



Hexa-X-II - Foudation for 6G E2E system design

Hexa-X-II workshop on 6G

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Hexa-X-II

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Outline



- Evolution toward 6G
- 6G design principles and system requirements
- E2E design
 - 6G blueprint
 - Design process
- SNS stream B project enablers integration

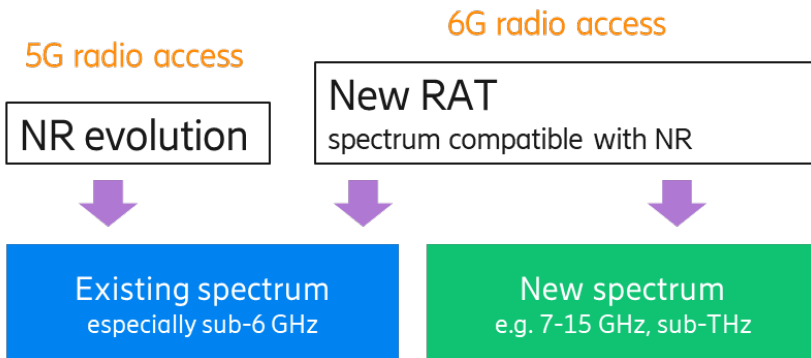


Evolution to 6G E2E system



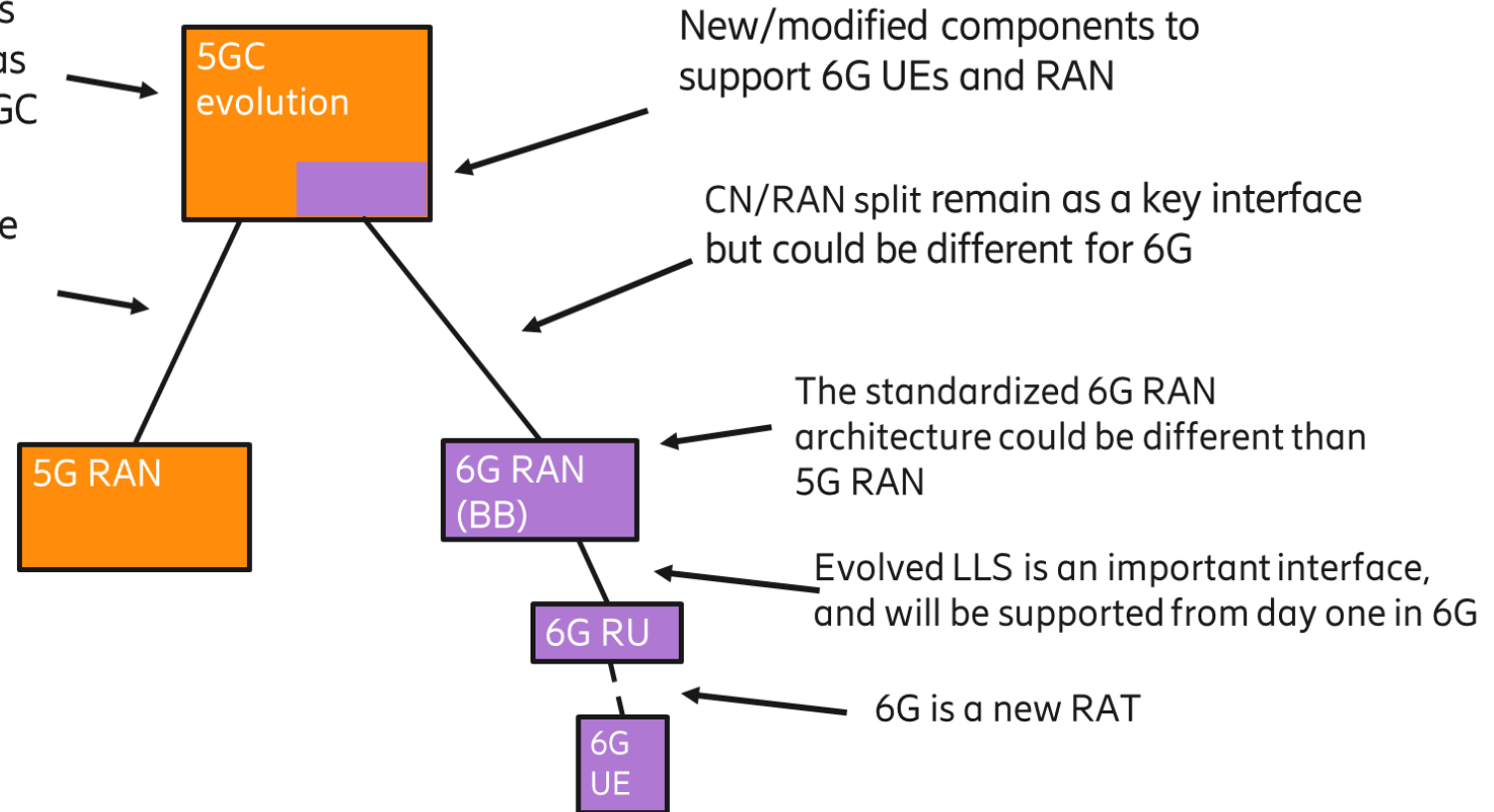
Evolution towards 6G

- A 6G RAT should support an extended spectrum range than 5G, provide open interfaces, and plug into an updated 5G CN



The CN of 6G is standardized as evolution of 5GC

5G will continue to use legacy CN/RAN interface



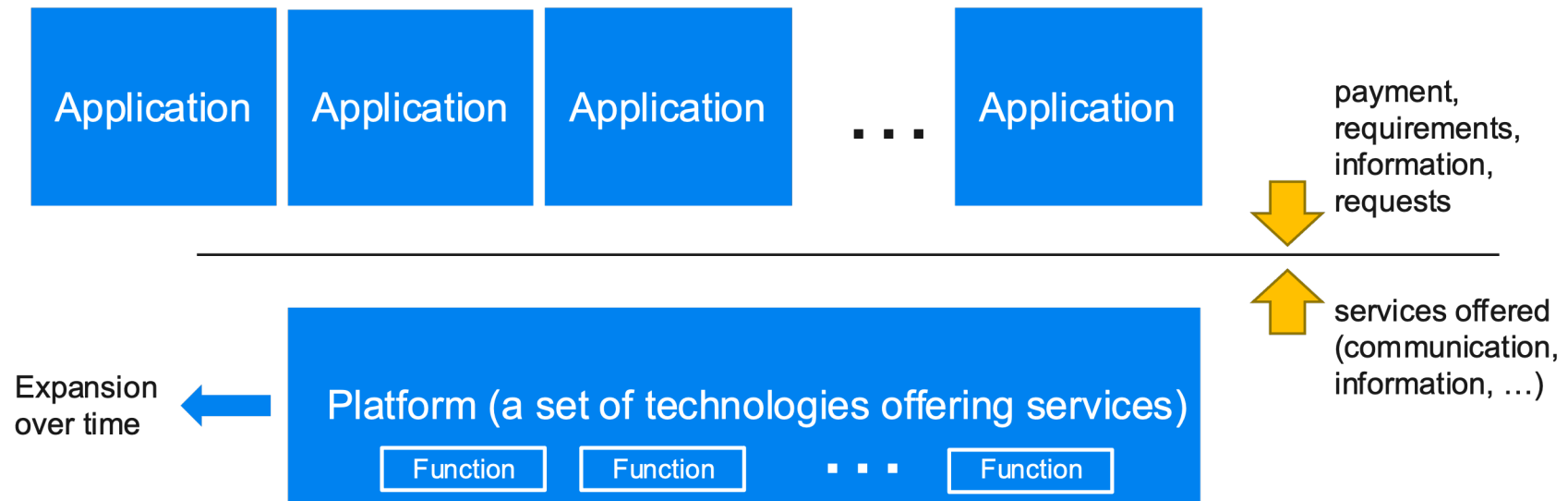
LLS = Lower layer split

6G Platform



- 6G networks should be platforms for a wide range of technologies towards a wide range of applications
- The networks should expose data through simple APIs and allow for interaction with applications

6G: a platform serving applications





6G Design Principles & system requirements

Architecture design principles for 6G End-to-End System



Principle 1

Support and exposure of 6G services and capabilities

Principle 2

Full automation and optimization

Principle 3

Flexibility to different network scenarios

Principle 4

Network Scalability

Principle 5

Resilience and availability

Principle 6

Persistent security and privacy

Principle 7

Internal interfaces are cloud optimized

Principle 8

Separation of concerns of network functions

Principle 9

Network simplification in comparison to previous generations

Principle 10

Minimizing environmental footprint and enabling sustainable networks

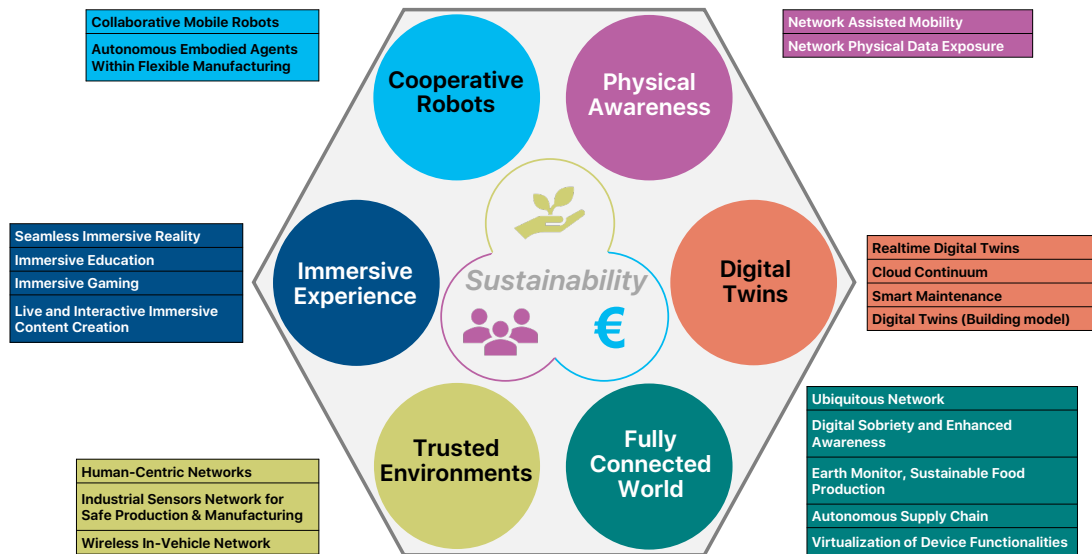
Ten 6G design principles

- Impacting 6G E2E system blueprint design
- Achieving the 6G key values realization of environmental, social and economical sustainability.

6G System Requirements (initial)



Capabilities of the system in terms of what it should do and relevant to a selected list of 6G use cases.



Hexa-X-II 6G use-cases (source Hexa-X-II D1.2)

Requirements\Use case	Ubiquitous Network	Real-time digital twin	Seamless Immersive Reality	Cooperating mobile robots	Human centric services	Network assisted mobility
Ubiquitous connectivity	X	X		X	X	X
Indoor coverage	X	X	X	X	X	
Extreme connectivity (high bitrate)			X			
Mobility support	X		X	X	X	X
Pervasive AI/ML		X	X	X	X	X
Efficient sleep states	X		X		X	X
Compute as a Service		X	X	X		X
Intent-based interfaces		X		X		
Reliability		X		X	X	X
Positioning/sensing		X	X	X	X	X
Ultra-low-cost	X					
Energy neutral	X					
Predictable low-latency E2E communication		X	X	X		X
Security/Privacy	X	X	X	X	X	X
Resilience	X	X		X		X
Service continuity	X		X			X



Operational requirements of 6G E2E system (initial)

A set of requirements which will not be directly visible to end-users, but provide functionality to efficiently fulfill use case requirements for operators.

Flexible
radio
protocols

Mobility
procedures

Improved
access
convergence

Native AI/ML
capabilities

Multi-
connectivity

Intent-based
management

Seamless orchestration across
the compute continuum

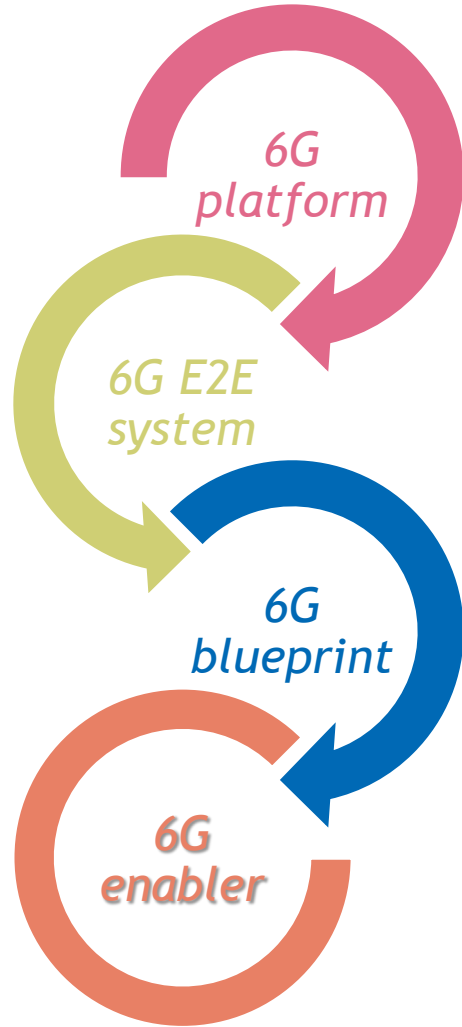
6G service delivery across
multiple digital service providers

New 6G capabilities
exposure



E2E design

Hexa-X-II key terms

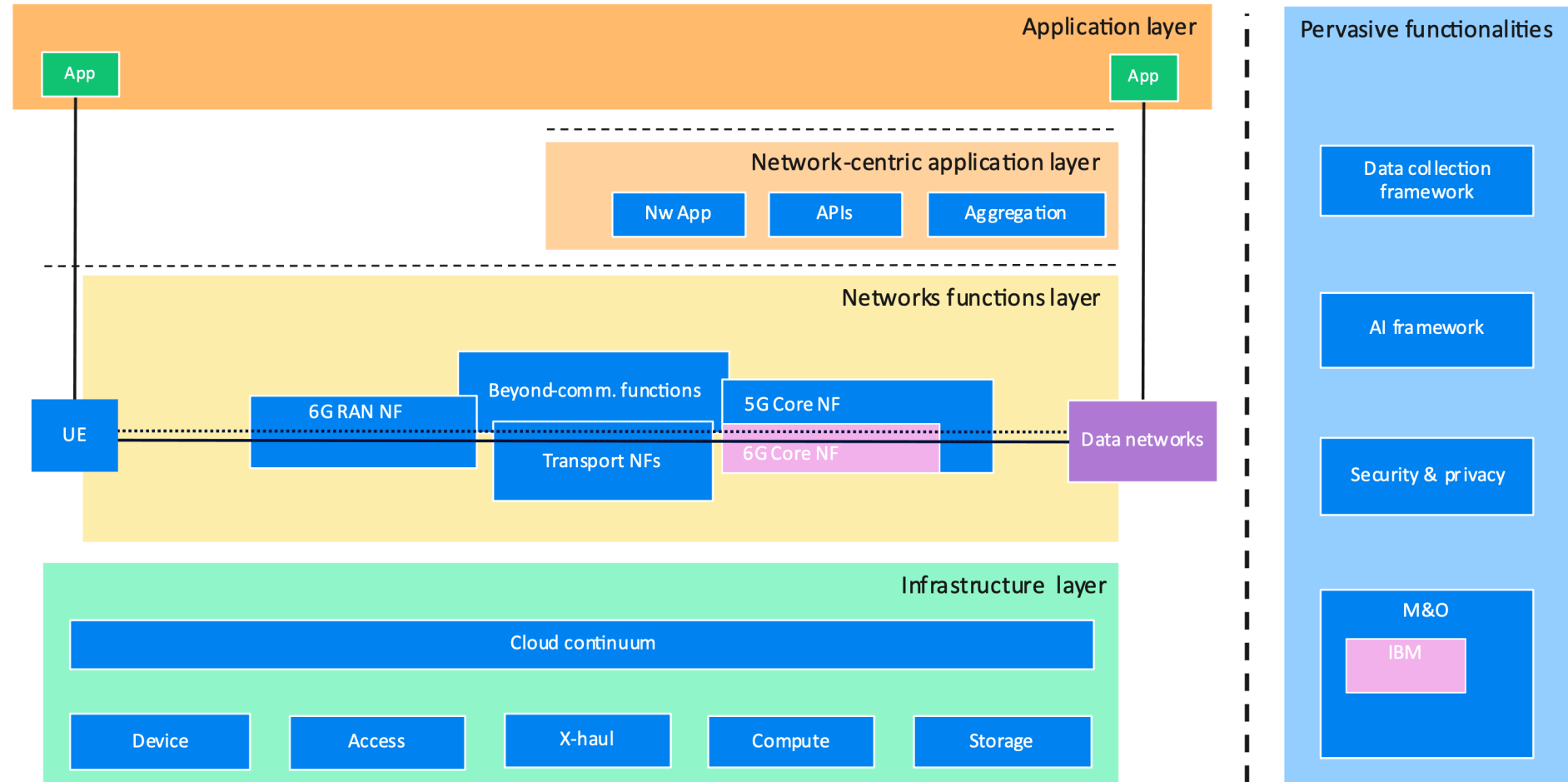
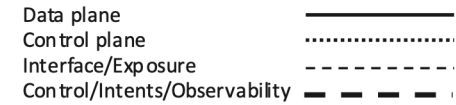


- The external view of a set of technologies and interfaces delivering 6G services to applications, ecosystems, verticals, users etc. enabling value.
- The technical realization of 6G platform which includes the technology enablers and their interaction.
- A reference architecture that meets the E2E system needs with respect to hardware, software and applications.
- a 6G technical enabler. It is defined as any technical asset that makes it possible to realize or enhance a 6G capability. It is recursive, e.g. 6G system enables new use cases, 6G radio is an enabler of 6G system to achieve system requirements. A 6G technical enabler can be further classified into different types that are extensible, e.g. architecture, system component, process, algorithms, etc

6G E2E system - 6G blueprint



- Foundation of the E2E 6G system architecture
- The 6G system should provide services and data exposure to E2E applications - covering new and existing capabilities
- New functionalities should be incorporated into established network structures
- Specific views to capture the holistic system, e.g. management and orchestration views, etc.



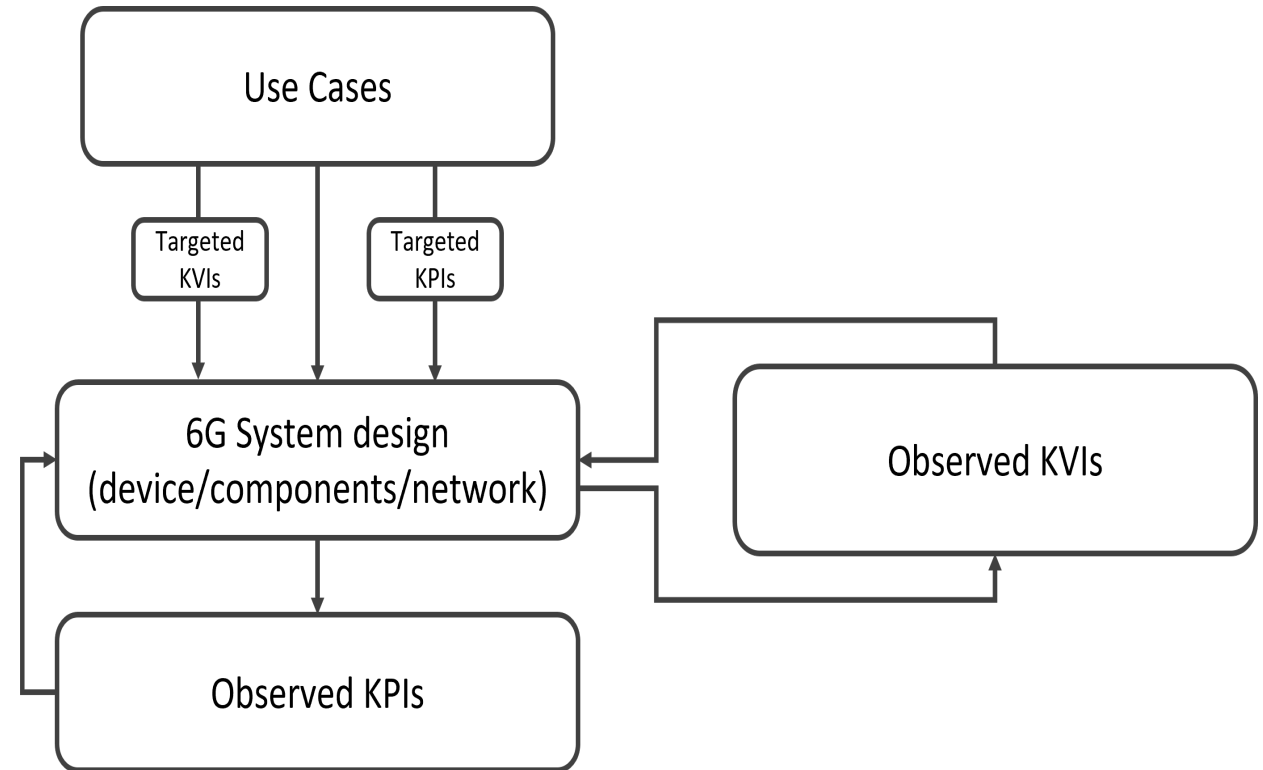


Iterative system design process

- Systemization towards 6G involves studying technical components and assessing how they contribute to performance and impact
- Trade-off between targets can be important as well as managing conflicting technical solutions

→ Iterative design process in a two-fold manner

1 KPIs/KVIs-based design iterative sub-process

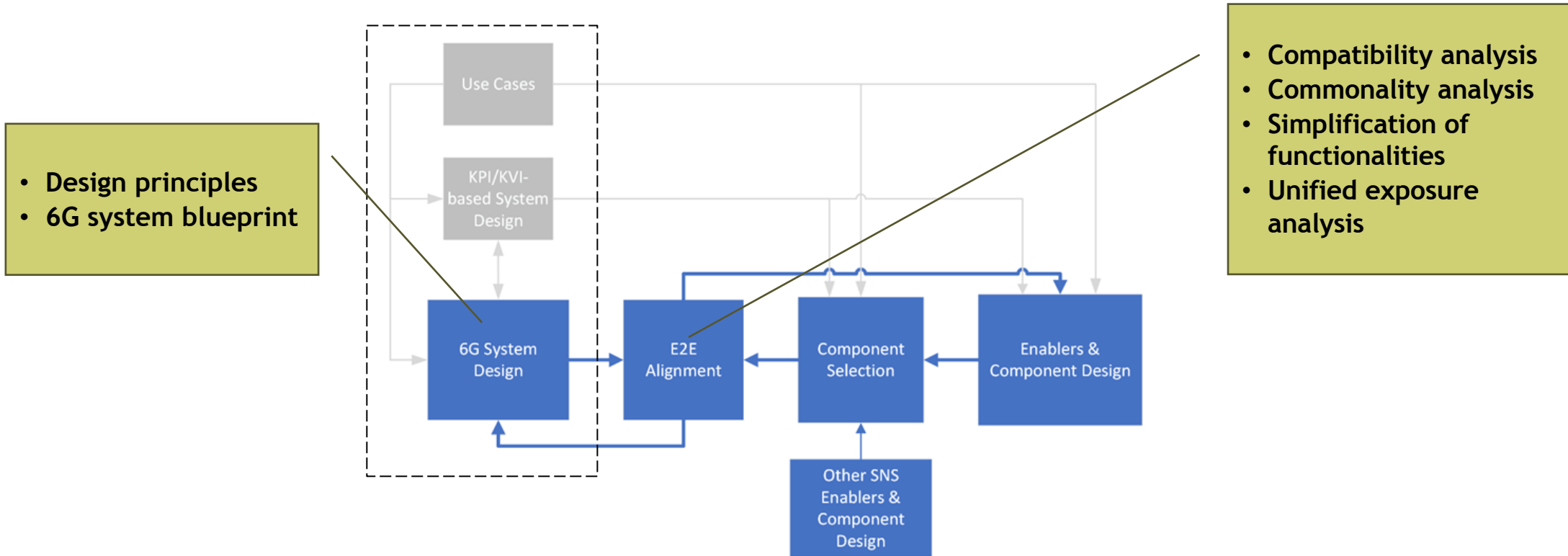


- Trade-offs as conformance to certain values can lead to degraded performance.



Iterative system design process

2 Top-down versus bottom-up alignment iterative sub-process



- Pros and cons of each promising enabler/component/subsystem
- Aligning technical components/enablers with the E2E performance and operation targets/expectations

Identification of key criteria for enabler integration in E2E system

Relevance and significance of enabler towards E2E system design

Impact of the enabler on the E2E system design

How the enabler fits with the system design principles

Feasibility (estimation) of enabler vs migration options

Dependency with other enablers

Any proposed updates to E2E system design and architecture design principles

Network performance, security/privacy, flexibility, resilience/robustness, and sustainability/energy efficiency

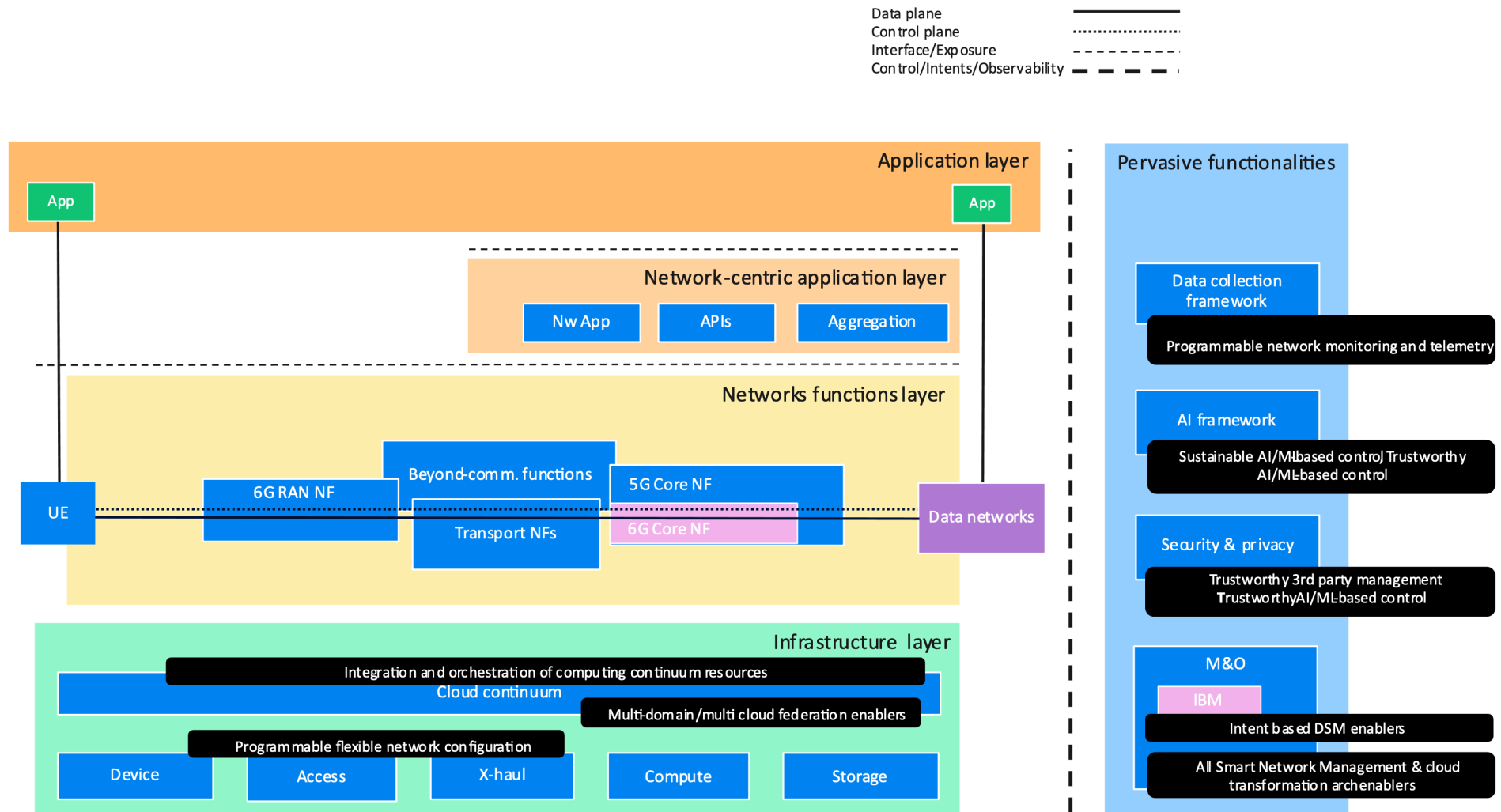


Analysis of Hexa-X-II enablers for integration in E2E system

<p>Intent-based management automation</p> <ol style="list-style-type: none">1. Intent translation and provisioning2. Data fusion mechanisms based on telemetry data3. Closed loop coordination for intent management4. Intent conflict administration5. Human-machine intent interface design6. Intent-driven placement7. Declarative intent reconciliation8. Intent reporting9. 3rd party facing services	<p>Smart network management and automation</p> <ol style="list-style-type: none">1. Programmable and flexible network configuration2. Programmable network monitoring and telemetry3. Integration fabric4. Trustworthy 3rd party management5. Multi-cloud management mechanisms6. Orchestration mechanisms for the computing continuum7. Sustainable AI/ML-based control8. Trustworthy AI/ML-based control9. Network Digital Twins10. Zero-touch closed loop governance11. Zero-touch control loop coordination	<p>Architectural enablers for cloud transformation</p> <ol style="list-style-type: none">1. Integration and orchestration of computing continuum resources into the 6G architecture2. Multi-domain/multi-cloud federation3. Network modules placements in the resource continuum4. Cloud transformation in 6G-quantum architecture
		<p>Architectural enablers for network function modularization</p> <ol style="list-style-type: none">1. Optimized network function composition2. Streamlined network function interfaces and interaction3. Flexible feature development and run-time scalability4. Network autonomy and multi-X orchestration

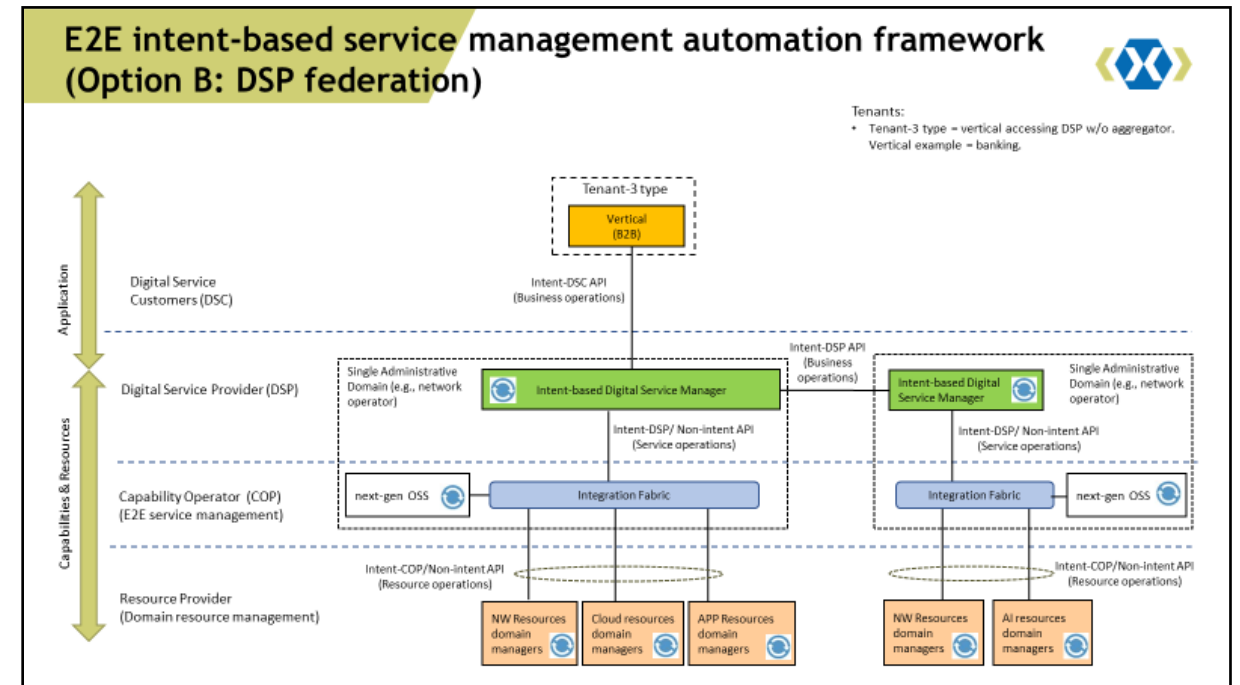
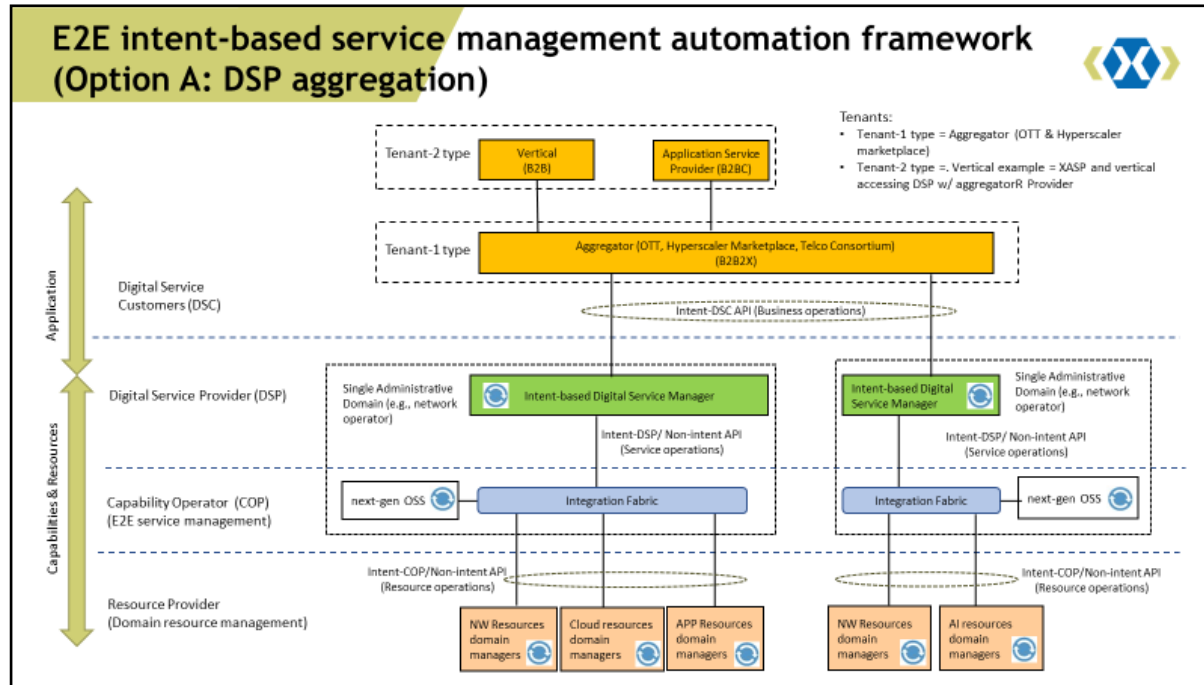
A preliminary set of Hexa-X-II enablers that have been identified as important technology innovations for the use case of cobot cooperating in the context of an industrial environment that is under study in the system-PoC A and B.

Mapping of management and orchestration enablers in E2E system blueprint



Representations the set of enablers analyzed in the first iteration that are part of the M&O view of the 6G E2E system blueprint.

Early M&O specific view



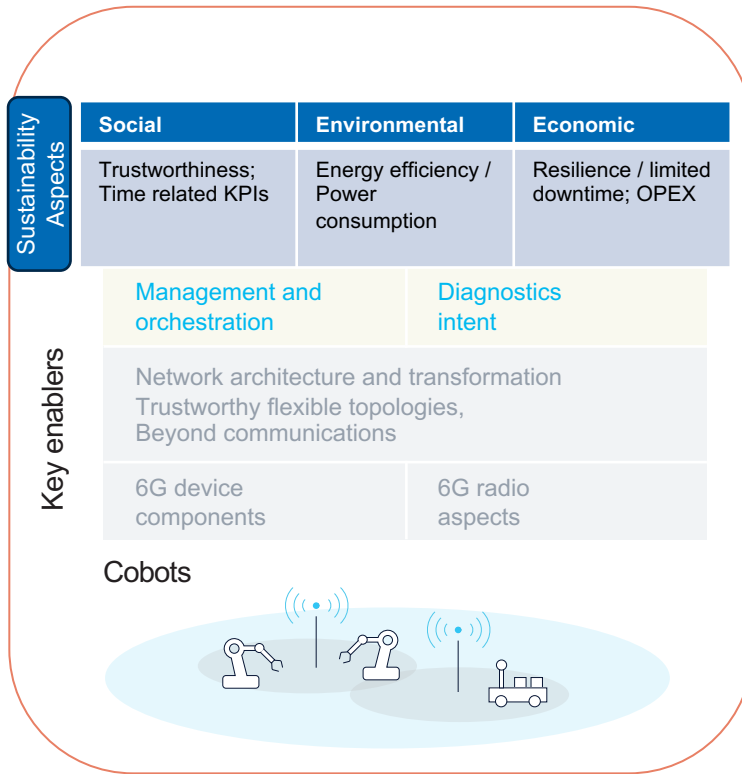
- A “TechCo” framework embraces new services beyond traditional connectivity, with a focus on digital and application-centric services resulting from an innovation ecosystem leveraging frictionless interactions between network and 3rd party application providers.



System Proof of Concepts

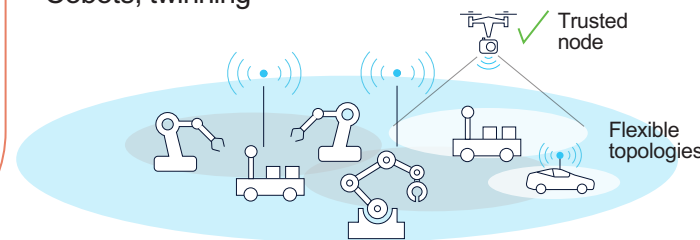
Three System-PoCs

- validating the system design and demonstrating the feasibility of achieving targeting 6G KPIs and KVIs.



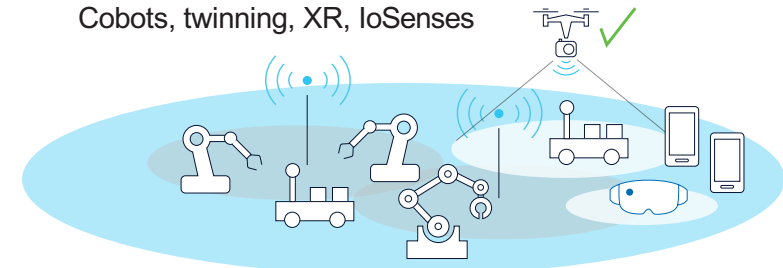
Social	Environmental	Economic
Trustworthiness; Exposure, security / privacy; Digital inclusion	Energy efficiency / Power consumption	Resilience / Limited downtime; OPEX; CAPEX
Management and orchestration	Diagnostics intent	
Network architecture and transformation Trustworthy flexible topologies, Beyond communications		
6G device components	6G radio aspects	

Cobots, twinning



Social	Environmental	Economic
Trustworthiness; Exposure, security / privacy; Digital inclusion	Energy efficient radio, zero-energy devices	Resilience / Limited downtime; OPEX; CAPEX
Management and orchestration	Diagnostics intent	
Network architecture and transformation Trustworthy flexible topologies, Beyond communications		
6G device components	6G radio aspects	

Cobots, twinning, XR, IoSenses



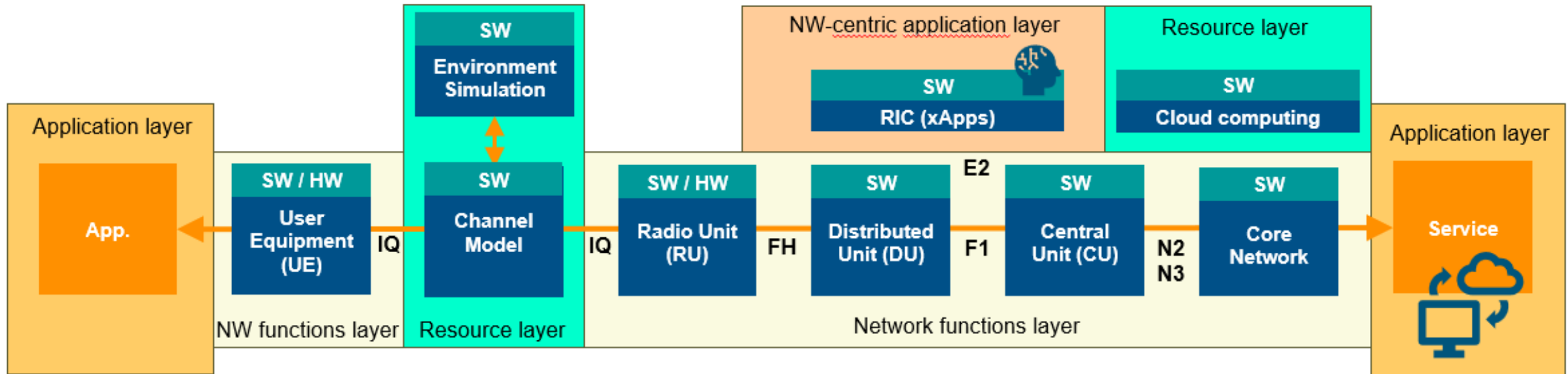
Gradual addition

6G



E2E simulation framework for connectivity

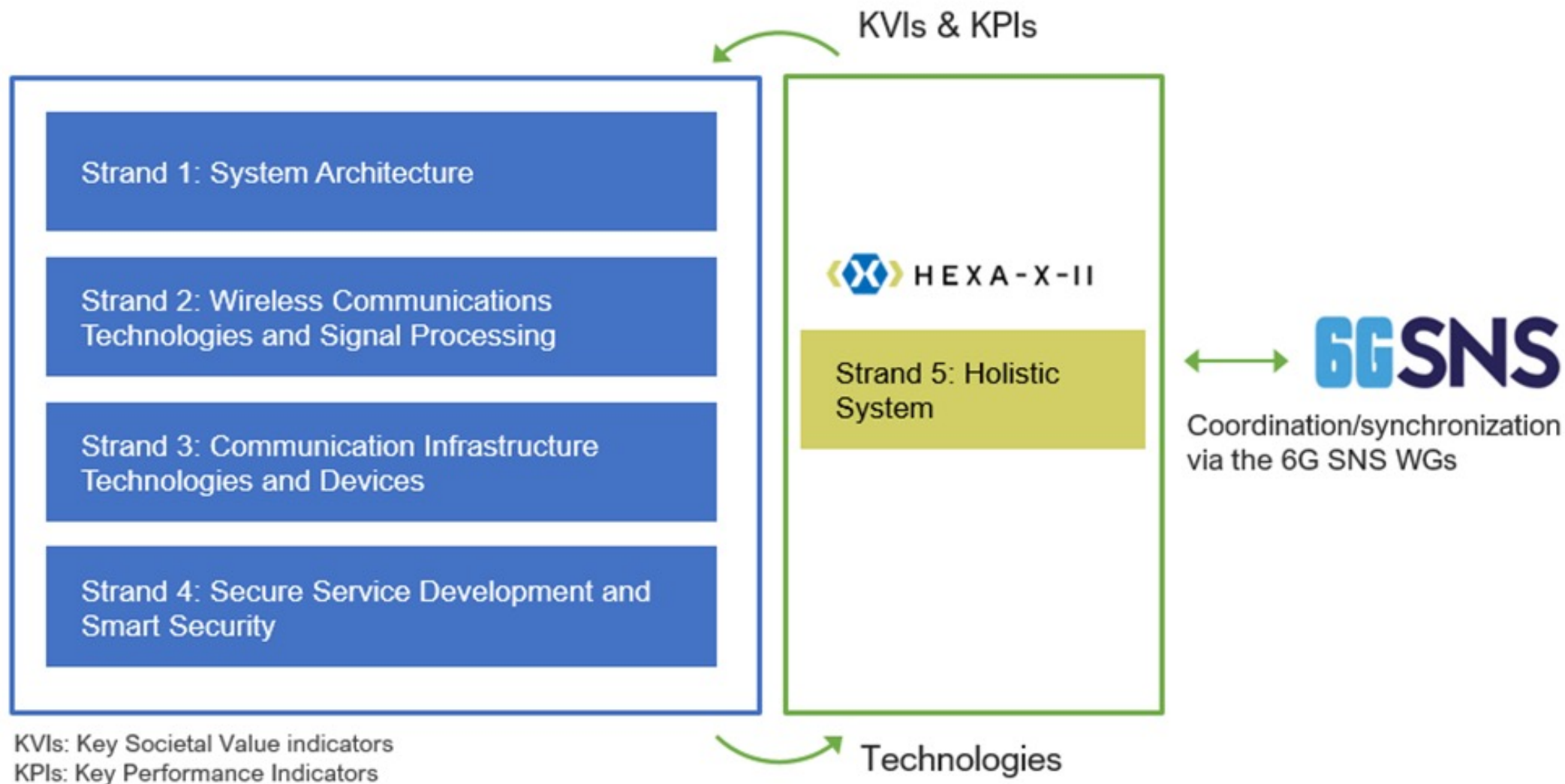
- E2E simulation framework is planned to be developed and used for selected 6G connectivity enablers performance evaluation





SNS Stream-B enablers integration

Interaction and interworking with other SNS projects and WGs



Interaction with the strands in the SNS stream B

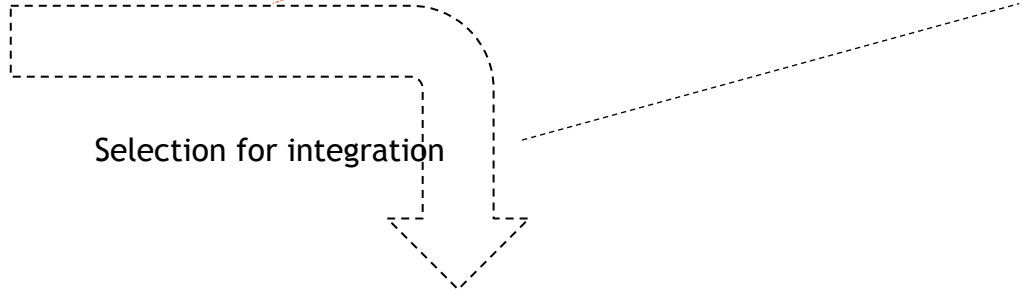
Hexa-X-II E2E system design in a nutshell



Hexa-X-II Enablers

Other Enablers
• *From other SNS projects*

- Analysis of other SNS stream B enablers
- Identify Missing/undercovered enablers in Hexa-X-II - but important for the 6G platform
 - Align and possibly complete Hexa-X-II design principles
 - Evaluate other Stream B project (sub) system architecture to align and possibly complete Hexa-X-II system architecture



System design guidelines

- Migration from 5G to 6G
- System design principles
- 6G system requirements

System design process

- Iterative design process
- System-PoC evaluation

6G blueprint design

- E2E system blueprint - overall
 - Specific views

WoW/ Template for enabler analysis for integration in the holistic 6G E2E design



Enabler name	Short description	Use case/ operational requirements (as identified in Hexa-X-II D2.2) tackled by the enabler	Requirement for Standards Update? (Yes/No)	Requirement for new Hardware entities for usage/implementation? (Yes/No)	Does the enabler is an 5G enabler enhancement or a new one?	Relevant system design principles (as defined in Hexa-X-II D2.1) applicable for enabler design	Impact of the enabler on the E2E system design	Dependency/ correlation with other enablers or Hexa-X-II enablers	Any other comments

- Outcome of analysis reported in
 - Hexa-X-II D2.3 - Interim overall 6G system design (June 2023) - input collected from this first workshop and via input to the template (before March 1st)
 - Hexa-X-II D2.5 Final overall 6G system design (April 2025) - input collected from a second workshop (end 2024) and the (possibly refined) updated template

Hexa-X-II standardization activities & way forward



- Communicating the results and impact on standardization
- Support harmonization across SNS stream B projects
- Assessing the performance of various concepts at E2E system level

Name of project	Target standards and industry groups	Topics contributed to standards	Outcome/impact

The outcome of the analysis will be reported in

- D7.8: *Impact to Industry activities standardisation and regulation – Final release (June 2025)*

More details



Available on
Hexa-X-II
website



A holistic flagship towards the 6G network platform and system to inspire digital transformation for the world to act together in meeting needs in society and ecosystems with novel 6G services.

D2.1 Draft foundation for 6G system design

DISCLAIMER: Smart Networks and Services Joint Undertaking approval pending



Hexa-X-II project has received funding from the [Smart Networks and Services Joint Undertaking \(SNS JU\)](#) under the European Union's [Horizon Europe research and innovation programme](#) under Grant Agreement No 101095759.

Date of delivery:	30/06/2023	Version:	1.0
Project reference:	101095759	Call:	HORIZON-JU-SNS-2022
Start date of project:	01/01/2023	Duration:	30 months

Available on
Hexa-X-II
website



HEXA-X-II

A holistic flagship towards the 6G network platform and system, to inspire digital transformation, for the world to act together in meeting needs in society and ecosystems with novel 6G services

Deliverable D2.2 Foundation of overall 6G system design and preliminary evaluation results



Hexa-X-II project has received funding from the [Smart Networks and Services Joint Undertaking \(SNS JU\)](#) under the European Union's [Horizon Europe research and innovation programme](#) under Grant Agreement No 101095759.

Date of delivery:	29/12/2023	Version:	0.2
Project reference:	101095759	Call:	HORIZON-JU-SNS-2022
Start date of project:	01/01/2023	Duration:	30 months



HEXA-X-II.EU //   



Co-funded by
the European Union

6GSNS

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Workshop input/output expectation and timeline

