CESAM Framework - MBSE

From complexity to clarity, a rigorous and collaborative approach to systems architecture

CESAMES

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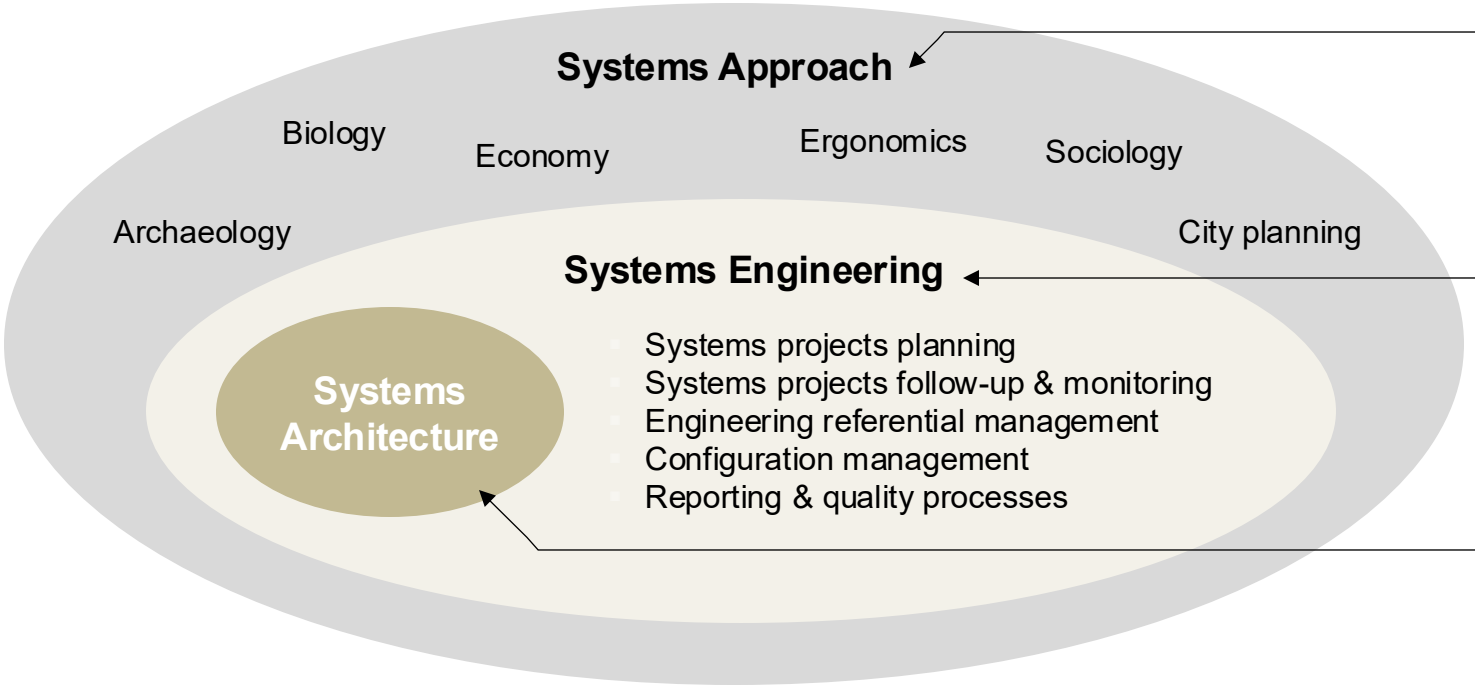
What is Systems Architecture ?

FROM SYSTEMS APPROACH TO SYSTEM ARCHITECTURE



Respective scopes of Systems Approach, Engineering and Architecture

A **holistic and integrative way of thinking** that considers all dimensions and interdependencies of a situation or system to better understand its complexity.

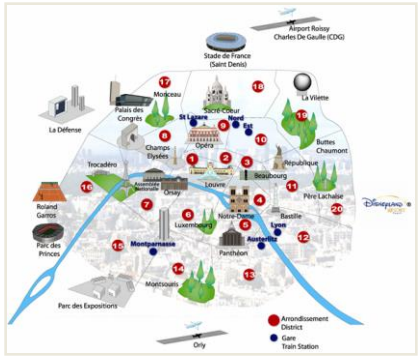
The **application of the systems approach to engineering activities**, enabling the structured development of complex systems across their life cycle.

The central activity within systems engineering, focused on **designing and building structured system models** to guide and align development efforts.

These three notions form a **continuum:** the **systems approach** provides the **mindset, systems engineering** brings it into **practice,** and **systems architecture** serves as the **structuring backbone** for system design

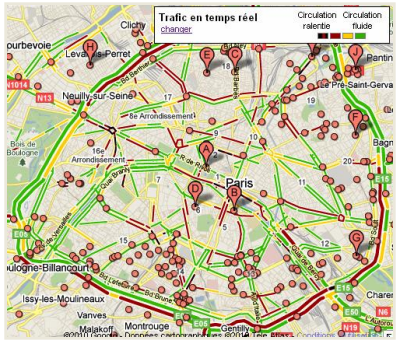
Why a Systems Architecture Framework

SPLITTING COMPLEXITY IN VIEWS …



Places to visit

« Real » Paris



Traffic

A complex system - e.g. Paris!
- looked through several views

Streets

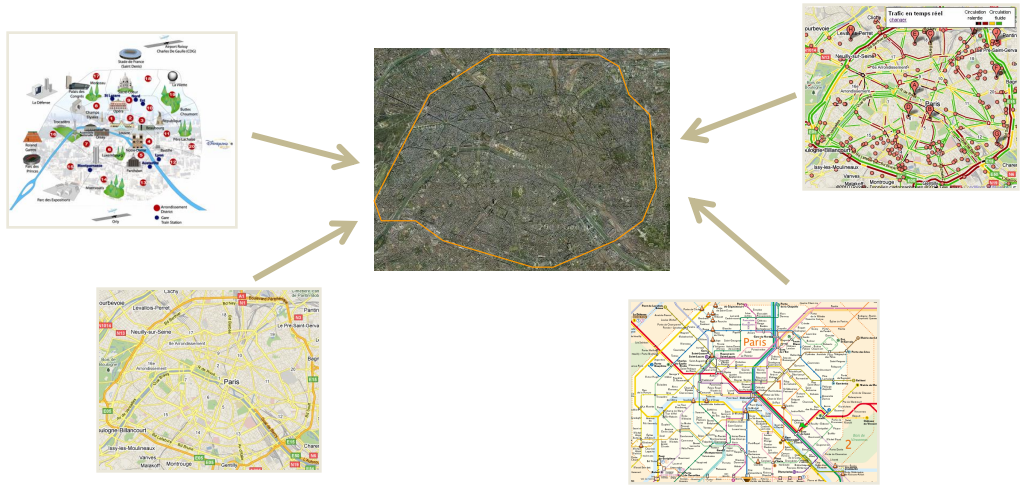
Ground transportation

Paris is a (more and more ?) complex system ☺

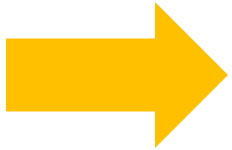
In the case of **complex systems**, **multiple representations** are necessary, each associated with a specific and inherently partial point of view.

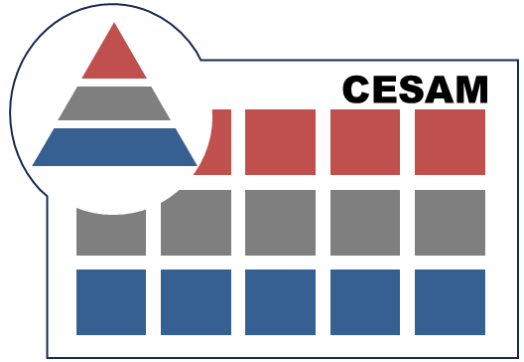
Why a Systems Architecture Framework

… STILL ORGANISED AND WELL-DEFINED



Uncoordinated, potentially unlimited views around a system





Structured, harmonized views defined through a framework

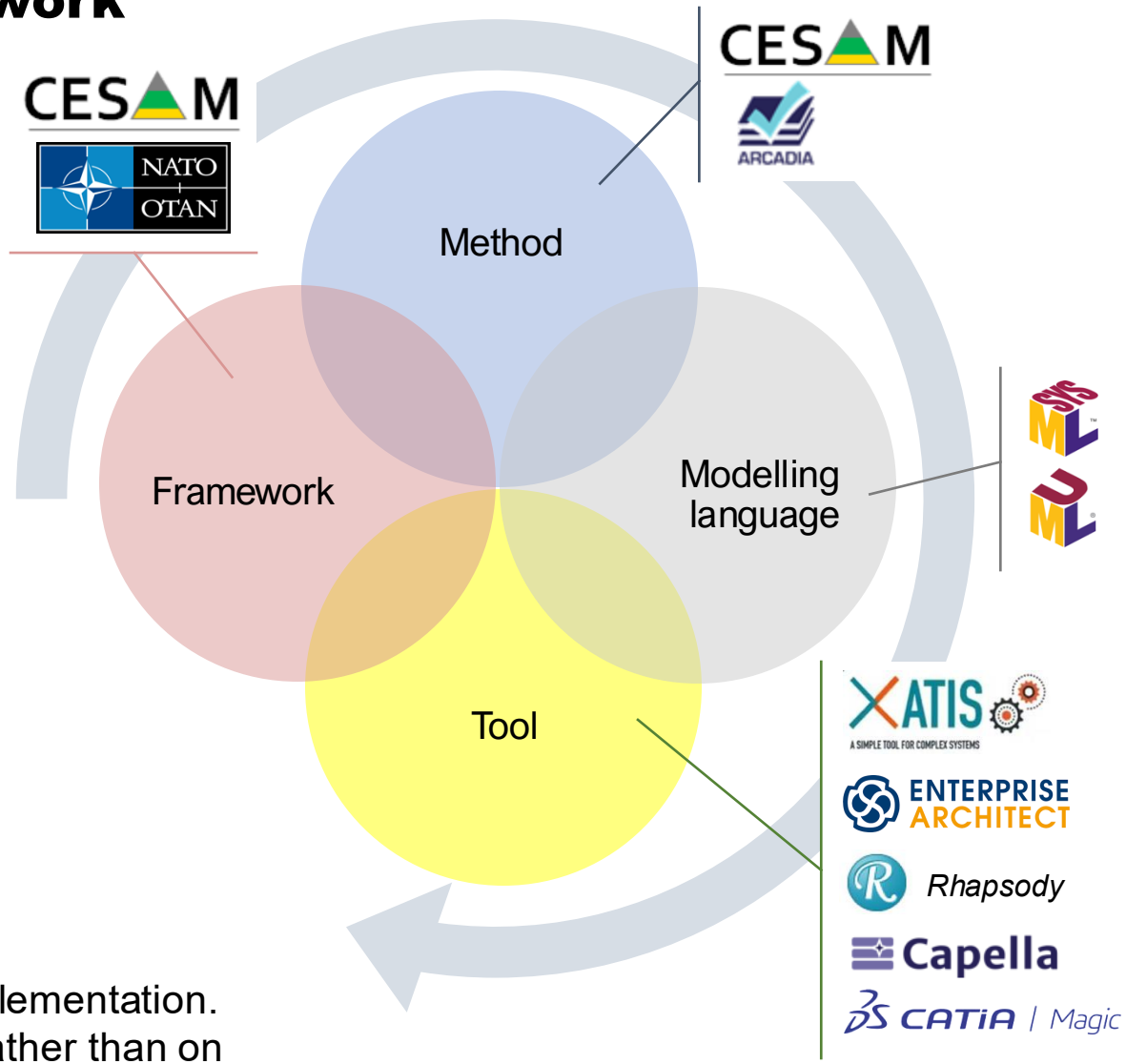
To ensure representations are useful and manageable, the **number of views** must be **limited**, and each must convey **clear** and **unambiguous** content. Defining these views, their content, and how they relate to one another is precisely the role of an architecture framework.

Why a Systems Architecture Framework

ALSO A KEY PILLAR FOR MBSE

Mastering MBSE requires understanding and addressing the following **four pillars:**

- **The Architecture Framework**
  What are the views that will form the model, and how are they interconnected?
- **The Method**
  How should these representations be defined, and who should be involved in each step?
- **The Modelling Language**
  Which formal language should be chosen to accurately transcribe these representations?
- **The Modelling Tool**
  Which tool should be used to formalize, capture, and manage the model?



MBSE Implementation 4 pillars

An architecture framework is a **key pillar** of MBSE implementation. Overlooking it leads to a focus on tool-driven outputs rather than on the key system aspects that need to be modelled

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CESAM framework

MADE OF 3 FUNDAMENTALLY COMPLEMENTARY LAYERS

1 Operational layer
WHY?

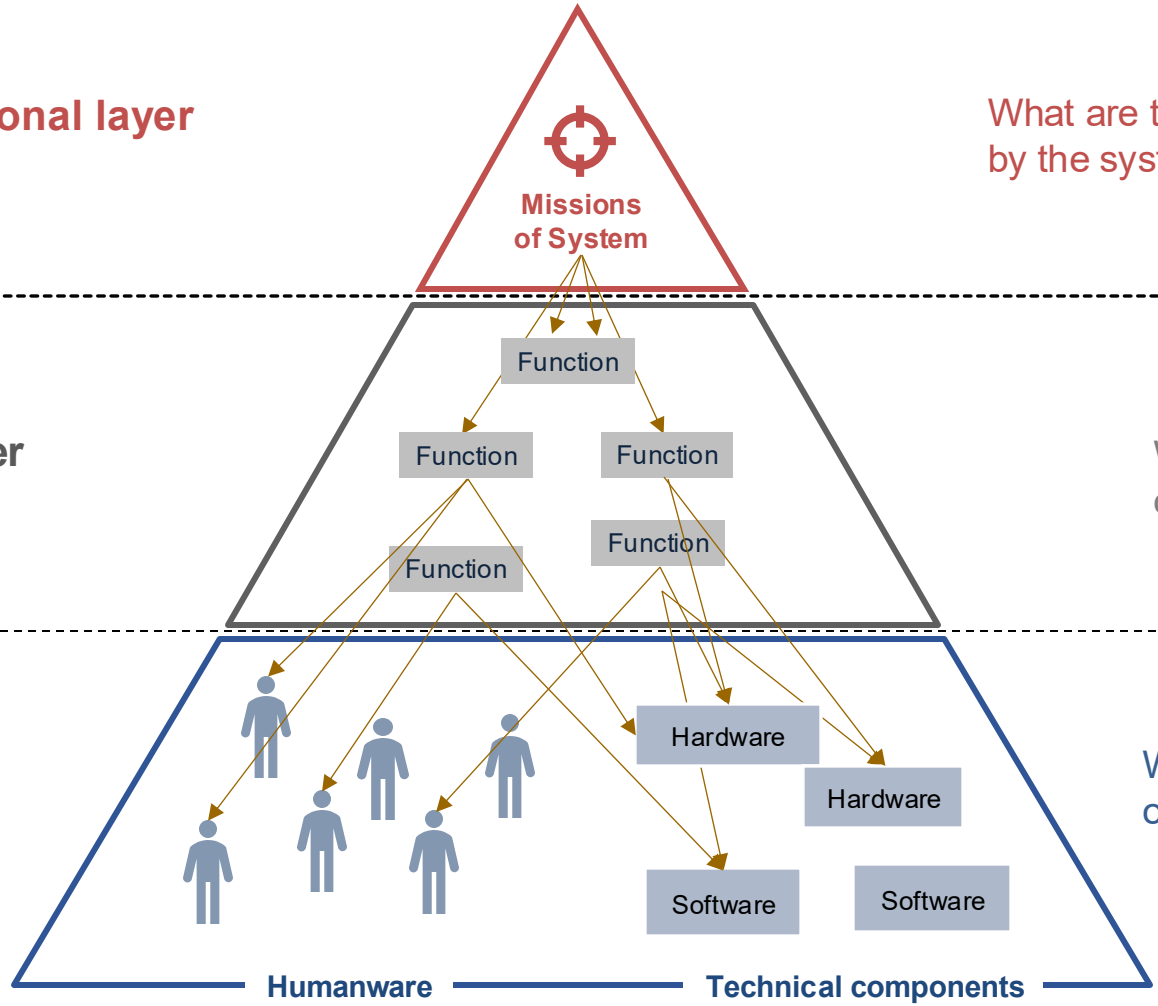
What are the **services provided** by the system to its environment?

2 Functional layer
WHAT?

What are the **functions** of the system?

3 Constructional layer
HOW?

What are the **resources** of the system?



The CESAM **Framework** enables to fully describe any system.
It is split in **3 layers** that analyse the system from a different perspective.

CESAM framework

OPERATIONAL LAYER

The **operational layer** of a system defines the **mission** of the system, analysed here as a **black box** from the **external perspective** of the system **stakeholders**

What we are looking at

We are looking at the **services** that the system shall offer and the **external constraints** that it shall take consider coming from its **environment**

Keywords

- Environment
- Stakeholder
- Service
- Need
- External interface
- Lifecycle
- Use case

Operational layer at a glance

Operational Breakdown Structure

The operational breakdown structure organizes all use cases of the system in a tree-like structure

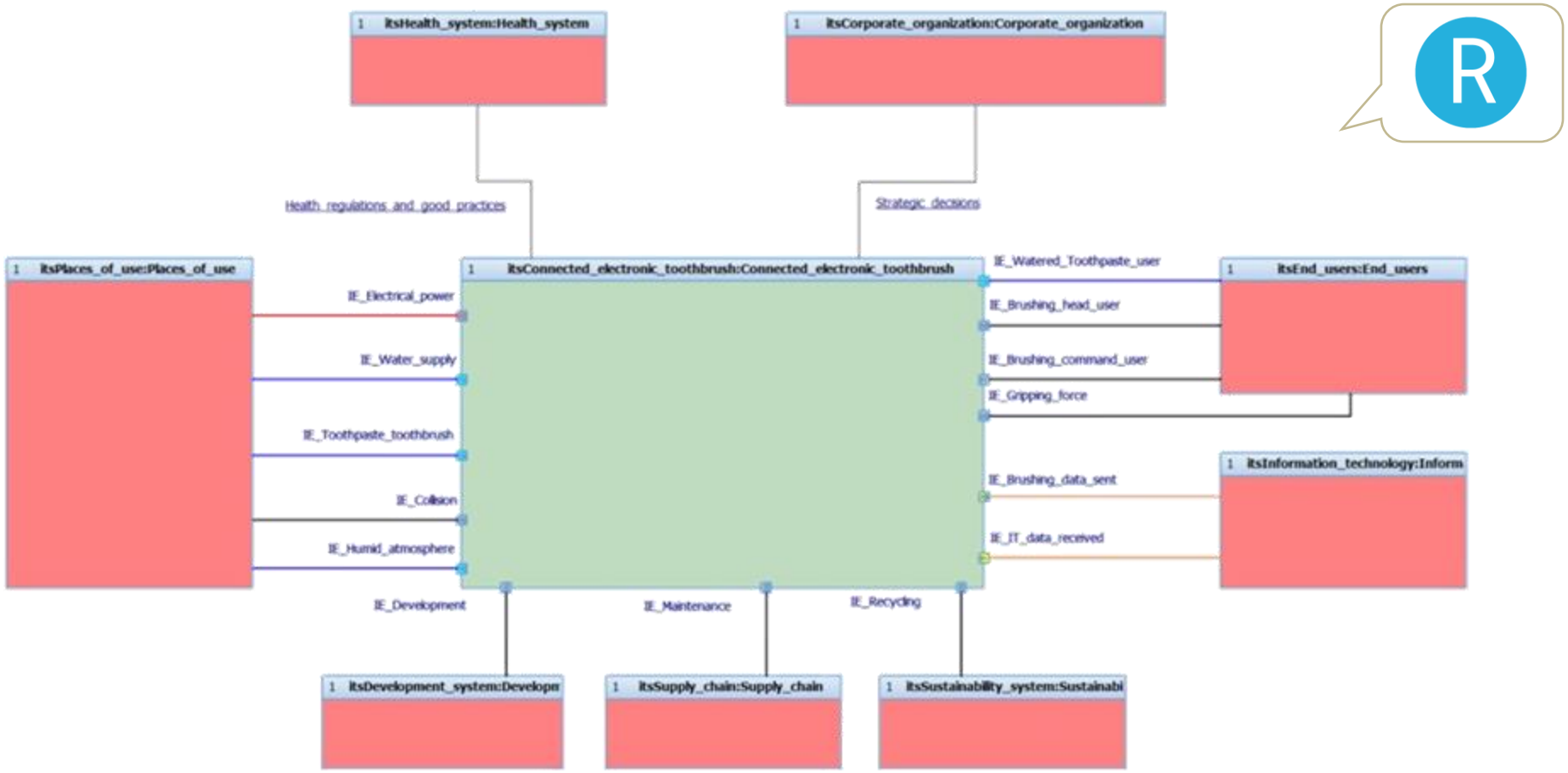
Stakeholder needs

The end-user wants to have a good dental hygiene with an objective of less than 1 cavity per year

Examples of outputs for the connected toothbrush

Environment Diagram

OPERATIONAL LAYER



Environment diagram for the Connected toothbrush, here modelled in Rhapsody

In the **operational layer**, a key diagram is the **environment diagram**, that intends to provide a view of all the external systems impacting the design, defining the system's boundary without ambiguity.

CESAM framework

FUNCTIONAL LAYER

The **functional layer** of a system defines the **abstract functions** of the system, analysed as a **grey box**, that are required to **deliver the system mission**

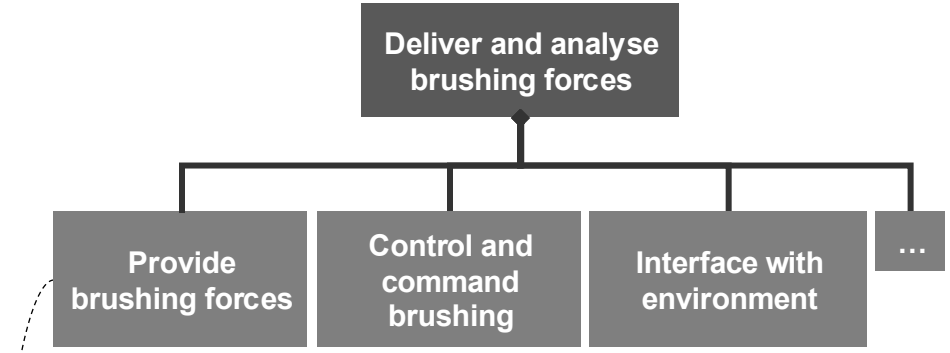
What we want to analyse

We are looking at the **functions** of the system, their exchanges and behavioural performances, but not yet looking at its components

Keywords

- Behaviour
- Function
- Functional breakdown
- Functional flow
- Functional Mode
- Functional requirement

Functional layer at a glance



Functional Breakdown Structure

The functional breakdown structure organizes all functions of the system in a tree-like structure

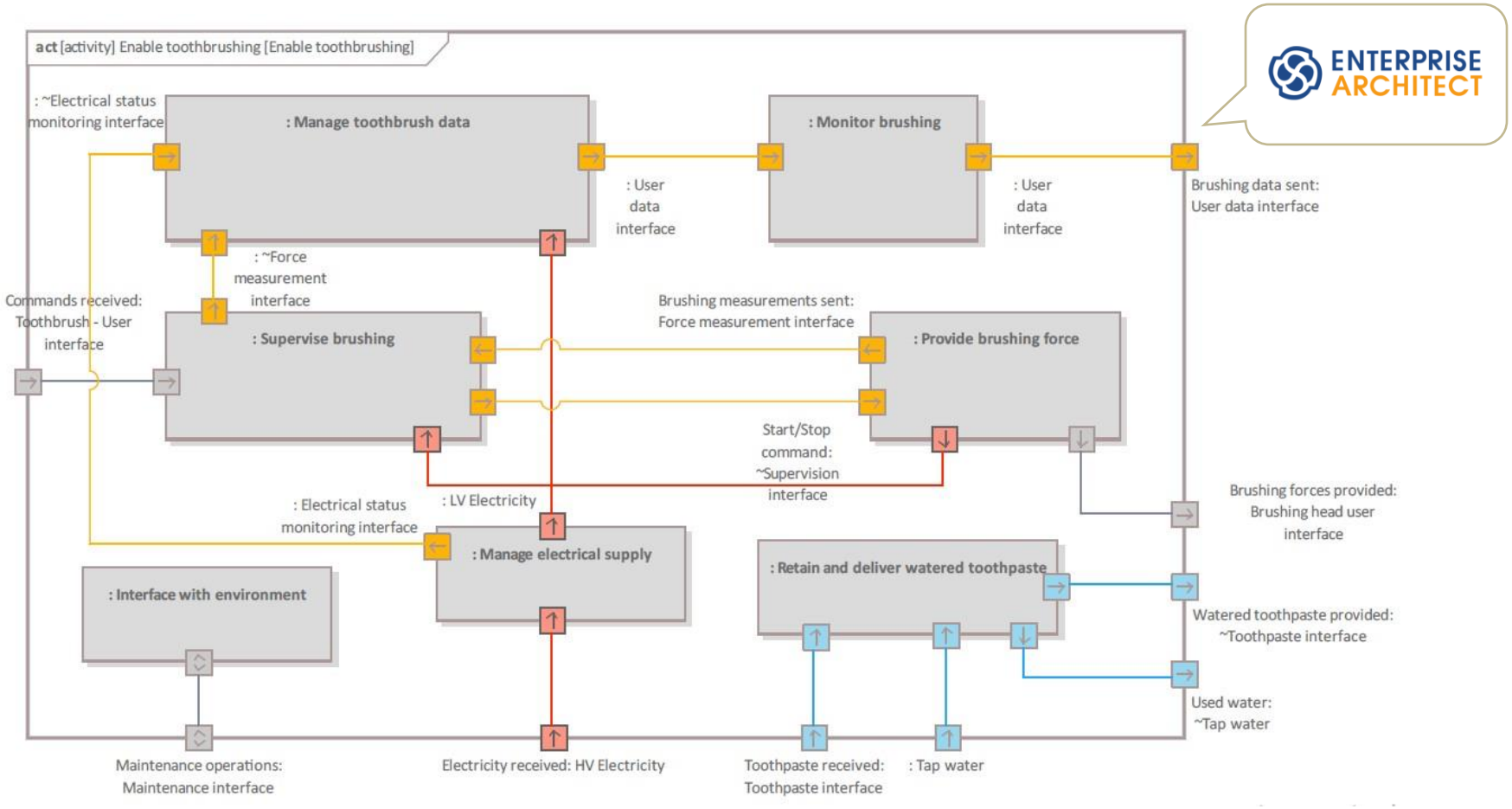
Functional Requirements

The connected toothbrush must provide brushing forces of 0.5N in brushing mode

Examples of outputs for the connected toothbrush

Functional interaction diagram

FUNCTIONAL LAYER



Functional interaction diagram for the Connected toothbrush, here modelled in Enterprise Architect

In the **functional layer**, a key diagram is the **functional interaction diagram**, that intends to provide a view of all the functions of the system, defining the system's behavior without ambiguity.

CESAM framework

CONSTRUCTIONAL LAYER

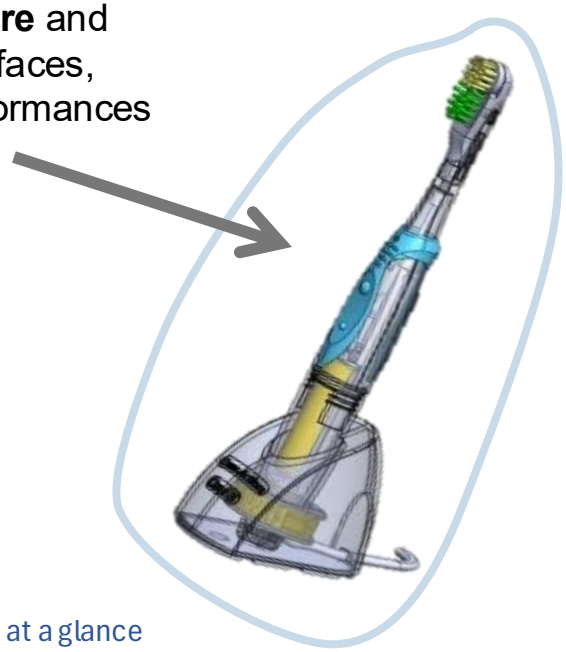
The **constructional layer** of a system defines the **components** and **building blocks** of the system, analysed as a **white box**, that **implement the functions** of the system

Constructional analysis

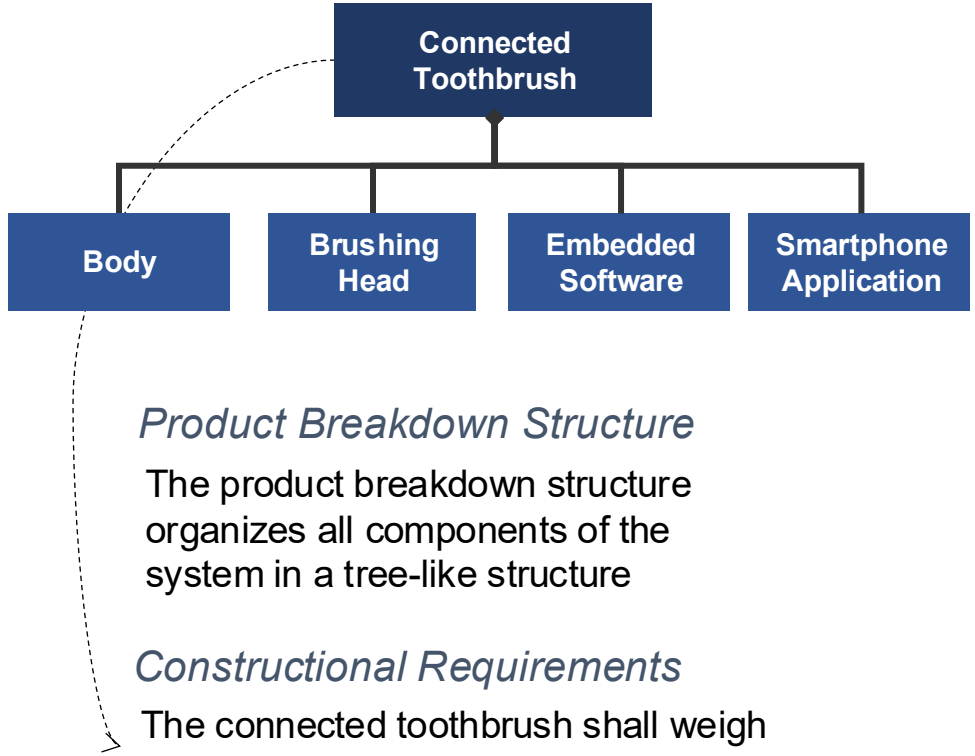
We are looking at system **structure** and **components,** their concrete interfaces, dependencies and structural performances

Keywords

- Structure
- Component
- Product Breakdown
- Building block
- Constructional requirements
- Technical Configuration



Constructional layer at a glance



Product Breakdown Structure

The product breakdown structure organizes all components of the system in a tree-like structure

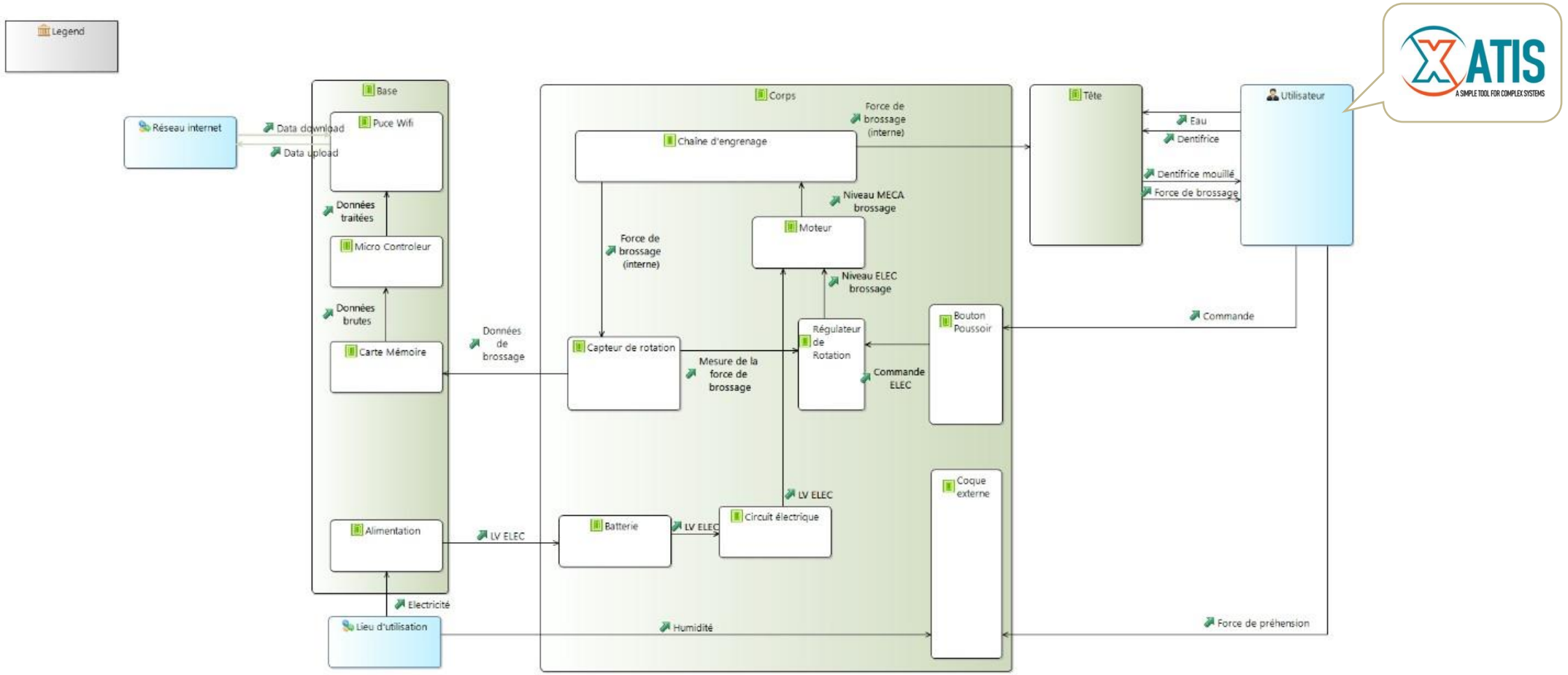
Constructional Requirements

The connected toothbrush shall weigh less than 250 g in all configurations

Examples of outputs for the connected toothbrush

Constructional interaction Diagram

CONSTRUCTIONAL LAYER



Constructional interaction diagram for the Connected toothbrush, here modelled in Xatis

In the **constructional layer**, a key diagram is the **constructional interaction diagram**, that intends to provide a view of all the components of the system, defining the system's structure without ambiguity.

CESAM framework

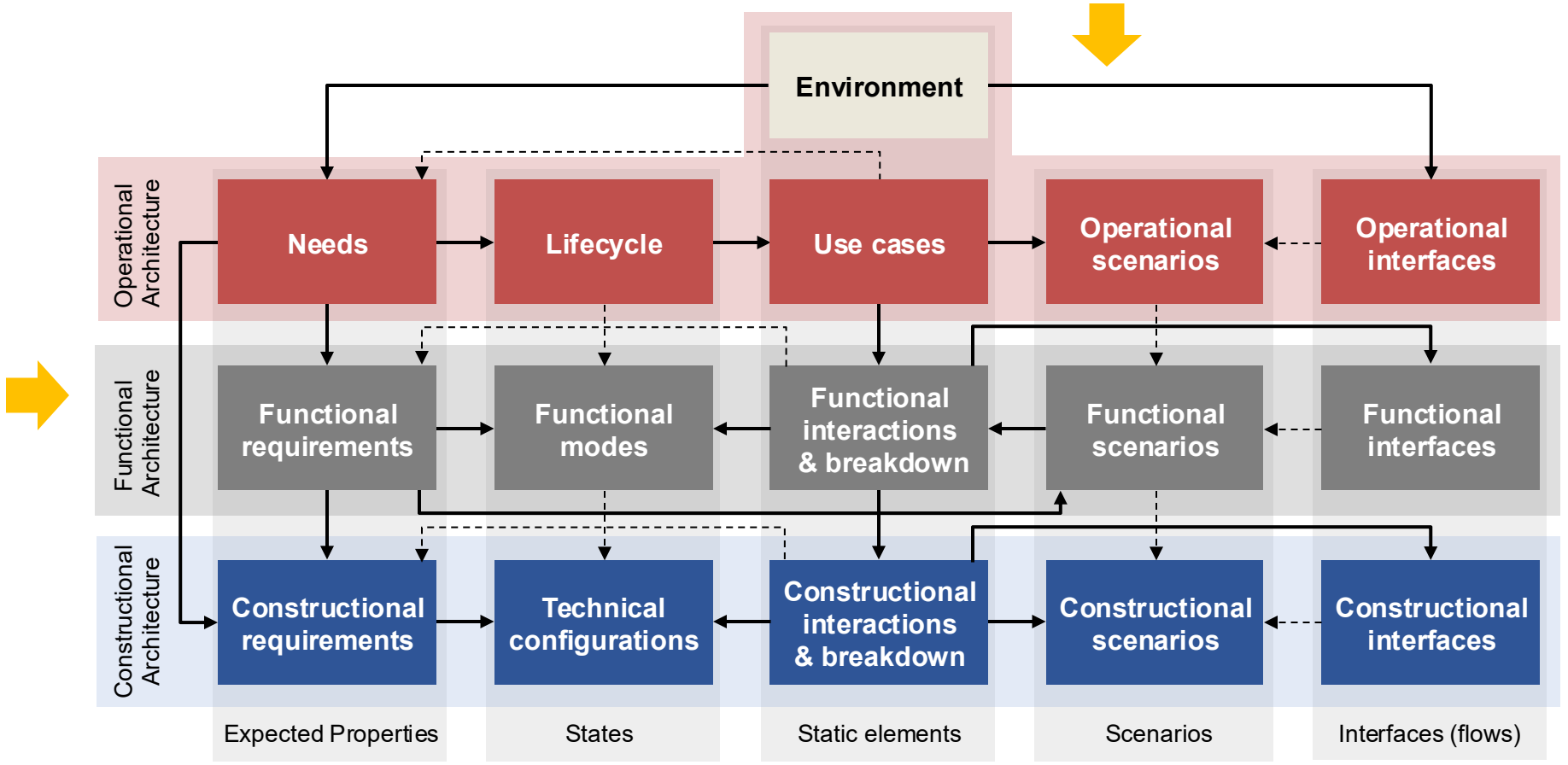
3 LAYERS … AND 16 VIEWS

The **aspects** (columns) correspond to what we can describe within each layer.

▼ Expected properties ▼ States ▼ Static elements ▼ Scenarios ▼ Flows

The layers (rows) correspond to the 3 perspectives from we can analyse the system

- its **environment**
- its **behaviour**
- its **structure**



The CESAM framework matrix representation : with each view intersecting a layer and an aspect

Each layer of the framework is described using the **same five aspects**. This reduces the number of concepts to learn and making it easier to connect information across and between views.

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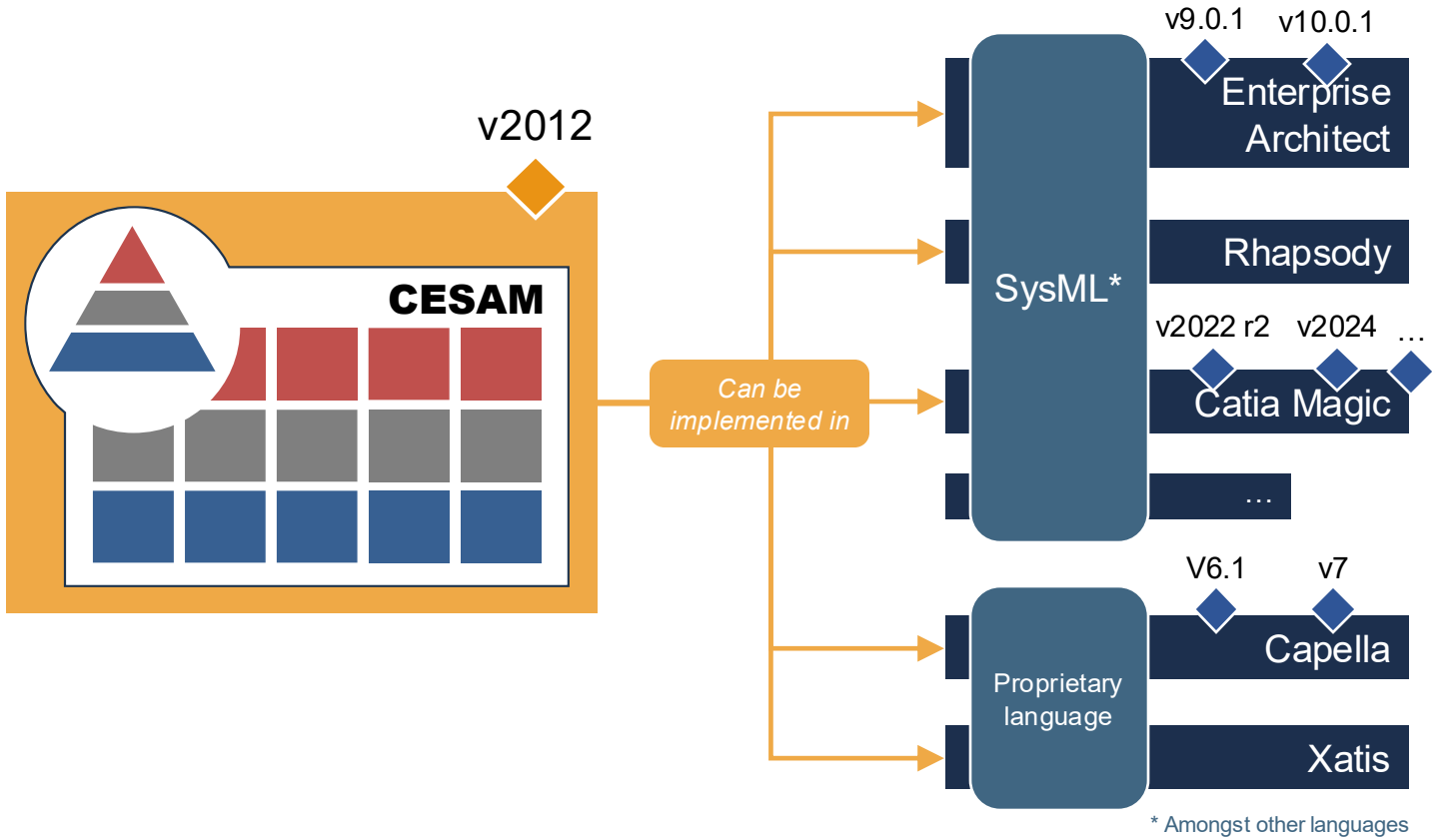
Implement in modelling Tools

INDUSTRIAL APPLICATIONS



The CESAM framework, as a stable modelling intention that can be implemented in various ways

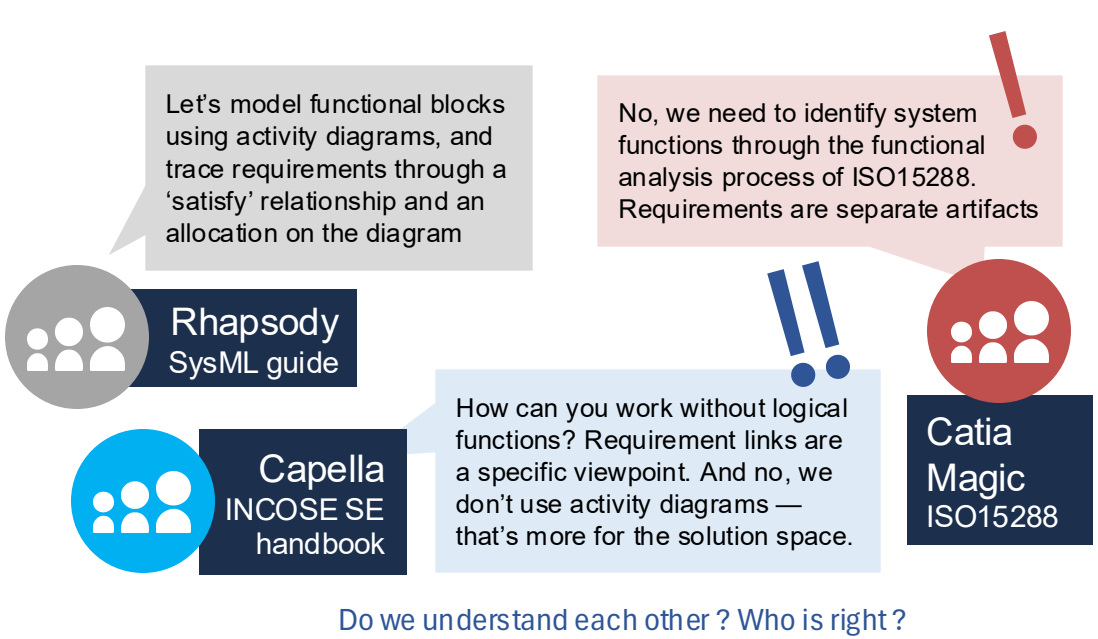
Fulfil your intention with any MBSE tool
thanks to the limited number of essential concepts easily mappable to MBSE tools

Tools change, your intention remains
thanks to stable way of working foundations that ensures continuity in your approach.

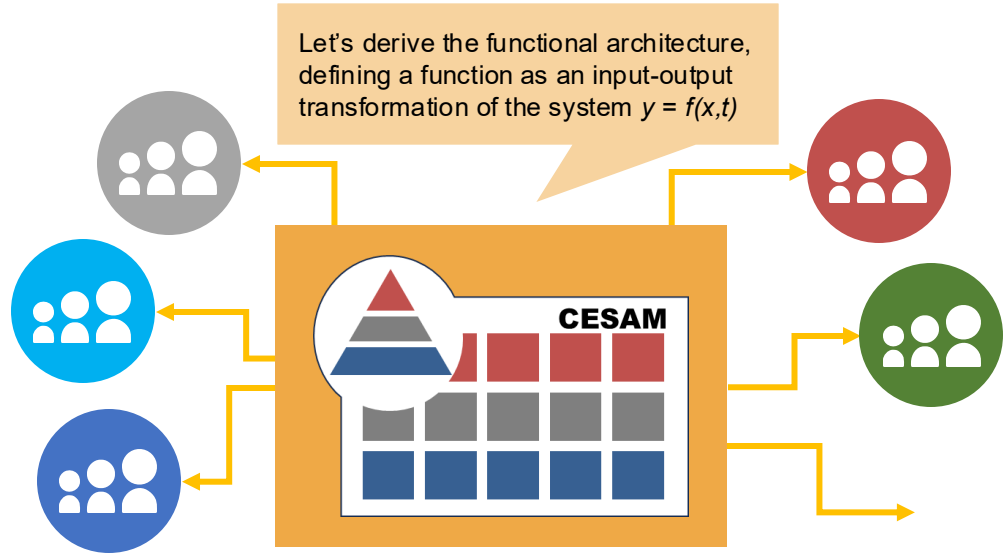
The CESAM Framework can be - and has been implemented! - in all the existing system modelling tools.
This implementation is done through a mapping of the framework with the tool modelling language concepts.

Foster collaboration

INDUSTRIAL APPLICATIONS



Do we understand each other ? Who is right ?



It was hard, but now we speak the same language

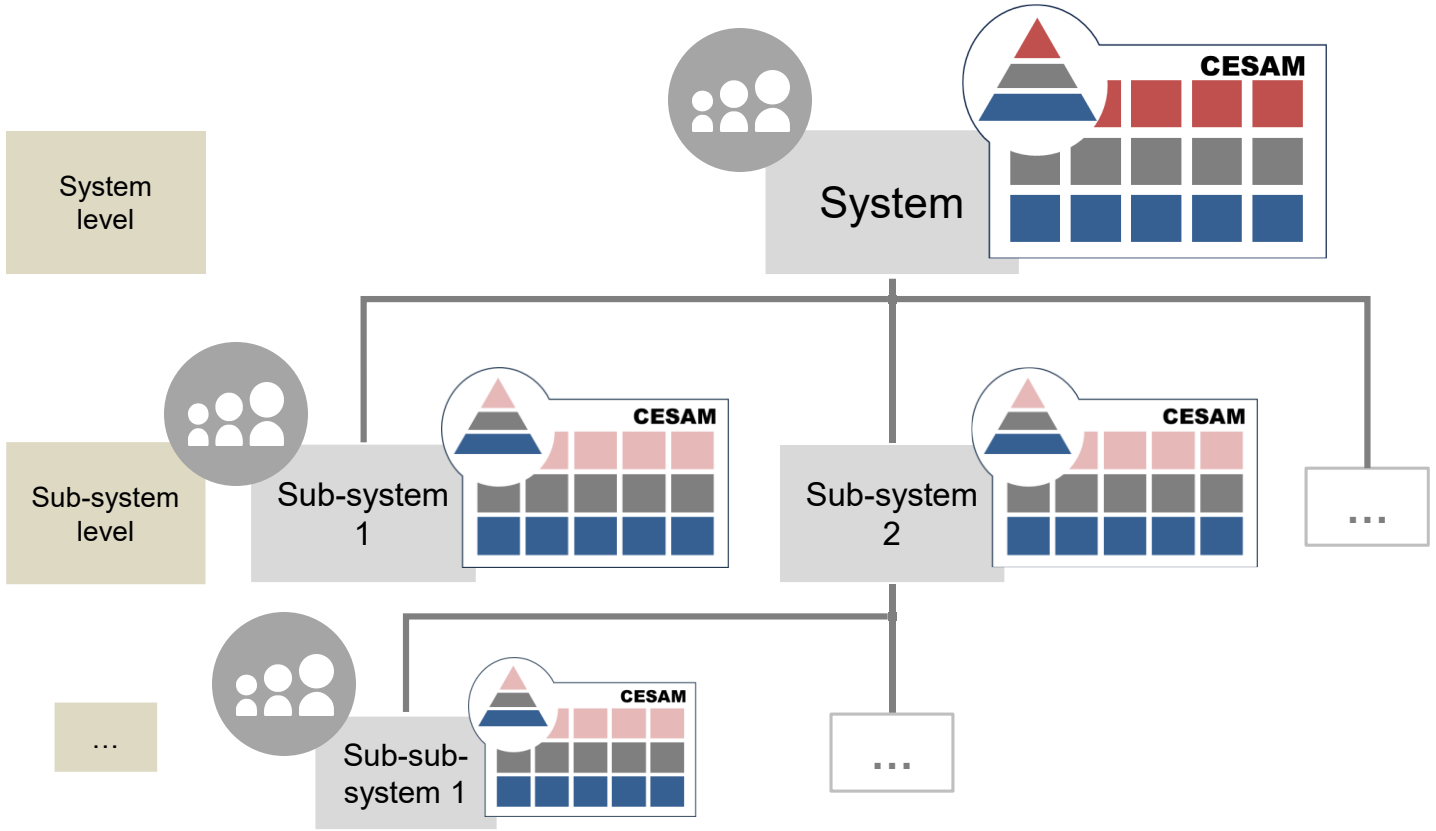
Various ways to name the same concept
Various definitions behind the same 'name'

Harmonization Across Teams and Tools
Sustaining Architecture Thinking

The CESAM Framework can be - and has been! - used as a common language for Engineering teams.
This common language comes from capturing as is situations, adapting the framework and training at various levels.

Organise modelling work

INDUSTRIAL APPLICATIONS



Simplified representation of the CESAM Framework's recursiveness

Optimizes system design efforts with a common understanding of :

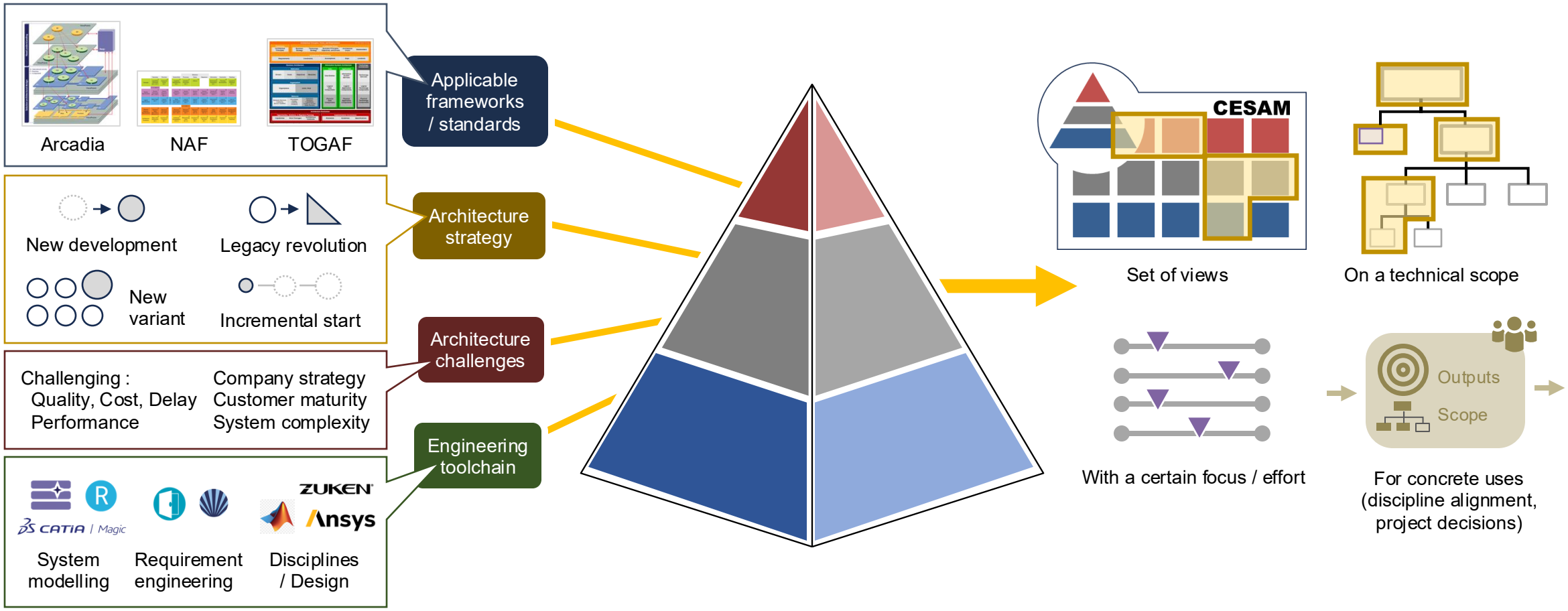
- what needs to be modelled at each level / by each team
- What are the "handover" artefacts (e.g. interfaces)

to maintain design consistency and limit **modelling effort** to the just necessary

The CESAM Framework is **recursive**, with a simple **handover of artefacts** across the developed scopes. enabling to **avoid redundancies, over-modelling while ensuring better consistency**

Adapt to all contexts

INDUSTRIAL APPLICATIONS



The CESAM framework provides a **powerful simple toolbox**, allowing companies to **understand**, **interpret** and **integrate** in **any context** and be able to optimize decision-making, in an efficient and global manner

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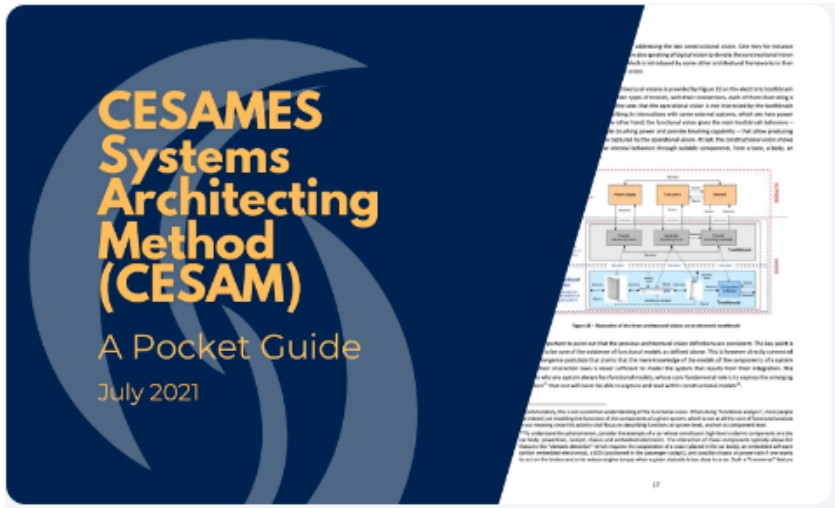
Resources

POCKET GUIDE



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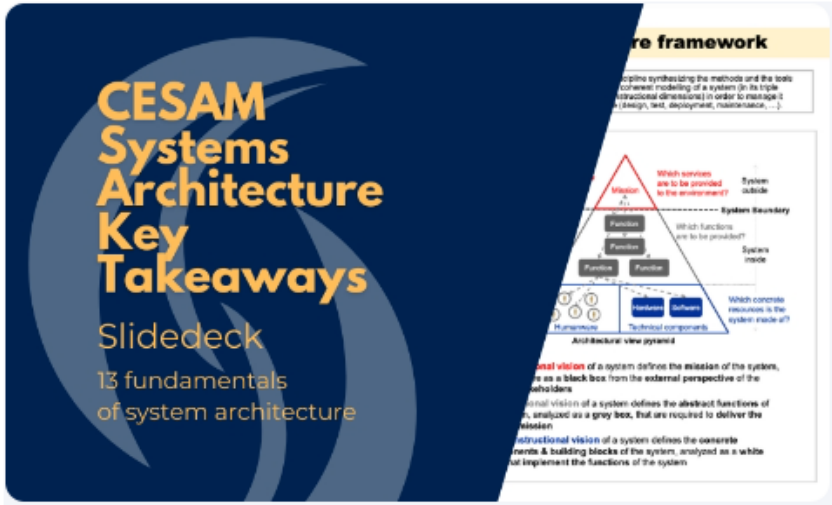
Pocket Guide

CESAMES Systems Architecting Method (CESAM) is a *systems architecting & modeling framework* which develops since 2003 in close interaction with many leading industrial companies in areas such as aeronautics, automotive, civil engineering, defense, energy, health, railway and space. It was initiated within the academic sphere in the context of the “Engineering of Complex Systems” industrial chair in France (Dassault Aviation – DCNS – DGA – Thales – Ecole Polytechnique). Nowadays the members of CESAM Community act however as the *core developers & contributors* of the CESAM framework which is presented in a light version in this pocket guide.

Download

Resources

KEY TAKEAWAYS



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CESAM Systems Architecture Key Takeaways

Complex projects are characterized by the multiplicity of components, technologies, and stakeholders and above all by the number of interfaces to be controlled. Complex projects duration combined with the acceleration of processes and services evolutions mean that most of the phases studies will be initiated while many of the structuring parameters are not yet defined… which can lead to many pitfalls.

Systems architecture provides valuable guidance to guarantee efficient and sustainable development while de-risking the projects. The objective is to anticipate design risks during the early phases of the project to minimize systemic problems and thus save time and cost.

Discover the **13 fundamentals of system architecture**.

Infographic Format | Presentation Format

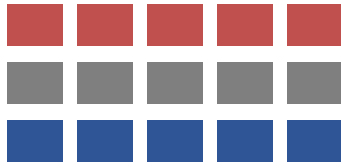
What can you do tomorrow?

Download free resources

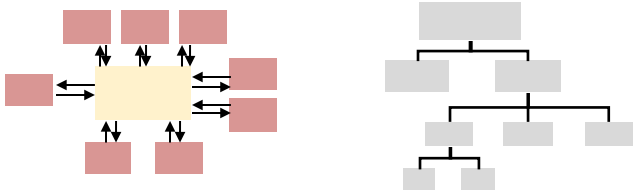
CESAM COMMUNITY

Expand your Systems Engineering knowledge, techniques and network by :

- Getting first-hand information and good practice on MBSE
- Participating to events (webinars, conferences…)



Join the CESAM Community



Explore and Practice

Get training

Our training catalogue

Raise awareness of the system approach

Discovering the Discipline 1d
- Introduction to System Engineering

Awareness of key challenges 0.5d
- Addressing key challenges with Systems engineering
- Enterprise transformation: why Architecture matters

Awareness of key content 1d
- Awareness of System Architecture
- Awareness of Enterprise Architecture
- 2025 Introducing Systemic Approach through a Serious Game

Master system engineering fundamentals

Mastering complexity of complex products 3d
- MBSE: System architecture fundamentals

Same course with reference:
- Defense: **NAF** framework
- Automotive: **ASPICE**
- **Embedded Systems Architecture**

Mastering business and information systems transformation 3d
- Enterprise architecture fundamentals

Same course with reference:
- Link with TOGAF framework

Tool the system engineering approach

Modeling Languages 2d
- Introduction to SysML Language

Structure a Model-Based approach ... 2025 2d
- in **Rhapsody**
- in **Catia Magic**
- in **Xatis**
- in **Capella**
- in **Enterprise Architect**
- Product lines with **Pure::Variant**

Develop specific activities or soft skills

A system engineering activity 2d
- Needs and Requirements
- Data Architecture
- 2025
- Verification & Validation
- Configuration Management
- 2025
- System Architecture and Safety

Soft skills to enhance the impact of architecture 1d
- Facilitate an architecture workshop
- 2025 Pitch architecture Effectively
- 2025 Support change management

Leverage architecture for your challenges

- Product Lines
- Eco-Design
- 2025 Information System Master Plan 2d
- Agility and Architecture
- Digital Twins
- 2025 Architecture Governance

And also ...
- 2025 AI to Boost MBSE Practices 0.5d

Excel through advanced practice

- On the job training in System Architecture 6 to 9 months
- Coaching sessions N × 2h

Our training courses cover **all MBSE lifecycle**, **population** and **maturity** levels, in English and online.

Contact our academy for more information: academy@cesames.net

Contact

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