.
		Velocity range [m/s]		Expected to be small. No use-case-specific requirements.
		Velocity resolution [m/s]		Expected to be small. No use-case-specific requirements.
		Resource constraints		refer to deployment characteristics (prev. section)
		Scalability		refer to deployment characteristics (prev. section)

Digital twins for manufacturing

		KPI	Target value	Reasoning / References
Communication	**Dependability Attributes**	Availability [%]	99.99 –99.999999	Taken from [22.104]. Higher target value for use-cases such as motion control and lower for use cases such as process and asset monitoring. Exact value depends on the service.
		Reliability [%]	99.9 – 99.999999	Network layer packet reliability [22.261]. Target value depends on the service. Lower reliability for process and asset monitoring and higher reliability for motion control and alarms.
		Safety	Critical	Constraints are set by the underlying use case/application. Critical for use cases involving humans on the factory floor working in close proximity with machines that are controlled by the digital twin.
		Integrity	Critical	Industry-specific norms and regulations apply, e.g., [ISO20] and activities in IEEE, e.g., P2806.1.
		Maintainability	High	Low tolerance to downtime in use cases where the digital twin is essential for maximizing the efficiency of the factory.
	QoS Attributes	Service latency [ms]	0.1 – 100	Depending on the service. Tighter latency requirements for use cases such as motion control. Less stringent latency requirements for use cases such as process and asset monitoring. Both values are taken from [22.104]. Tolerable Jitter is taken as 10% of the targeted service latency.
		Data rate (minimum expected, desired, maximum) [Gbit/s]	Peak: 10 – 100 Average: 1 – 10	[HEX21-D71]
		Resource constraints		refer to deployment characteristics (prev. section)
		Scalability		refer to deployment characteristics (prev. section)
AI and computation	**Dependability Attributes**	Agent availability [%]	99.99 – 99.999999	Same as communication service availability. We do not expect agent availability and reliability requirements to be more stringent than those placed on the communication link.
		Agent reliability [%]	99.9 – 99.999999	Same as for network layer packet reliability.
		Safety	Critical	If a digital twin is utilised for controlling robots, safety constraints for human-machine co-working need to be guaranteed, e.g., [ISO20].
		Integrity	High	
		Maintainability	High	Low tolerance to downtime in use cases where the digital twin is essential for maximising the efficiency of the factory.
	QoS Attributes	AI service RTT [ms]	-	Not different from the QoS of any conventional algorithm. The computations of an AI model for inferencing are deterministic in time.
		Inferencing accuracy [%]	-	Use-case dependent.
		Interpretability level	high	Especially in safety-related applications (e.g., in control applications), the explainability of utilised algorithms is a key requirement.
		Training/model transfer latency [ms]	-	Assuming offline training.
		Resource constraints		refer to deployment characteristics (prev. section)
		Scalability		refer to deployment characteristics (prev. section)
Localisation and Sensing	**Dependability Attributes**	Service availability [%]	99.99	[HEX21-D31]
		Service reliability [%]		No use-case-specific requirements are known.
		Safety	Critical	Constraints are set by the underlying use case/application. Critical for use cases involving both humans and machines on the factory floor.
		Integrity	High	Constraints are set by the underlying use case/application. For robots/ automated guided vehicles (AGVs) operating alongside humans and controlled by a digital twin, location information has to be robust to attacks.
		Maintainability	High	Depends on the service/use case. High when the digital twin is essential for smooth functioning of the factory.
	QoS Attributes	Location accuracy [m]	cm-level	[HEX21-D31]
		L/S service RTT [ms]	10 – 1000	[22.804]
		Orientation accuracy [°]	Yaw: 0.1 – 5 Pitch + roll: 1 - 10	Accuracy of heading (yaw) is more important than pitch and roll in the case of AGVs
		Refresh rate [1/s]	10 to 10000	[HEX21-D31]
		Minimum and maximum resolvable range [m]	cm-level	[HEX21-D31]
		Angular resolution [°]	Sub-degree level	[HEX21-D31]
		Velocity range [m/s]	±8	[HEX21-D31]
		Velocity resolution [m/s]	0.5	[HEX21-D31]
		Resource constraints		refer to deployment characteristics (prev. section)
		Scalability		refer to deployment characteristics (prev. section)

Fully merged cyber-physical worlds

		KPI	Target value	Reasoning / References
Communication	Dependability Attributes	Availability [%]	99	Acceptable with some service gaps, depends on the robustness of utilised codecs (i.e., impact on user-perceived quality should be low to avoid nausea).
		Reliability [%]	99.9	When QoS must be met to avoid nausea and user distress.
		Safety	Critical	Geo-fencing service must protect users from physical harm due to occlusion issues or shut service down.
		Integrity	High	Bystander integrity protection and protection against 3rd party misuse of usage data.
		Maintainability	Mid	Acceptable with some service downtime.
	QoS Attributes	Service latency [ms]	<20 ms	E2E roundtrip UL+DL less than 20 ms for at least 99% of the time. Should be <100ms for 99.99% of packets to avoid distress and discomfort if video frames are dropped due to late arrival (depending on codec).
		Data rate (minimum expected, desired, maximum) [Mbit/s]	1 Gbit/s DL 0.1 Gbit/s UL	Per user (from multiple devices): ~1 Gbit/s DL (AR stream 0.5 Gbit/s, spatial map 0.5 Gbit/s), ~100 Mbit/s UL (spatial map + user data).
		Resource efficiency		Refer to deployment description (e.g., frequency, energy consumption)
		Scalability		Refer to deployment description (e.g., number of users, mobility, ...)
AI and computation	Dependability Attributes	Agent availability [%]	99%	Same level as communication.
		Agent reliability [%]	99.9%	Same level as communication.
		Safety	Critical	Same level as communication.
		Integrity	High	Same level as communication.
		Maintainability	Mid	Same level as communication.
	QoS Attributes	AI service RTT [ms]	<20 ms 99%	Same level as communication.
		Inferencing accuracy [%]	N/A	No specific requirements.
		Interpretability level	N/A	No specific requirements.
		Training/model transfer latency [ms]	N/A	No specific requirements.
		Resource efficiency		Refer to deployment description (e.g., frequency, energy consumption)
		Scalability		Refer to deployment description (e.g., number of users, mobility, ...)
Localisation and Sensing	Dependability Attributes	Service availability [%]	99%	Sensing functionality must work for service to be safe.
		Service reliability [%]	99.99%	Considering the sensing functionality as a whole but not individual sensors.
		Safety	Critical	Same level as communication.
		Integrity	High	Same level as communication.
		Maintainability	Mid	Same level as communication.
	QoS Attributes	Location accuracy [m]	0.1	Application may need higher precision to place a digital overlay on surroundings but can improve the precision with image analysis. User's devices also need to be located relative to each other.
		L/S service RTT [ms]	50	Synchronisation of movement and a digital overlay.
		Orientation accuracy [°]	5	Application may need higher the precision to place digital overlay on surroundings but can improve precision with image analysis. User's devices also need to be oriented relative to each other.
		Refresh rate [1/s]	20	Synchronisation of movement and digital overlay.
		Minimum and maximum resolvable range [m]	0.1-10	No general upper bound (maximum range) is specified for this use case, depends on deployment.
		Angular resolution [°]	1	Giving ~15 cm resolution at 10 m distance.
		Velocity range [m/s]	0.1-10	Unclear if needed.
		Velocity resolution [m/s]	< 10	In the order of human mobility to accurately overlay rendered objects with the real world.
		Resource efficiency		Refer to deployment description (e.g., frequency, energy consumption)
		Scalability		Refer to deployment description (e.g., number of users, mobility, ...)

Interacting & cooperative mobile robots & flexible manufacturing

		KPI	Target value	Reasoning / References
Communication	**Dependability Attributes**	Availability [%]	99.9999	Survival time is equal to the transfer interval of control packets [22.104], with periodic deterministic communication.
		Reliability [%]	up to 99.9999999	[HEX21-D71]
		Safety	critical	Regulations for product safety for machines apply. Signalling of alarms and incidents, geo-fencing for human-machine interaction.
		Integrity	critical	Protection against 3rd party usage or manipulation of (sensitive) production data
		Maintainability	high	Restoration of service is a key priority, also by non-5G/6G experts available on-site.
	QoS Attributes	Service latency [ms]	0.5 - 25	RTT (sensor to a controller to an actuator) of 1-50 ms for collaborating robots [HEX21-D71]. Deterministic communication is required for control applications.
		Data rate (minimum expected, desired, maximum) [Mbit/s]	< 0.1 for control	Per-UE control traffic is expected to be in the kbit/s range, with small packet sizes (<1.5 kByte)
		Resource efficiency		refer to deployment characteristics (prev. section)
		Scalability		refer to deployment characteristics (prev. section)
AI and computation	**Dependability Attributes**	Agent availability [%]	99.9999 for control, less otherwise	If used as part of the control algorithm, requirements as stated for the communication service apply. Requirements are less strict if AI is utilised for offline process optimisation or recommendations to human operators.
		Agent reliability [%]	up to 99.9999999 for control, less otherwise	C.f. reasoning for agent availability.
		Safety	critical for control	If utilised for controlling robots, safety constraints for human-machine co-working need to be guaranteed.
		Integrity	high	Protection against 3rd party usage or manipulation of production data (model) and training data.
		Maintainability	high	Required to recover within the required time to ensure application productivity. Depends on the area of utilisation of AI in the use case (e.g., online or offline optimisation of processes and the impact on productivity).
	QoS Attributes	AI service RTT [ms]	part of overall RTT budget of 1 – 50 ms	If utilised in control applications. Less strict for offline optimisation or recommendations to human operators.
		Inferencing accuracy [%]	high	Depends on utilisation of AI in the use case and respective quality function. Generally, accuracy is required to be high to lead to a realization of the expected benefits when utilising AI.
		Interpretability level	high	Especially in safety-related applications (e.g., in control applications), the explainability of utilised algorithms is a key requirement.
		Training/model transfer latency [ms]	-	Assuming offline training in the use case.
		Resource efficiency		refer to deployment characteristics (prev. section)
		Scalability		refer to deployment characteristics (prev. section)
Localisation and Sensing	**Dependability Attributes**	Service availability [%]	> 99.99	[HEX21-D31]
		Service reliability [%]		No use-case-specific requirements are known.
		Safety	critical	If used for safety-critical aspects (e.g., machine shutdown in case of human presence within close proximity). If used for monitoring and/or optimization purposes with less stringent requirements, safety might not be an issue due to limited/no impact.
		Integrity	high	Robustness against unintended or intended interference, especially if used in safety-critical scenarios.
		Maintainability		No use-case-specific requirements are known. Application productivity needs to be high.
	QoS Attributes	Location accuracy [m]	0.01 – 0.05	[HEX21-D31]
		L/S service RTT [ms]	0.1 – 100	Inverse of required update rate.
		Orientation accuracy [°]	sub-degree	[HEX21-D31]
		Refresh rate [1/s]	10 – 10000	Once per 100 ms to once per 0.1 ms
		Minimum and maximum resolvable range [m]		No use-case-specific requirements are known.
		Angular resolution [°]	sub-degree	[HEX21-D31]
		Velocity range [m/s]	0 – 10	Required accuracy is expected to vary for different velocities. Collaboration with high required location accuracy might only occur in situations with reduced velocity.
		Velocity resolution [m/s]	0.5	[HEX21-D31]
		Resource efficiency		refer to deployment characteristics (prev. section)
		Scalability		refer to deployment characteristics (prev. section)

Immersive smart cities & integrated micro-networks for smart cities

		KPI	Target value	Reasoning / References
Communication	Dependability Attributes	Availability [%]	99 - 99.99	Higher target value for use-cases such as localisation of control utilities and traffic monitoring. Lower target value for use-cases such as landscape sensing and digital twins of smart buildings. [HEX21-D31]
		Reliability [%]	99.999	Related to digital twin use case taken from [5GP21]
		Safety	high	Signalling of incidents in infrastructure city sector (roads, railways, buildings, transport, energy, water, etc.), environment city sector and healthcare city sector as well as safety/stability city sector where this KPI is of great interest.
		Integrity	critical	Protection against 3rd party usage or manipulation of sensitive production data.
		Maintainability	medium - high	Restoration is crucial in most of the city sectors' use cases.
	QoS Attributes	Service latency [ms]	0.1 - 100	Depending on the use case. Lower target value for indoor use cases and higher target values for outdoor use cases. Tolerable Jitter is expected to be 10% of the targeted service latency depending on the use case.
		Data rate (minimum expected, desired, maximum) [Mbit/s]	10 - 100	[HEX21-D71]
		Resource constraints		refer to deployment characteristics (prev. section)
		Scalability		refer to deployment characteristics (prev. section)
AI and computation	Dependability Attributes	Agent availability [%]	99 – 99.99	Same as communication
		Agent reliability [%]	99.999	Same as communication
		Safety	critical	Especially when considering human-machine interactions for instance in the healthcare city sector.
		Integrity	critical	Protection against 3rd party usage of AI models and (sensitive) training data.
		Maintainability	medium - high	Depends on the area of utilisation of AI.
	QoS Attributes	AI service RTT [ms]		Depends on the application.
		Inferencing accuracy [%]		Depends on the application.
		Interpretability level	high	Especially in safety-related applications.
		Training/model transfer latency [ms]	N/A	Assuming offline training mostly.
		Resource constraints		refer to deployment characteristics (prev. section)
		Scalability		refer to deployment characteristics (prev. section)
Localisation and Sensing	Dependability Attributes	Service availability [%]	Up to 99.9999	[HEX21-D71]
		Service reliability [%]	99.999	Same as communication
		Safety	critical	Same as communication.
		Integrity	critical	Robustness against unintended or intended interference.
		Maintainability	medium - high	Same as communication.
	QoS Attributes	Location accuracy [m]	< 1 m horizontal and vertical for utility services such as transportation, piping, garbage etc. < 0.025 m for future smart buildings (half thickness of typical wall)	[HEX21-D31]
		L/S service RTT [ms]		No use-case-specific requirements are known.
		Orientation accuracy [°]		No use-case-specific requirements are known.
		Refresh rate [1/s]	1/3600 - 1	Once per hour for use cases such as digital twins of smart buildings, once per minute for use cases such as landscape sensing and, once per second for use cases such as traffic monitoring and localisation of control utilities. [HEX21-D31]
		Minimum and maximum resolvable range [m]		No use-case specific-requirements are known.
		Angular resolution [°]		No use-case-specific requirements are known.
		Velocity range [m/s]	-20 m/s to 20 m/s	For use cases such as traffic monitoring. [HEX21-D31]
		Velocity resolution [m/s]	0.5	For use cases such as traffic monitoring. [HEX21-D31]
		Resource constraints		refer to deployment characteristics (prev. section)
		Scalability		refer to deployment characteristics (prev. section)

Infrastructure-less network extensions and embedded networks

		KPI	Target value	Reasoning / References
Communication	Dependability Attributes	Availability [%]	critical	Often part of safety-related applications, see [HEX21-D71]
		Reliability [%]	Very high	Often part of safety-related applications
		Safety	critical	Often part of safety-related applications
		Integrity	Very high	Often part of safety-related applications and accessible by third parties
		Maintainability	Very high	Often part of professional applications
	QoS Attributes	Service latency [ms]	1 ms	Assuming that Time-Sensitive Networking (TSN) applications are not covered. Can be significantly higher for some use cases where multi-hop communication and/or energy preserving strategies are utilised.
		Data rate (minimum expected, desired, maximum) [Mbit/s]	Kbit/s up to some 10 Mbit/s	Video
		Resource constraints		refer to deployment characteristics (prev. section)
		Scalability		refer to deployment characteristics (prev. section)
AI and computation	Dependability Attributes	Agent availability [%]	Very high	Safety-critical applications
		Agent reliability [%]	Very high	Safety-critical applications
		Safety	N/A	
		Integrity	High	
		Maintainability	N/A	
	QoS Attributes	AI service RTT [ms]		Depending on the application, no use case-specific requirements are known.
		Inferencing accuracy [%]		Depending on the application, no use case-specific requirements are known.
		Interpretability level		Depending on the application, no use case-specific requirements are known.
		Training/model transfer latency [ms]		Depending on the application, no use case-specific requirements are known.
		Resource constraints		refer to deployment characteristics (prev. section)
		Scalability		refer to deployment characteristics (prev. section)
Localisation and Sensing	Dependability Attributes	Service availability [%]	Very high	Manoeuvring and safety applications
		Service reliability [%]	Very high	Manoeuvring and safety applications
		Safety	Very high	Manoeuvring and safety applications
		Integrity	Very high	Manoeuvring and safety applications
		Maintainability		Depending on the application, no use case specific requirements known.
	QoS Attributes	Location accuracy [m]	0.01	Shopfloor, agriculture
		L/S service RTT [ms]	1 - 10	
		Orientation accuracy [°]	1, 6D	
		Update rate [1/s]	100 - 1000	
		Minimum and maximum resolvable range [m]	0.01 - 1	
		Angular resolution [°]	1	
		Velocity range [m/s]	0.1 - 100	
		Velocity resolution [m/s]		Depending on the application, no use case-specific requirements are known.
		Resource constraints		refer to deployment characteristics (prev. section)
		Scalability		refer to deployment characteristics (prev. section)