CAPELLA DAYS 2025 – Session 1: Tuesday, Nov. 18

Tailoring MBSE and ARCADIA for a Complex Ground-Breaking Space Program

Rivada Space Networks

Agenda

1. **Introduction**
   - Rivada Space Networks (RSN) and the OuterNET

2. **MBSE Implementation Strategy at RSN**
   - Need for MBSE (ARCADIA & Capella)
   - MBSE Scoping in the RSN Ecosystem

3. **RSN Model-Based System Engineering Workflow**
   - System Model Initialization
   - System Functional Design via Use Case Approach
   - SE tool integration
   - Practical example on UC (Use Case)

4. **Lesson Learned: Domino Effect, Challenges, Solutions**

Who We Are

RIVADA SPACE NETWORKS

Vincenzo D'Onofrio

System Engineering Manager

Linkedin

Sahil Metta

Model-Based Systems Engineer

LinkedIn

Headquartered in Munich & Berlin

More than 150 employees across 31 nationalities

Over

300

Years of Collective Experience

In The Satellite & Wireless Industries

Leading Experts from

SES your satellite company

EUTELSAT

AIRBUS

OneWeb

AVANTI

ThalesAlenia Space

Some Notable Partners

NETWORK INNOVATIONS US & UK GOVERNMENT

Tekniam

artel

aws

Peraton

IEC telecom

Challenges to Global Telecommunications

- Cybersecurity threats
- Lack of coverage
- Network fragmentation
- Data sovereignty
- High latency
- No end-to-end quality of service assurance
- Lack of scalability

THE OUTERNET

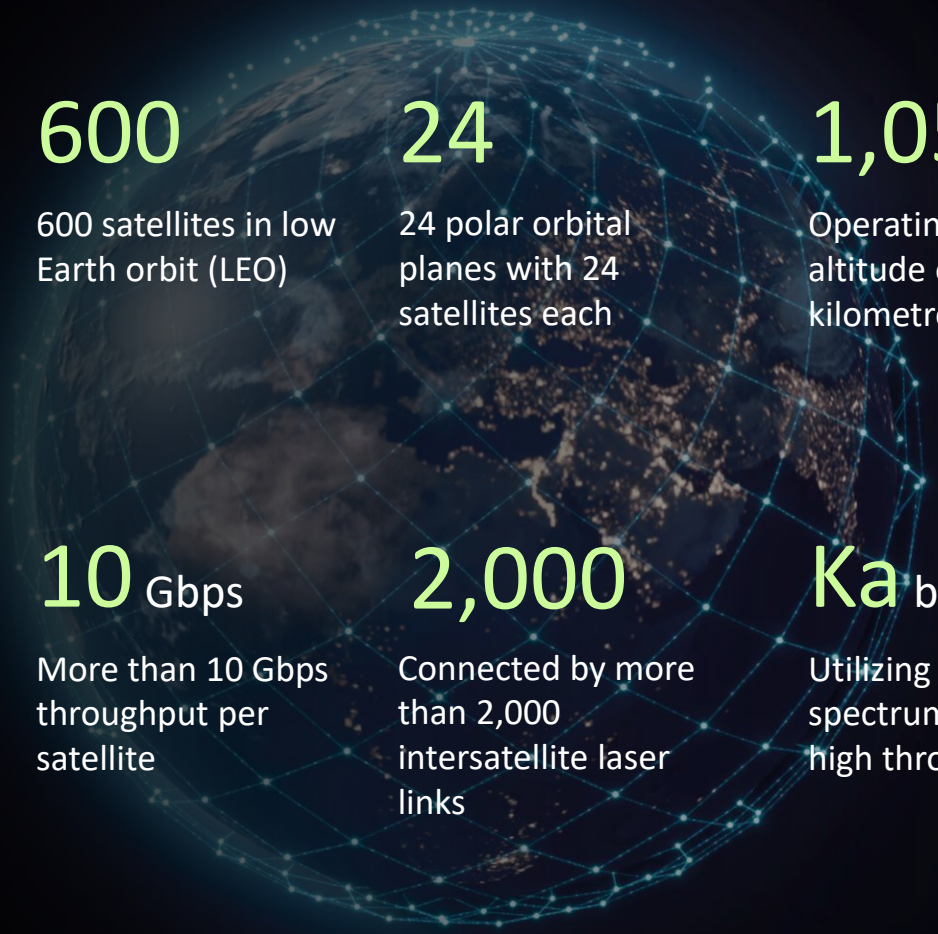
Fast, Secure, Everywhere

A Private Network in Space

Rivada is revolutionizing global connectivity with its unique gateway-less satellite constellation in low Earth orbit (LEO).

This orbital network, **the Outernet**, is the first satellite constellation purpose-built to transport all of our customers' data in space from end-to-end.

Launching in 2026, it is the dawn of the world's first single global, fully inter-connected independent orbital network.



600

600 satellites in low Earth orbit (LEO)

24

24 polar orbital planes with 24 satellites each

1,050 km

Operating at an altitude of 1050 kilometres

10 Gbps

More than 10 Gbps throughput per satellite

2,000

Connected by more than 2,000 intersatellite laser links

Ka band

Utilizing 4 GHz of spectrum to achieve high throughout

THE
OUTERNET

Fast, Secure, Everywhere

A Private Network in Space

HIGHEST SECURITY

Data stays on the network from origin to destination

GLOBAL CONNECTIVITY

Every place on Earth connected, even the sea and the poles

DATA SOVEREIGNTY

No connection to third party networks or the Internet

ULTRA-LOW LATENCY

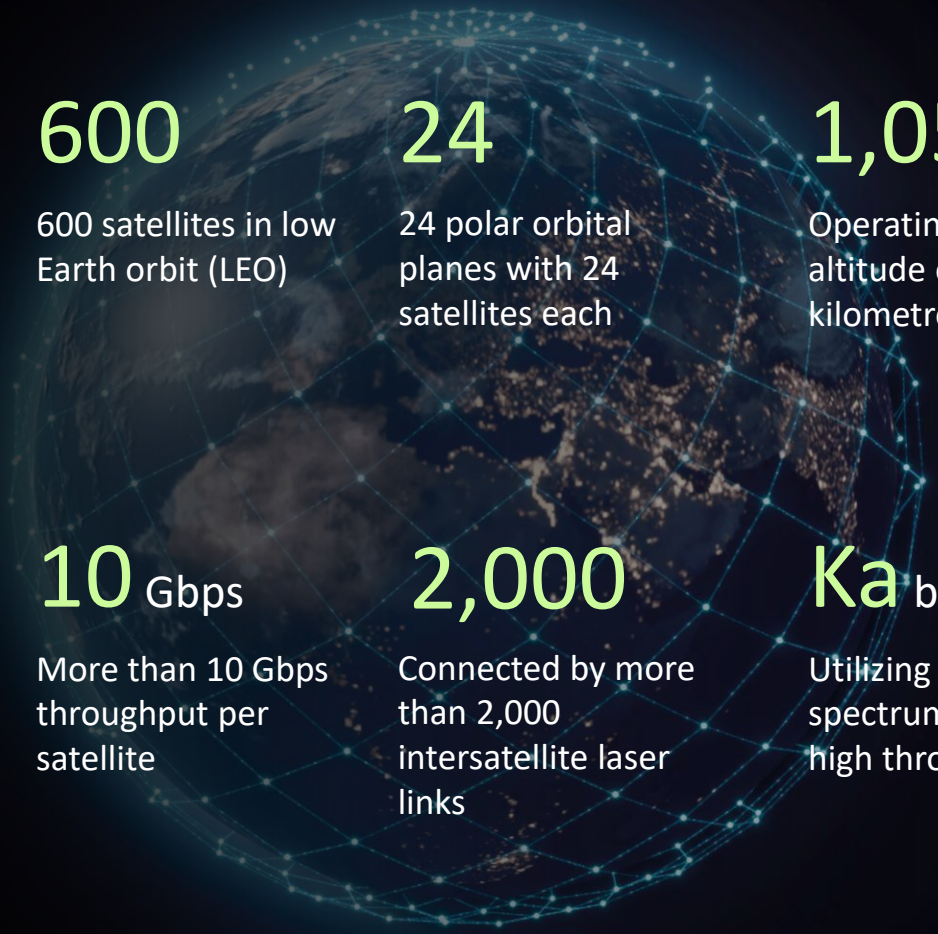
Minimum latency, maximum efficiency

HIGH THROUGHPUT

Multigigabit speeds at any distance, anywhere on the globe

PLUG AND PLAY

Seamless Integration with MEF and SD-WAN



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Need for MBSE @ RSN

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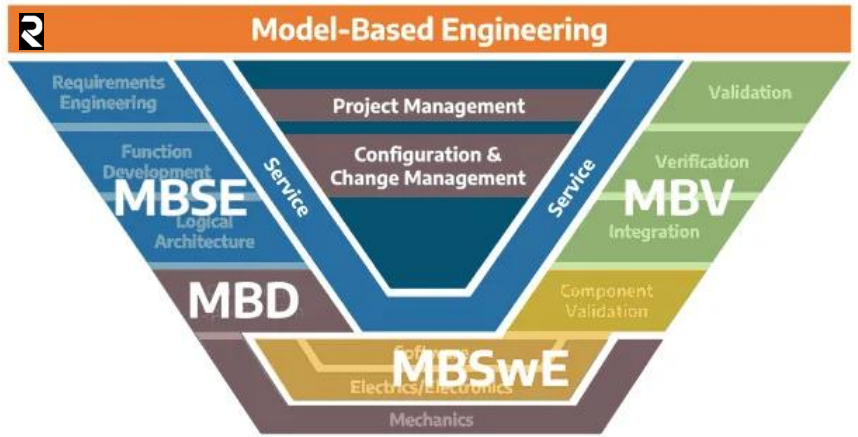
Main identified factors driving the need for MBSE deployment in the OuterNET program.

Factor: Groundbreaking space project, in a context requiring a much faster development pace compared to traditional space programs (time constrained).
Need: Systems Engineering required for mitigating risks but needs to be digital to be effective.

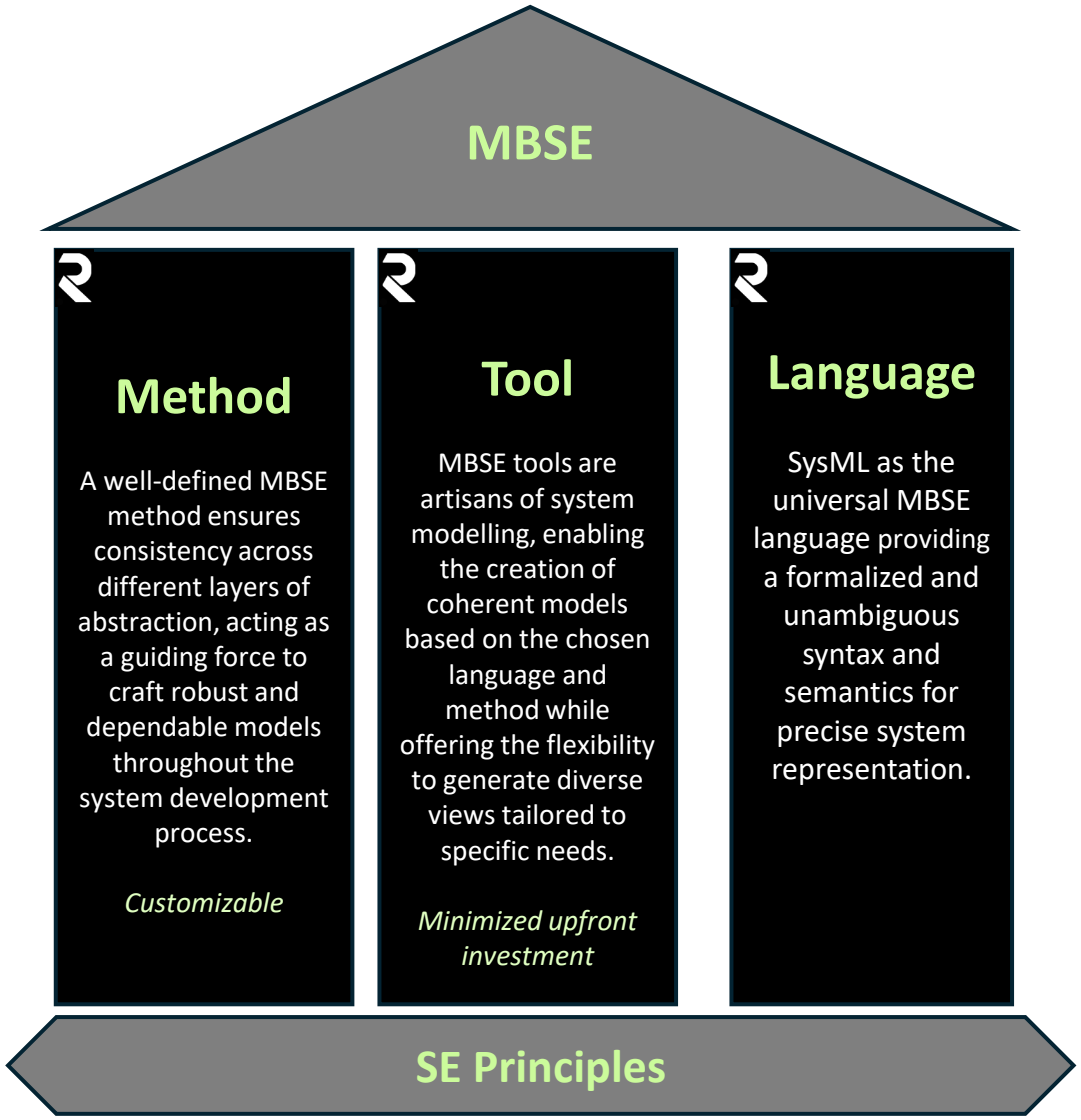
Factor: Wide range of subsystems involvement and geographically distributed over the World → This is complicated!
Need: Have Single Source of truth at system level for proper coordination and have effective dependency establishment and…

Factor: Unique System Architecture, with N number of new technologies development ongoing → This is complex!
Need: To have system control to be able to manage emergent behavior induced by factors like: technology advancement

*How to ensures **C**onsistency, **C**orrectness, and **C**ompleteness throughout the design and development, while remaining agile and adaptable to highly dynamic environments?*

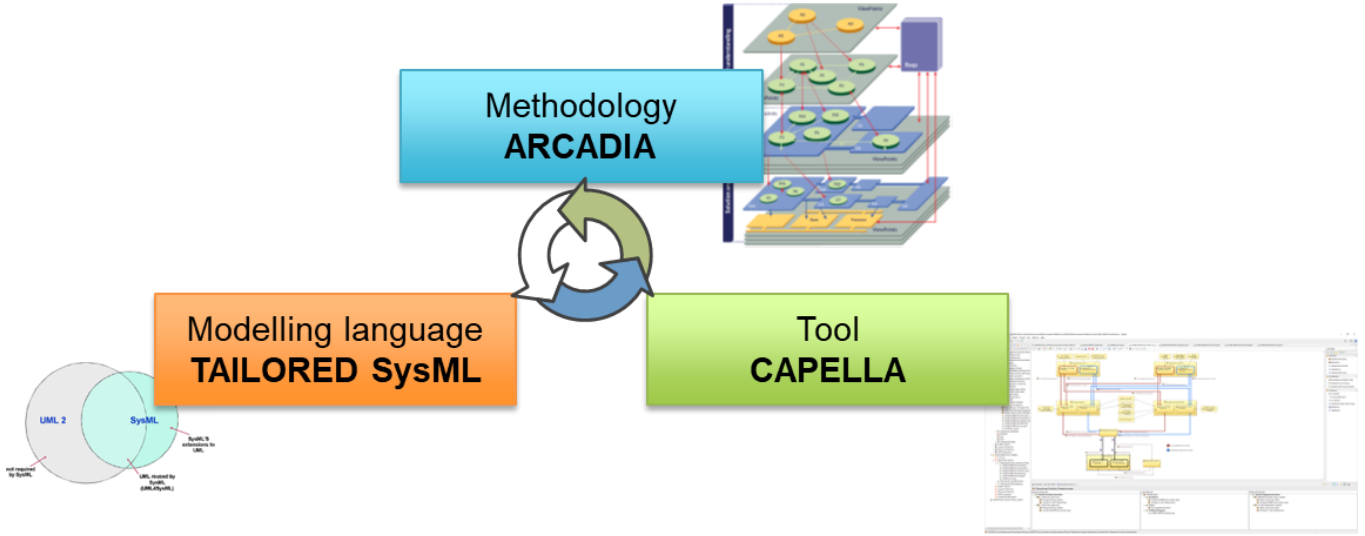


RSN-selected Method and Tool



ARCADIA (*Architecture And Design Integrated Approach*): methodology and high-level concepts and viewpoints.

Capella is purpose-built to provide the notation and diagrams fitting the Arcadia approach.

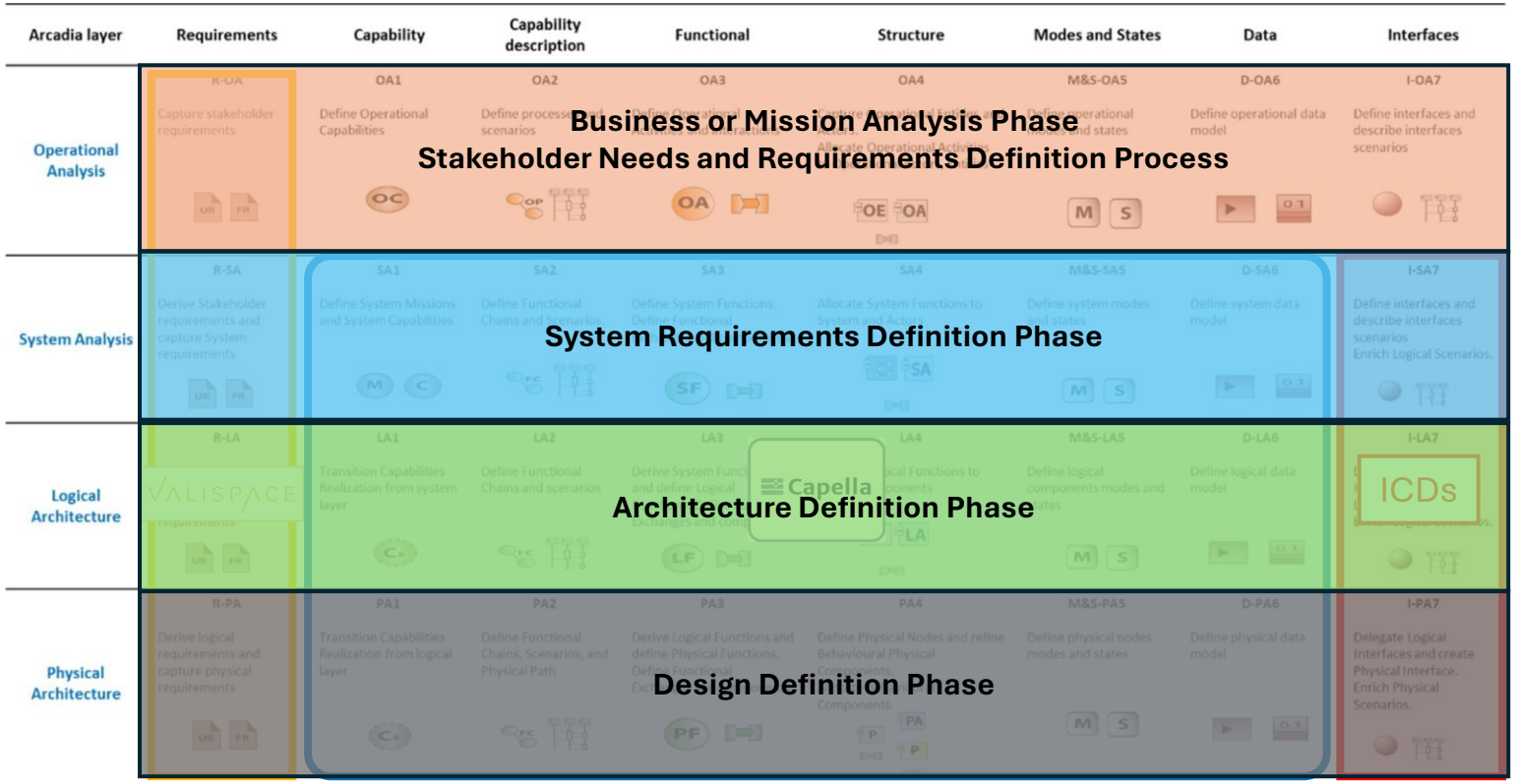


MBSE Deployment Strategy

RSN's **implementation-first** approach to MBSE - key strategies:

- ✓ Defining and communicating a clear scope tailored to the organizational structure and context
  - Having the organizational view, is imperative to assess what processes are **in-place** and what needs to be **added for Value**
  - Aligning MBSE with RSN's philosophy relying heavily on **procurement** and **co-engineering** with partners
- ✓ Retrofitting documents to reflect prior design decisions
  - In our organization MBSE was implemented at the mid way of Phase A/0 like status of Space Projects (**T0 = April/2024**: 1FTE until Sep./2024)
- ✓ Harmonizing engineering workflows
  - Focus on **interoperability** with other organization tools: e.g. requirements management tool (*Valispace*)
  - Establishing System Functional Design via Use Case: a new MBSE-driven process thoroughly defined to be adopted by different multidisciplinary teams

Synoptic View
Scoping & SE Phases



RSN Ecosystem – MBSE P.o.V.

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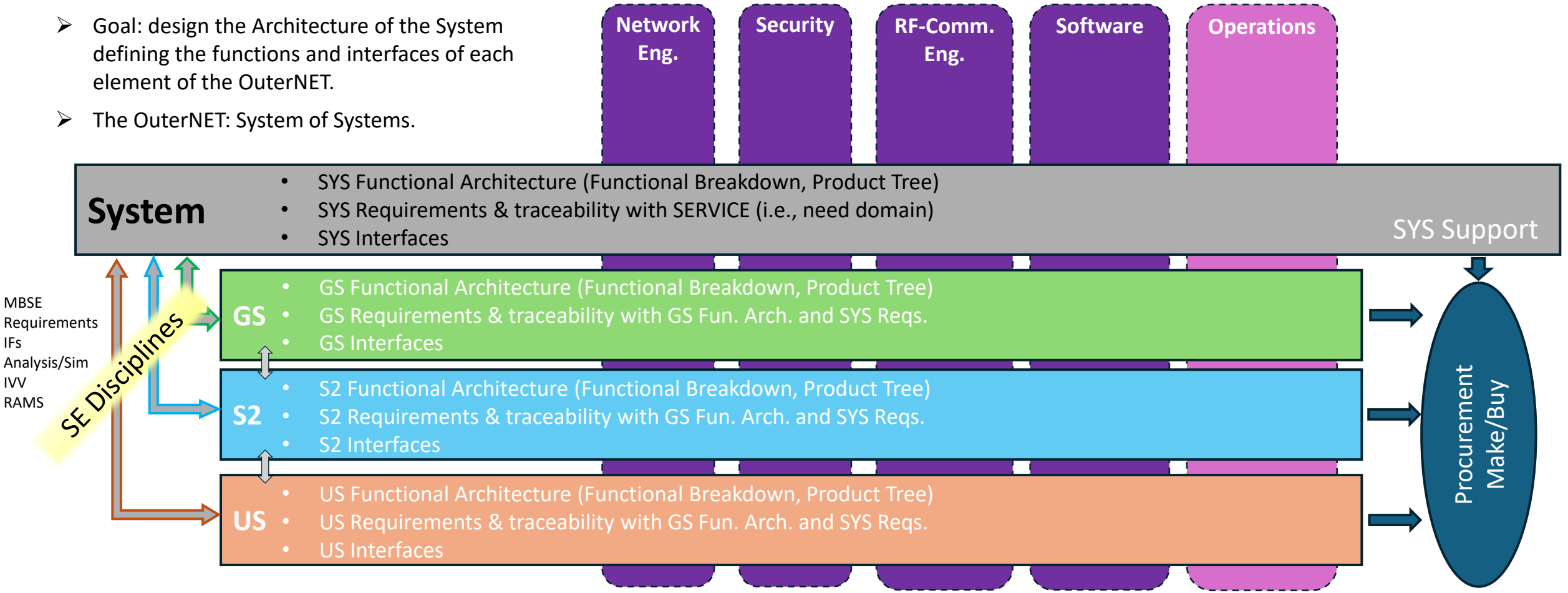
Solution Domain – OuterNET SoS

- Goal: design the Architecture of the System defining the functions and interfaces of each element of the OuterNET.
- The OuterNET: System of Systems.

The OuterNET technologies as Functional Design Drivers



How?

- Design Concepts (e.g., Network Design Concept) → expression Functional Needs.
- Deriving Functional Requirements (→Functions) allocated to Logical Components (e.g., from Network Requirement Document) of the OuterNET.

RSN Ecosystem – MBSE P.o.V.

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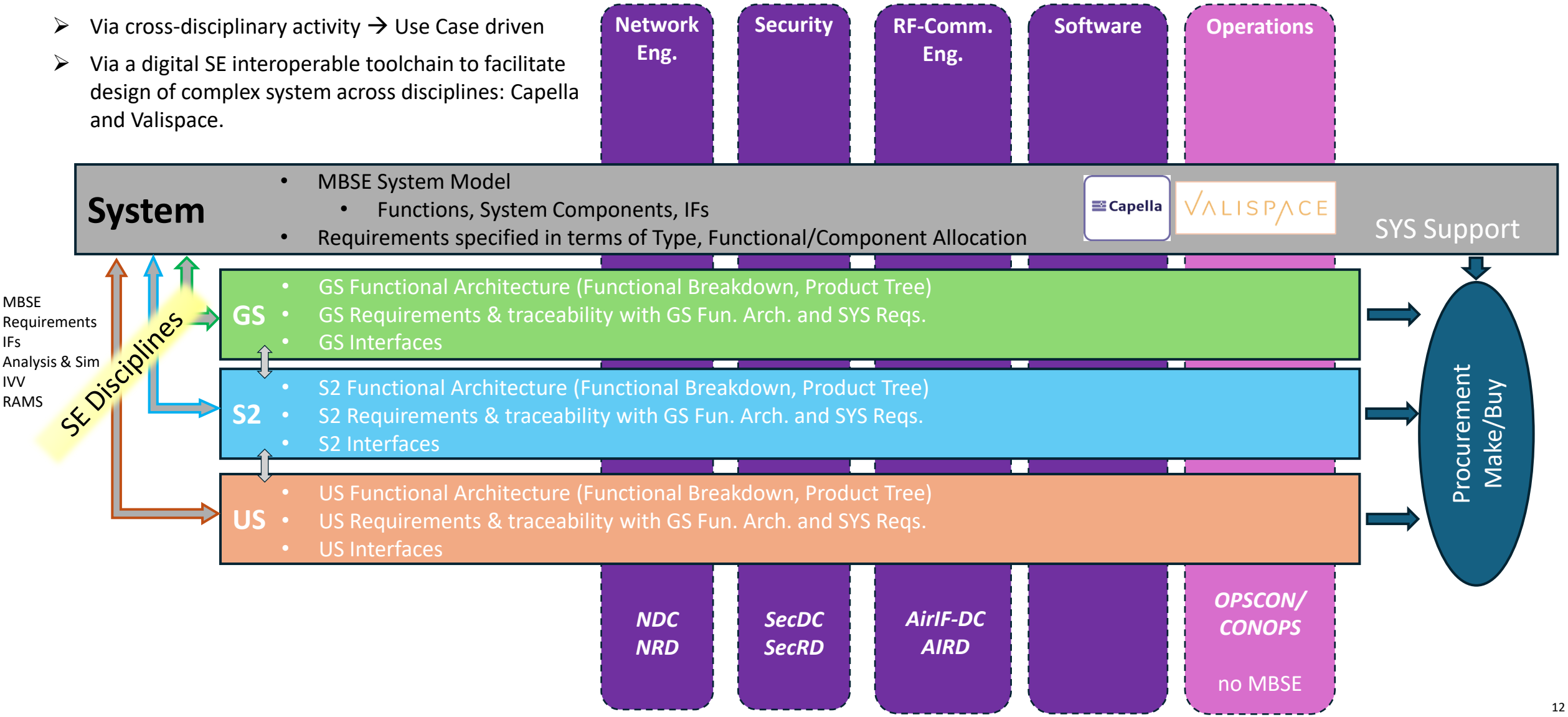
Architectural Design for Complex SYS:

- Via cross-disciplinary activity → Use Case driven
- Via a digital SE interoperable toolchain to facilitate design of complex system across disciplines: Capella and Valispace.

The OuterNET technologies as Functional Design Drivers



RSN Ecosystem – MBSE P.o.V.

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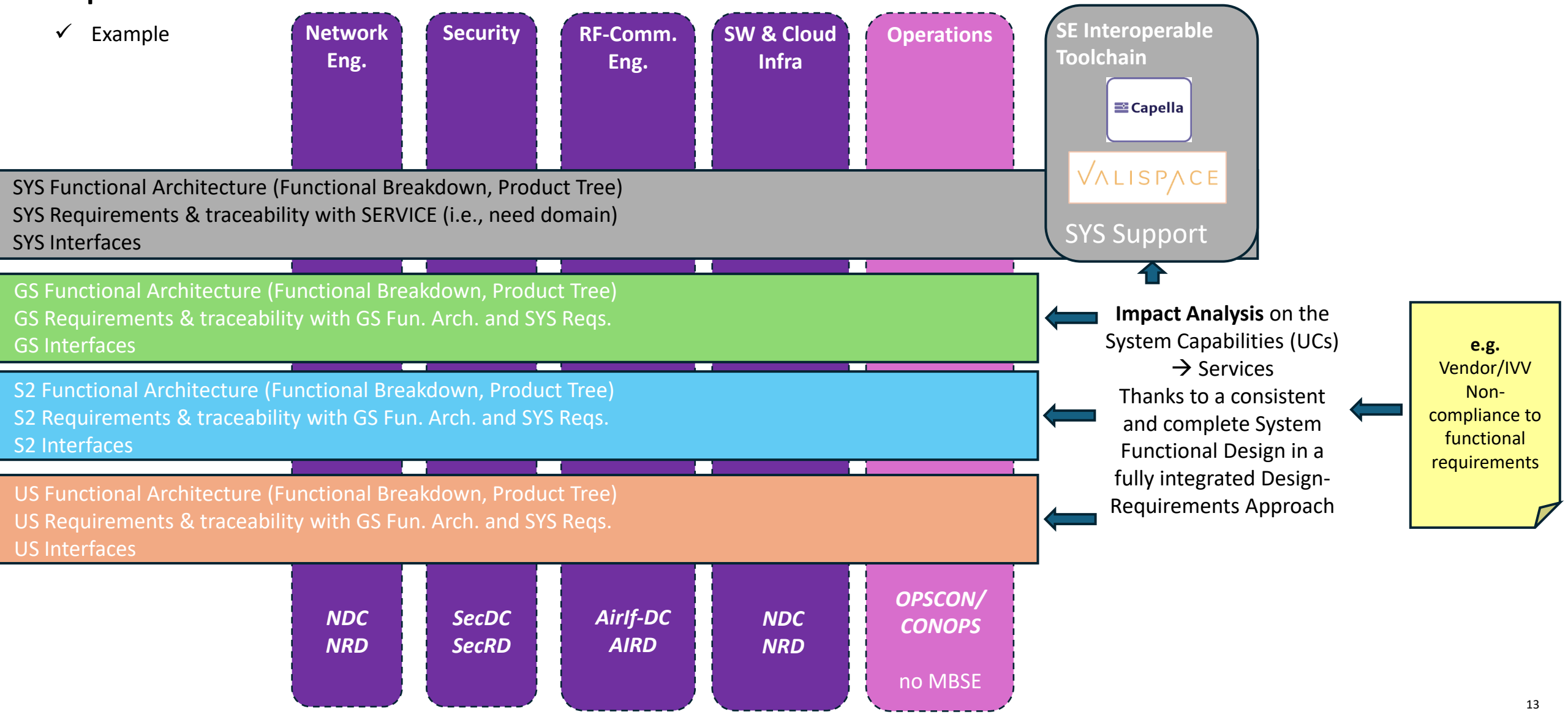
In practice…

✓ Example

The OuterNET technologies as Functional Design Drivers



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System Model Initialization

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T=0

time

Inputs

At T=0 => Initialization Activities started in April '24:

- Retrofitting Technical document (mainly the **SDD** System Design Definition baselined at 1st System Baseline Review) into Modelling Language
- ARCADIA and Capella tailoring

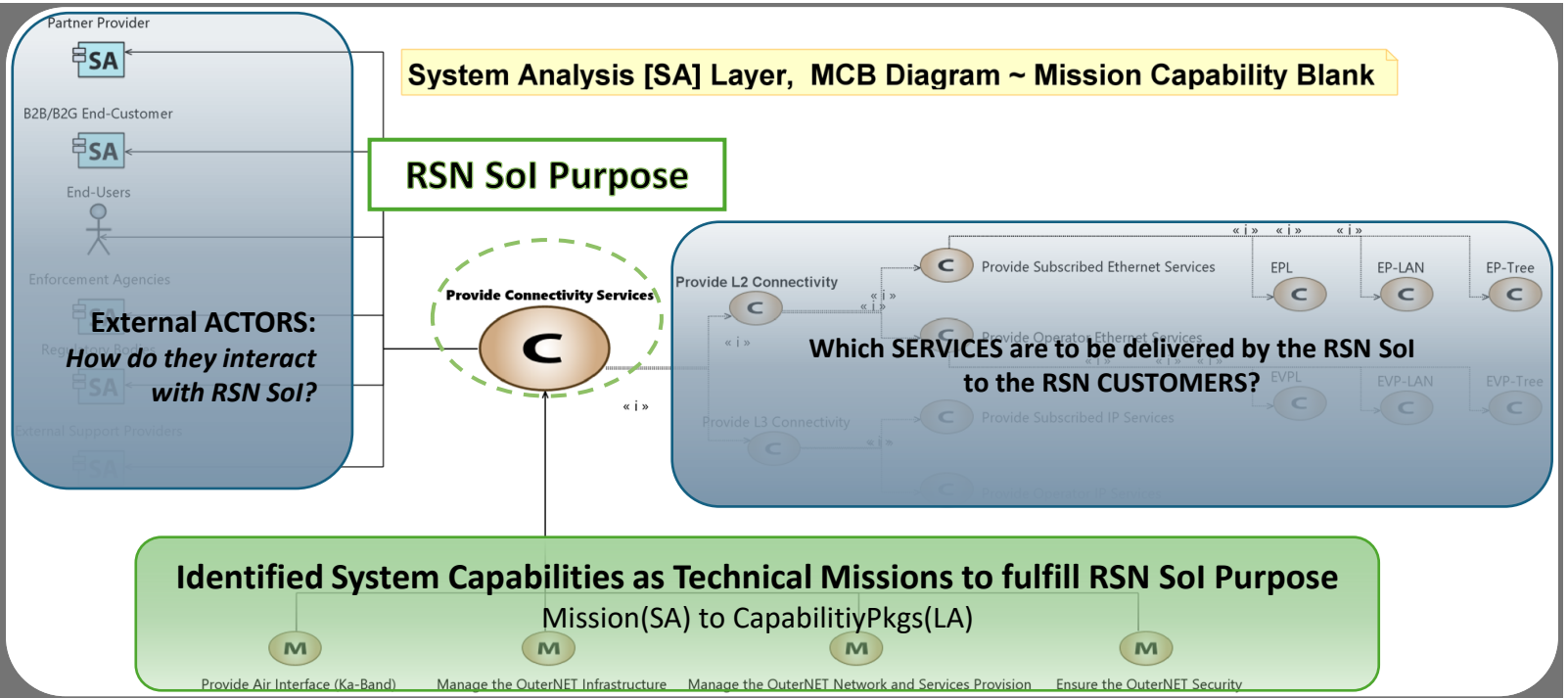
Initialization Logic

System Missions defined in the SA-layer identify the System Capabilities needed to deliver the services. They are transitioned to the LA-layer as *Capability Packages.*

Each *CapabilityPkg* is composed of different *Capability Realization Cr* – modelling the System Functions initialized from the SDD.

Each Cr is broken down in Logical Functions in LA-layer, allocated to logical components at Segment-level.

Segment to Element level detailed designed happens in PA-layer.



Workflow

- ✓ **The OuterNET system is pictured by a certain number of System Capabilities.**
- ✓ **Each capability is described by a set of identified Use Cases illustrated by functional chains and/or sequence diagrams (functions, functional exchanges, and associated requirements).** Modelling granularity: Segment-level in LA-layer, Element-level in PA-layer.

MBSE-driven Technical Workflow

Two main concurrent activities were proposed by the MBSE team to perform the **System Functional Design**

Use Cases and Use Case Scenarios

1. Identification & Categorization
2. Development

concurrent

Functional Analysis on the Requirement Documentation

- ❑ *UCs: How the OuterNET works?*

Which Functions are performed by which element of the System?

How the identified above functions interact with each other to deliver a certain system capability needed to provide service? I.e., interfaces.

- ❑ *Is the design translated into requirements in a complete, correct and consistent form?*

Are all the needed functions specified in dedicated requirements (and vice versa)?

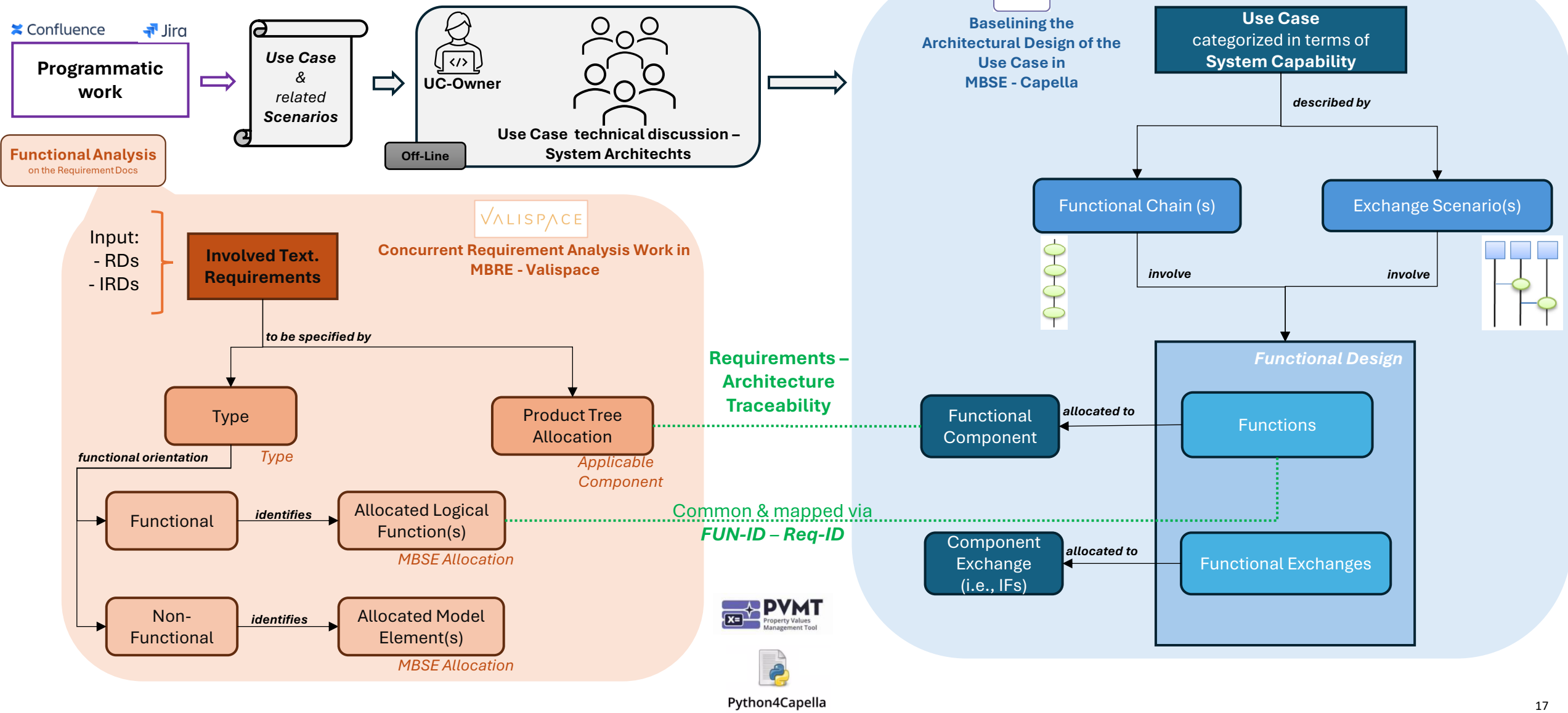
Is the set of technical specifications representative of the design entirely?

System Functional Architecture

Technical Specifications (Spec Tree)

MBSE-driven Technical Workflow - Detailed view

MBSE and MBRE workflow to ensure consistency and traceability



Addons Use Example : PVMT, Python4Capella

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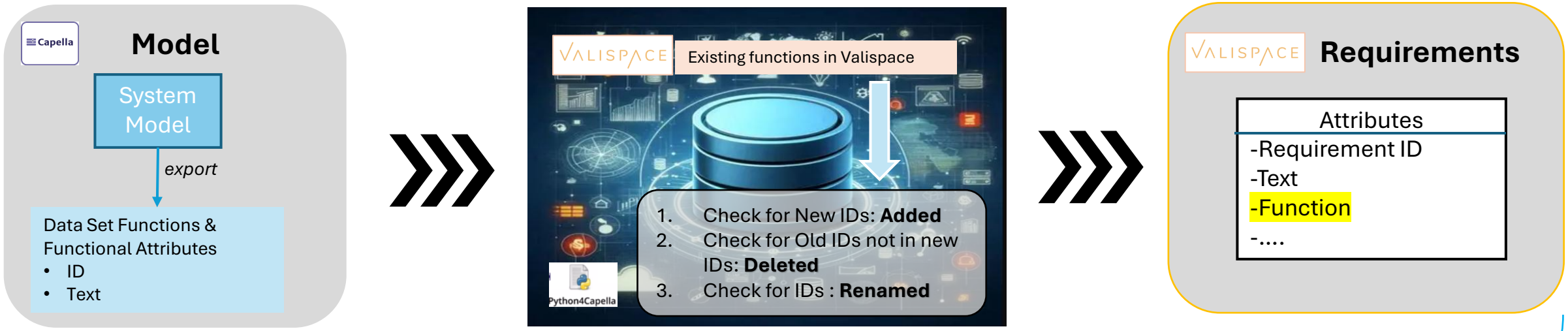
✓ Capella's Addons gave us the capability of high degree of flexibility
Situation: Even with a **no-OSLC compliant** tool an Interoperability Chain is established



Once the functions coming from Capella are imported in Valispace, the function needs to be attached to functional requirement (Req-IDs):

- the allocation activity is performed by the SME in Valispace for each requirement.
- Bi-directional link continuously highlights the justification of Functions & Requirements.
- Property Value is used for capturing requirement as an attribute of function in Capella

Example: Use Case and High Level

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- MBSE activities scope is at **system level**:

A **use case** at system level incorporates several technologies interfacing between the various segments come together to realize a specific objective set for a particular Use Case:

Example:
Two set of technologies (**A&B**) are employed for a specific way in which a User terminal on ground will connect to a satellite in the OuterNET's Constellation.

Technology A

Team A

Concept Document,…

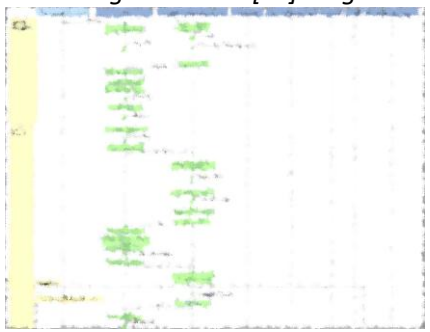
Technology B

Team B

Concept Document,…

Capella

Exchange Scenario [ES] diagram



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Facilitates

- ✓ Clear Visual representation of concepts
- ✓ Cross-Engineering Discussion
- ✓ Acts as the single source of truth

The High-Level View of Use Case provides:

- **Components** Involved
- Major **Functions** invoked and at which sequence
- Major **Functional Exchanges**

✓ Reviewed and agreed high-level view in Exchange Scenario [ES] is followed by lower-level, detailed modelling captured in [LAB]/[PAB] and relevant Functional Chains [FC].

Example : Use Case and Low Level

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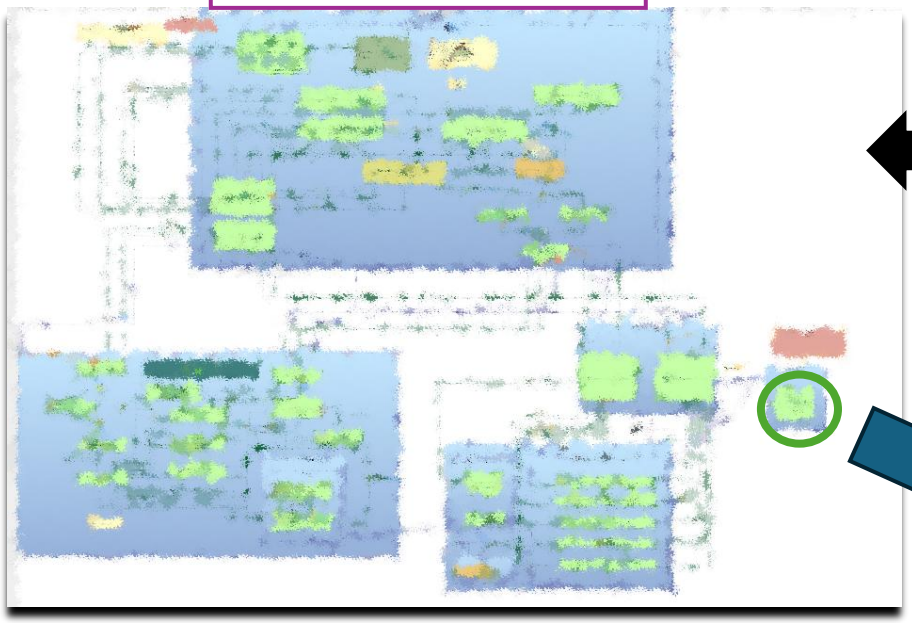
PAB diagrams



concurrent

Requirements view

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The detailed design of use case helps in:

- Identification of Exchanges, Interface Flows and Exchange Items
- Facilitates automatic validation of completeness of functional design i.e. **Use Case** with **Requirements**

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Domino Effect: Impact due to Technology Re-Design

Reasons possible :

- ❑ Facilitating the inclusion of technology advancement during development
- ❑ A major engineering tradeoff leads to an alternative design concept

Action to take:

- ✓ The Customized traceability gives a clear system-wide view, helping teams assess how a technology impacts each subsystem and account changes effectively.

Impacts due to Technology Re-Design

- Functions
- Interfaces
- Use Cases

Report Generated via excel

Provides Key Info:
- Function **owners** on change
- System Capabilities Impacted, ~ **Use cases**

Blurred due to clearance!

RSN Challenges & Solutions

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Being a process change required, challenges include:

- Adapt the way of working in the design process: more System Thinking!
- Scope of MBSE is very large and relative value can vary a lot within project scope.
- Integrating legacy products and models into the MBSE model.
- Quantity of data to be handled by the model.
- Upfront investment for MBSE approach
- Process definition and adoption by the different multidisciplinary teams
- Team training on MBSE processes and tools

A tough and steep uphill climb

LLs and best practices that work~

- Educate and train an initial cadre of modelers
- Scope MBSE activities clearly to organization
- Communication is key~
  - Develop system models that have immediate benefits to the project's needs
  - Model only what you need at the time
- Establish an institutionally-supported modelling environment
- Define modelling standards
- Partner modelers with system architects to get early buy-in
- Evolution not revolution!

To Summit, Collaboration + Gradual infusion is required

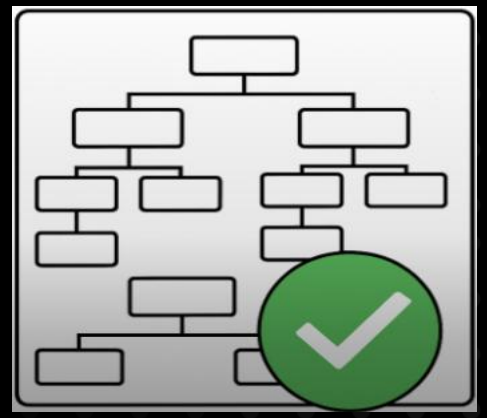
A Few KPIs we track

Functional Analysis in terms of MATRIX

Function	Requirement	Use Case
Function 1	Requirement 1	Use Case 1
Function 2	Requirement 2	Use Case 2
Function 3	Requirement 3	Use Case 3
Function 4	Requirement 4	Use Case 5
Function 5	Requirement 5	Use Case 5
Function 5	Requirement 5	Use Case 5
Function 5	Requirement 5	Use Case 5

- ✓ Matrix is Output of Model
- ✓ Highlights Gaps and ties **action items** to future Milestone
- ✓ Completely incorporated process within RSN

Model Quality and Validation Rules



- ✓ Automated checks, due to customization of Arcadia various validations done via scripts.
- ✓ Highlights discrepancies like : Duplication, Missing Traceability and more
- ✓ Periodically checked by MBSE team

Thank you for your attendance!

Vincenzo D'Onofrio

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Sahil Metta

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