

# SUSTAINABLE PRODUCT DESIGN THE TIME IS NOW

Elmeri Mehtomaa, Junior PLM Consultant

Christophe Surdieux, Senior Systems Engineering & Sustainability Architect

Urte Steponkute, Senior Systems Engineering Consultant

An aerial photograph of a lush green mangrove wetland. A prominent, winding waterway cuts through the dense vegetation, creating a complex network of channels and islands. The water appears calm and slightly murky. The overall scene is vibrant and natural, highlighting the intricate patterns of the ecosystem.

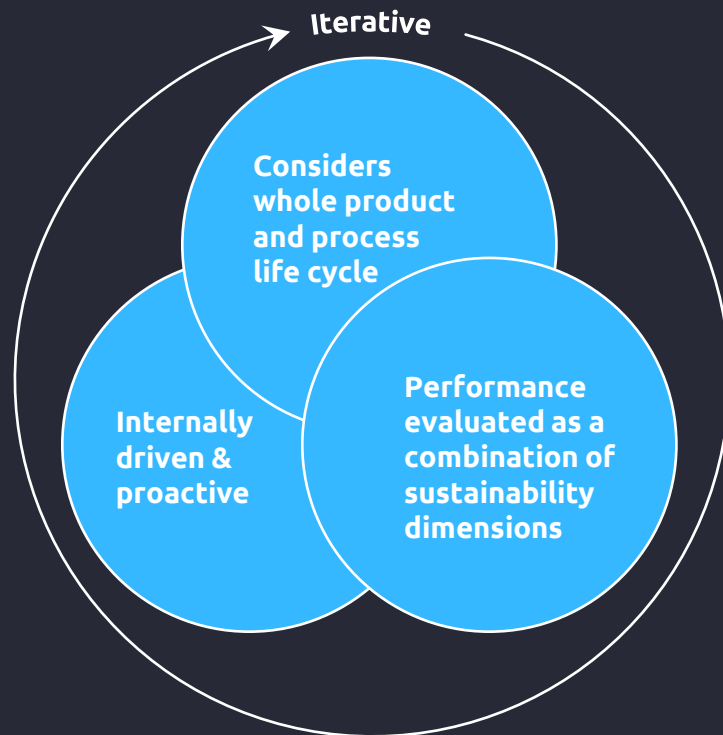
**SUSTAINABLE  
PRODUCT  
DEVELOPMENT –  
LATEST INSIGHTS**



# DECISIONS MADE DURING PRODUCT DEVELOPMENT PHASE HAVE SIGNIFICANT IMPACTS TO COMPANIES' BUSINESS ACTIVITIES

Due to complexity of SPD, it is necessary to understand its basic principles

## Characteristics of SPD



When cost concern hinders sustainable product design, sustainability is the key enabler for success now and in the future



**TOP LINE BENEFITS**



**BOTTOM LINE BENEFITS**



**RISK MANAGEMENT BENEFITS**



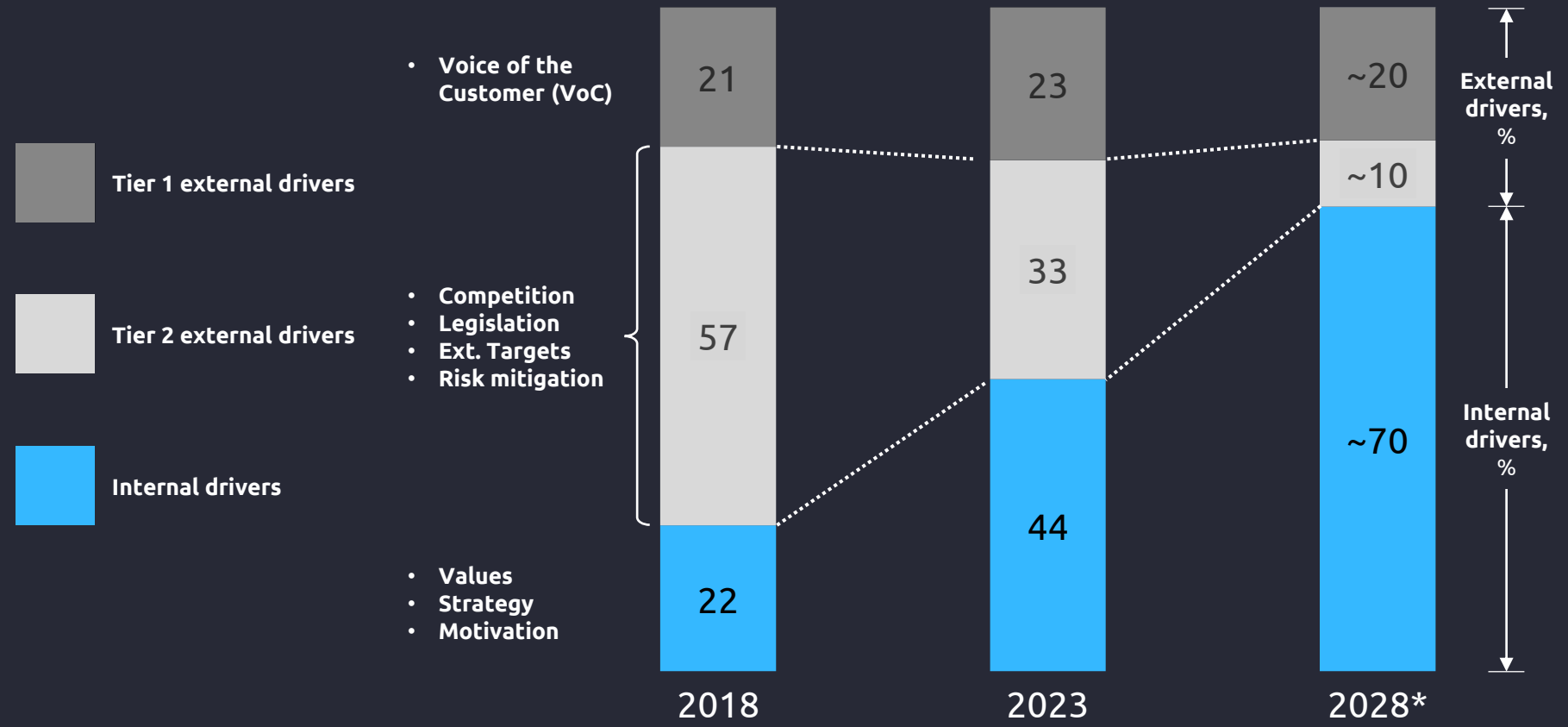
**PRODUCT INNOVATION BENEFITS**



# EUROPEAN MANUFACTURING COMPANIES HAVE RECOGNIZED THE IMPORTANCE OF SUSTAINABILITY, BUT THEY ARE ONLY HALFWAY THERE

Externally driven sustainability approach usually leads to poor sustainability performance

Distribution of SPD drivers





# SUCCEEDING IN SUSTAINABLE PRODUCT DESIGN REQUIRES COMPANIES TO STEP UP

Four domains which companies must master to achieve sustainability in product design

OBTAIN MUTUAL SUSTAINABILITY UNDERSTANDING



ENSURE COOPERATION IN LONG VALUE CHAINS

FORM A COMPREHENSIVE LIFE CYCLE APPROACH

ENABLE SUSTAINABILITY CONTINUITY

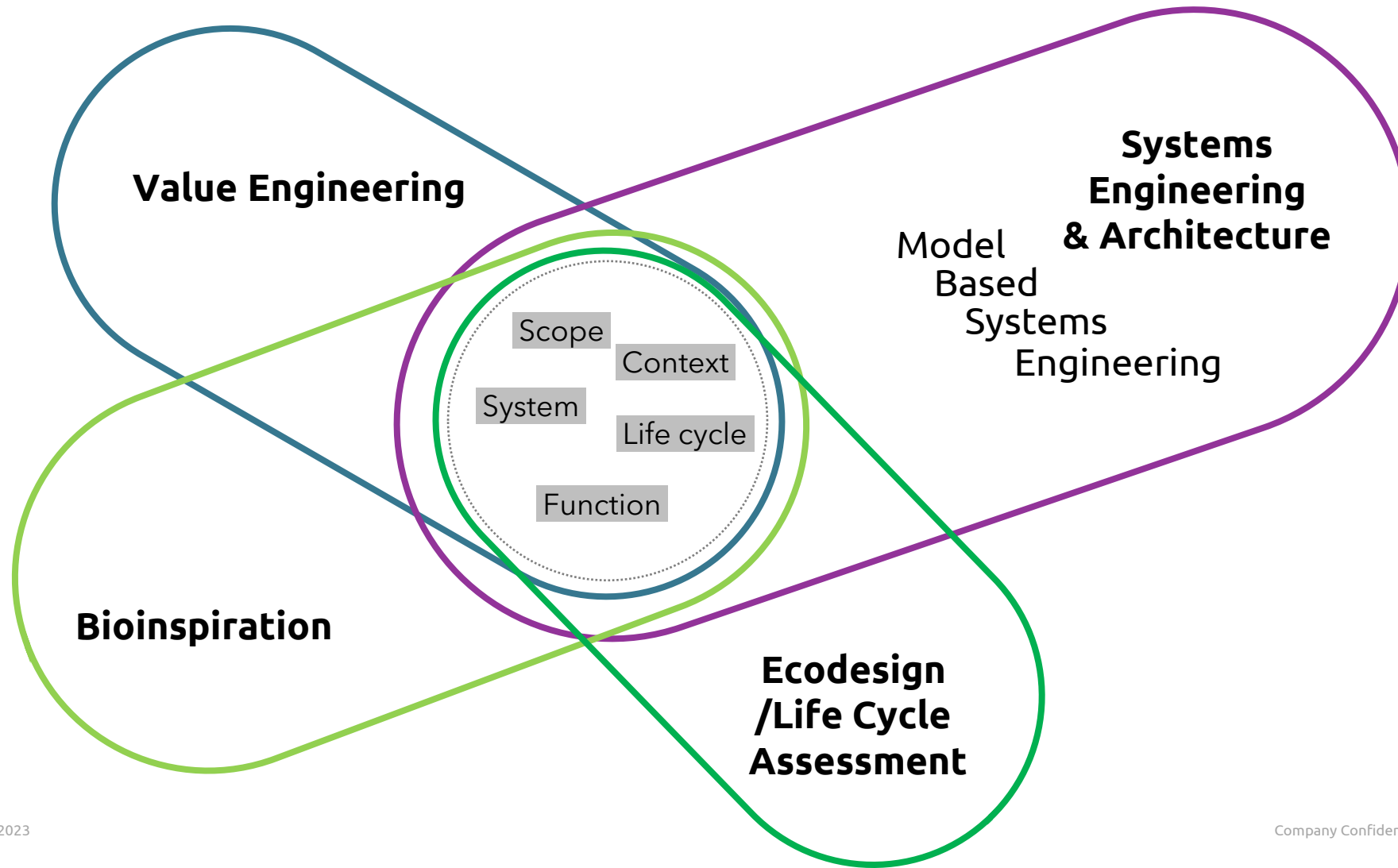
An aerial photograph of a mangrove wetland. The landscape is a complex network of winding, light-colored waterways that meander through dense, vibrant green mangrove forests. The water appears calm and slightly turbid. The overall scene is a lush, natural environment. The text is overlaid on a dark, semi-transparent vertical band on the left side of the image.

**WHAT DOES  
SUSTAINABILITY  
MEAN AT  
CAPGEMINI?**



# LET'S ZOOM INTO SUSTAINABILITY IN PRODUCT DEVELOPMENT

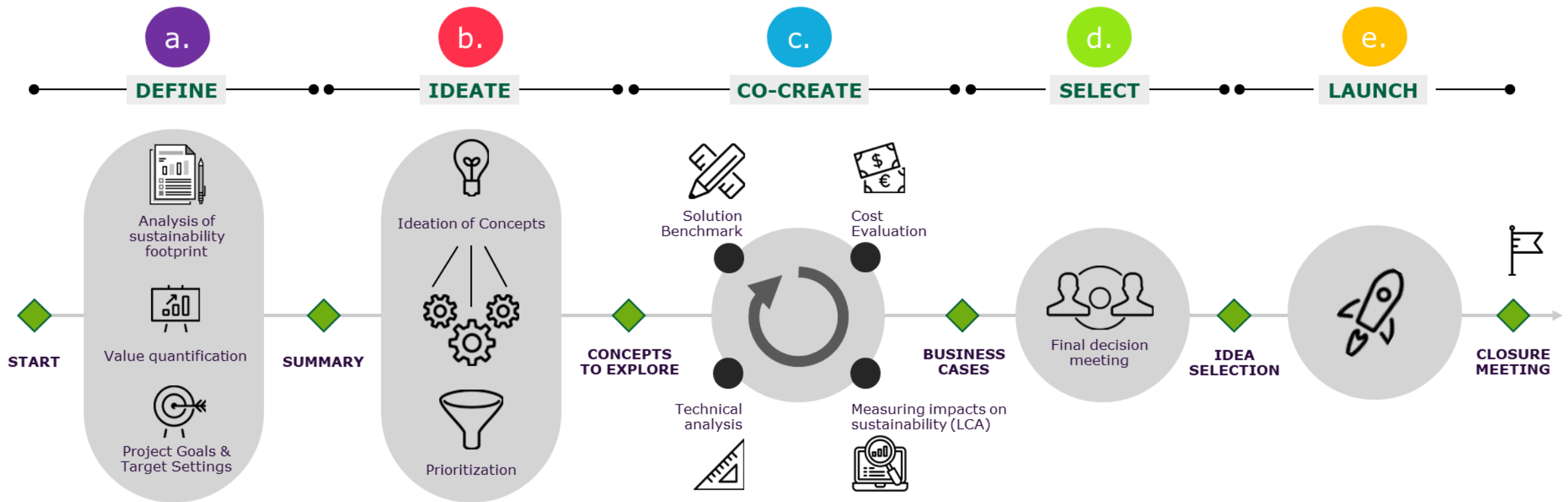
SYSTEMS ENGINEERING & ARCHITECTURE & SOME DOMAINS LINKED TO SUSTAINABILITY – FINDINGS





# LET'S ZOOM INTO SUSTAINABILITY IN PRODUCT DEVELOPMENT

All along development lifecycle, some questions need to be tackled concerning **environmental concerns** (one part of Sustainable concerns)





# “WHAT” – THIS MEANS TO YOU?

## The ambition is to

- Propose a structured approach
- Be compliant with existing frameworks & on-going initiatives
- Answer the needs

SHARE

**Share** the descriptions of the system in terms of Needs /Problems /solutions

DEFINE

Define objectives / Sustainability for taking **decisions** based on objective elements

DEVELOP

Develop **together** System-of-Interest & some key Enabling Systems

OPTIMIZE

Optimize **architectures** & build ecosystemic-centric architectures

ASSESS

**Assess** Environmental impacts based on same reference data

IDENTIFY

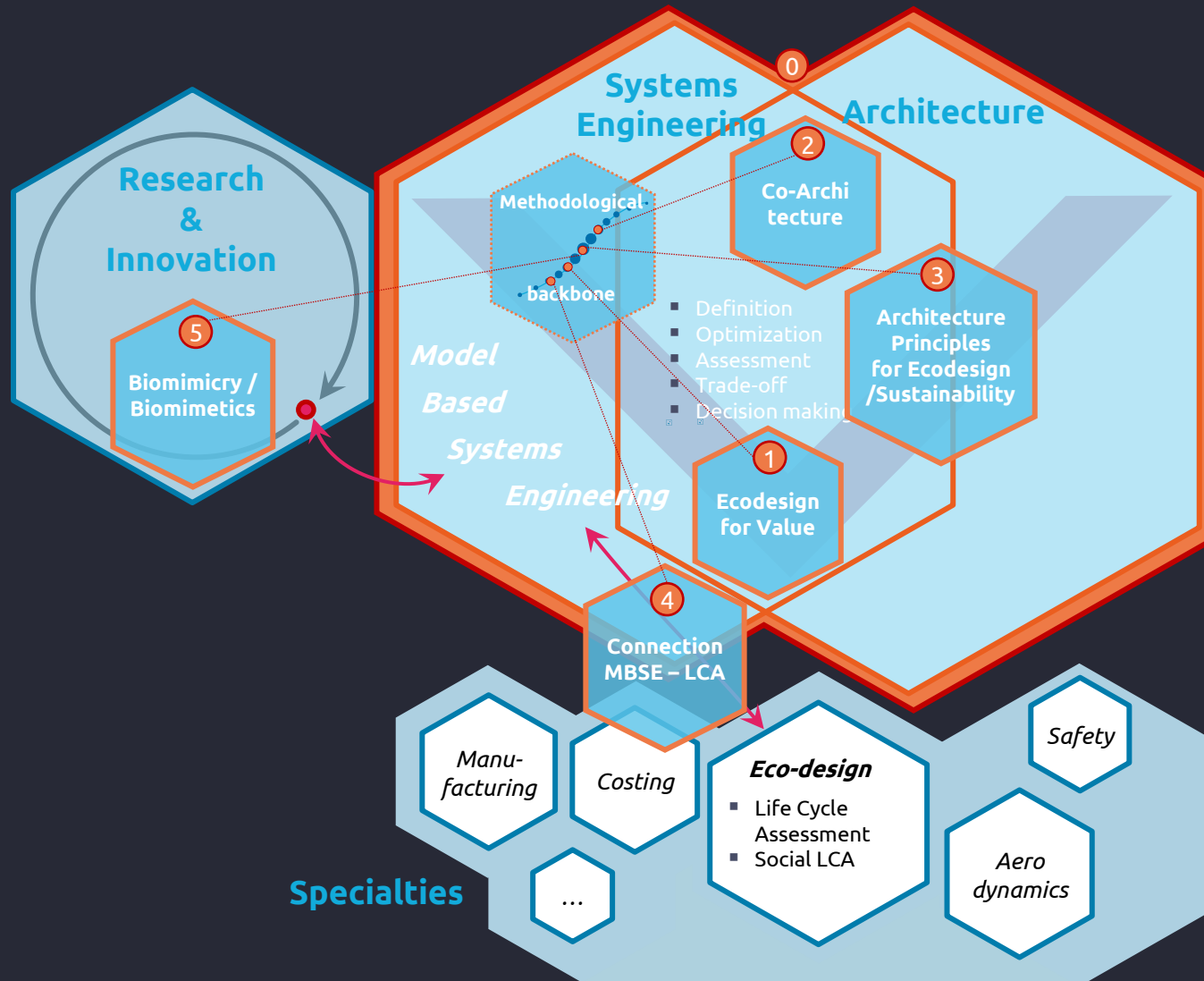
Identify **sustainable solutions** for building more sustainable solutions



# AN ANSWER

An extensive methodological framework of development with methodological bricks off-the-shelf

- Integrated via Methodological backbone
- Supported by Systems Engineering & Architecture framework



An aerial photograph of a mangrove forest. A winding, light-colored waterway meanders through the dense, vibrant green vegetation. The waterway has several sharp turns and loops, creating a complex network of channels. The surrounding land is covered in thick, low-lying plants, typical of a mangrove ecosystem. The overall scene is lush and natural, with a mix of bright green and darker, shadowed areas.

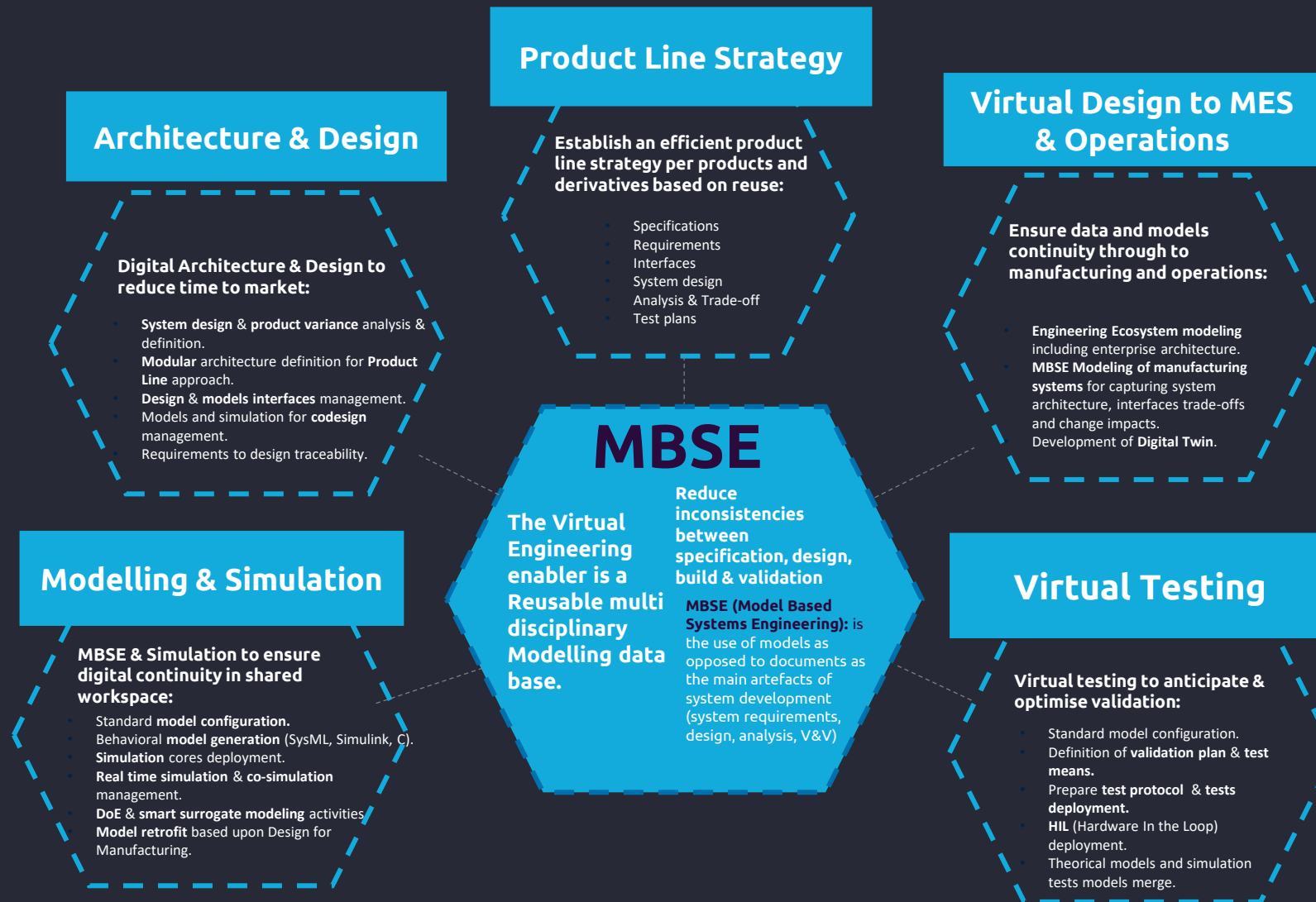
**HOW DOES MBSE  
ENABLE  
SUSTAINABLE  
PRODUCT  
DEVELOPMENT?**

*Model-based systems engineering (MBSE) is the formalized application of modelling to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing **throughout development** and later life cycle phases*





# WHAT IS THE ROLE OF MBSE?



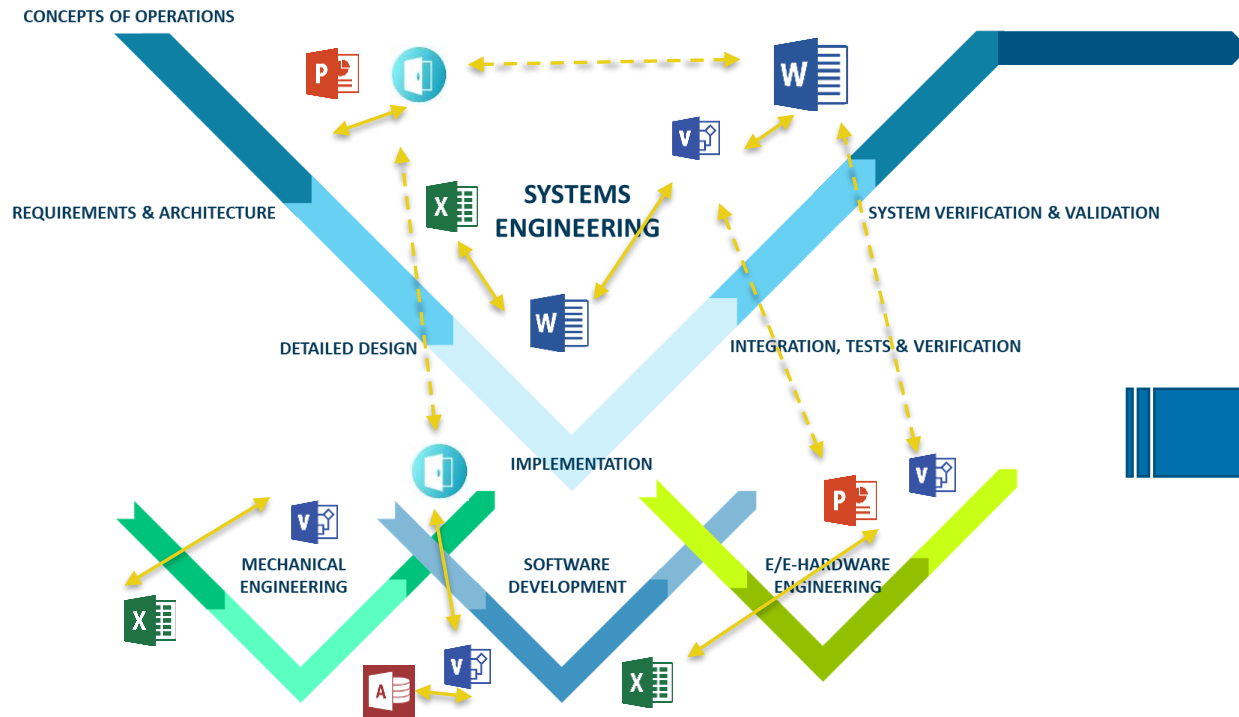


# SYSTEMS ENGINEERING IMPLEMENTATION

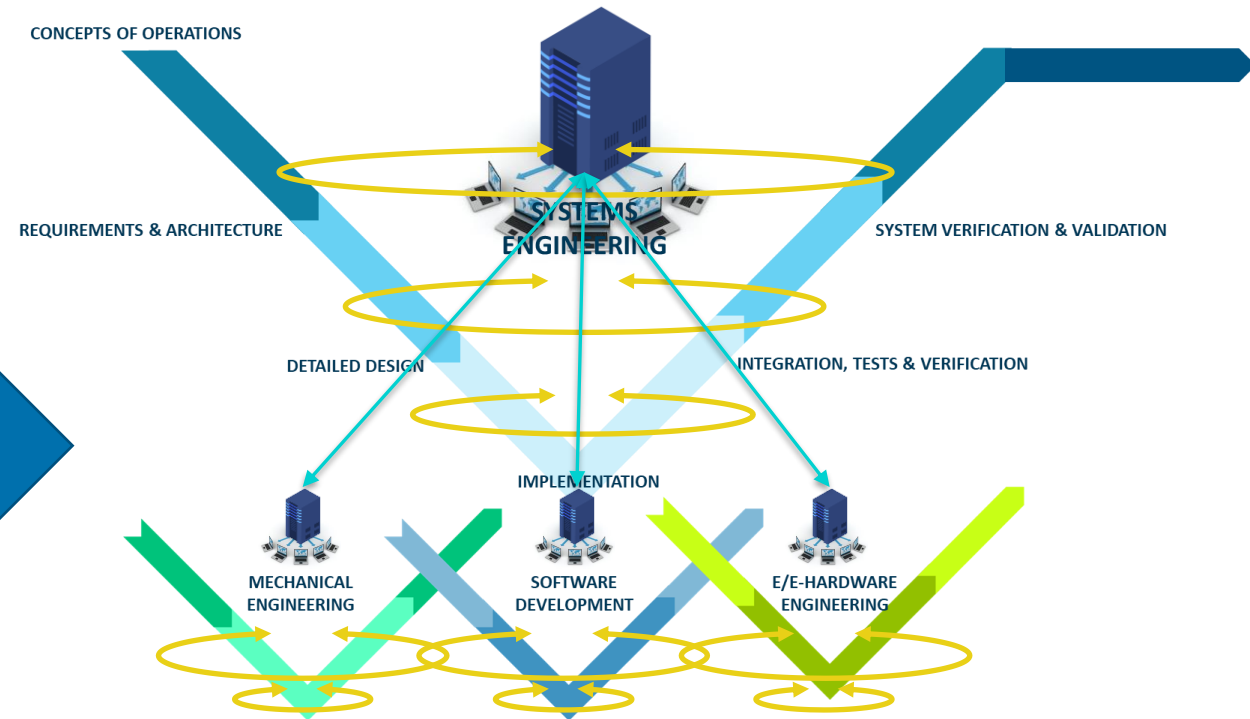
Traditional approach

vs.

Model-based approach (MBSE)



**Document centric**



**Model centric**

# CHALLENGES OF ENTERPRISE MBSE ADOPTION

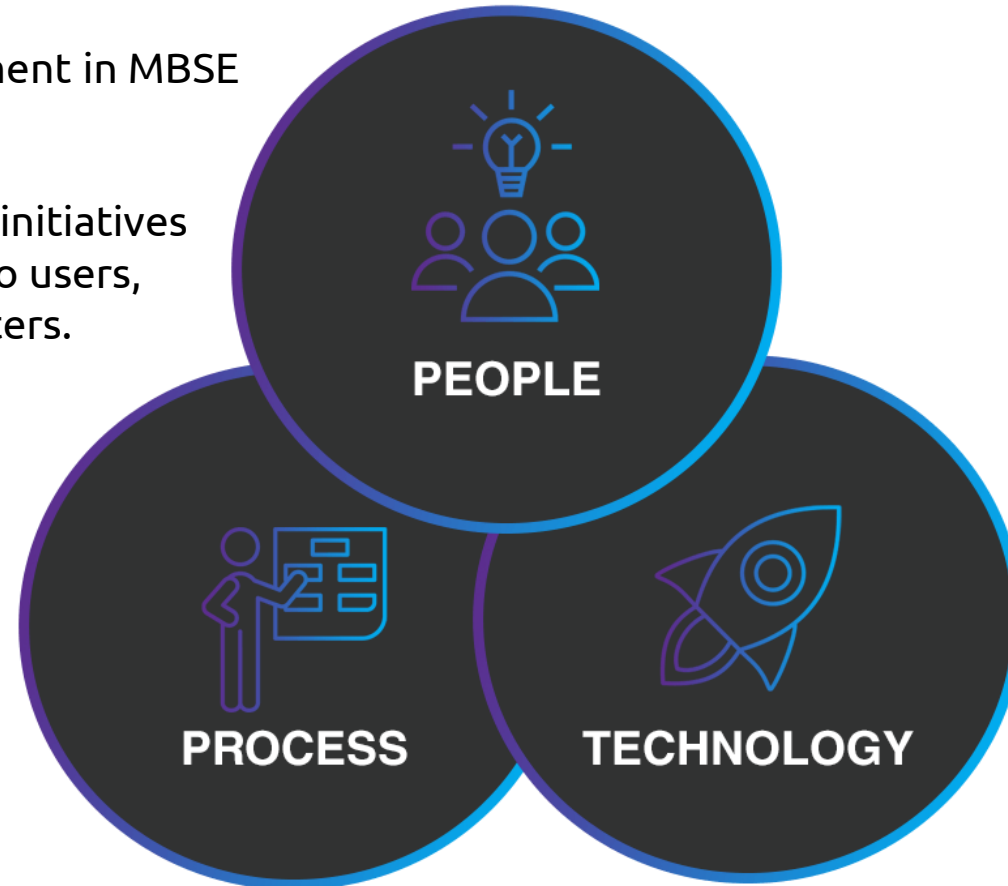


## Cultural Change:

- Resistance to change
- Skilled workforce
- Continuous development in MBSE competencies
- Management buy-in
- Global MBSE training initiatives
- Continuous support to users, especially early adopters.

## Global Processes:

- Common MBSE approach across the organisation
- Governance of MBSE approach
- Maintenance & updates to MBSE approach
- Reuse strategy



## Tools & Infrastructure:

- Fully collaborative development environments.
- Toolset integration across lifecycle.
- Configuration management of full digital thread across toolsets.
- Maintenance & updates of tools & infrastructure.



# CAPGEMINI MBSE OFFERING

## What do we propose?

Bring best in class industry process and tools, raising Collaboration & Digitalization at scale, to achieve your business drivers across the lifecycle (Engineering, Manufacturing, Service):

- **Speed to Market:** Reduce Time To Market, from Lead time to Cycle time
- **Efficiency at Scale:** Improve Efficiency on local and scaled scope of your Lifecycle
- **Future-Proof:** continually innovate, manage complexity and guarantee best practice with certifications
- **Business agility:** and address market demands by delivering flexibility for your assets.
- **Improved Quality:** reduce design & manufacture defects through early validation of solutions in the model based environment.

## How do we do it?



### 1. Systems Engineering Consulting

Supporting strategic business ambitions with an ROI-oriented enterprise transformation roadmap.



### 2. Transformation and Implementation

Implementing at scale best in class methods and tools to modernise your industry business



### 3. Engineering-as-a-Service

Industry expertise running collaborative engineering for complex products & systems across the lifecycle

## Our assets

Over **4500 Experts on Systems Engineering** practice and more than **20 years** of investment and development:



### MBSE Deployment Approach

Process and maturity model for MBSE value assessment and capability growth with actionable guidance during capability development areas and approach



### MBSE Academy

A coordinated training capability includes on-line and in-person training and conformance to certified higher education standards.



### MBSE Eco-System


Capgemini partners with international systems engineering standards organizations such as INCOSE, sectorial organizations for Automotive, A&D, LS, and with the major platform vendors.



### MBSE Labs

Capgemini dedicated MBSE labs focus on solution benchmarking for various industries. The labs serve as both customer experience centers and training environments.



An aerial photograph of a lush green mangrove forest. A prominent, winding waterway cuts through the dense vegetation, creating a complex network of channels and islands. The water appears slightly turbid, reflecting the surrounding greenery. The overall scene is a vibrant, natural landscape.

**WHERE HAS  
CAPGEMINI  
DELIVERED  
SUCCESSFUL  
OUTCOMES?**

# "WHERE" – HAS CAPGEMINI DELIVERED SUCCESSFUL OUTCOMES?



### Ecodesign for Value

From R&I Program : Future of Engineering | R&I Project : CORAC OneVoice

**Pitch:** How to define the Value of a product/service including sustainability aspects for taking objective & robust decisions all along the development process? How to ensure assessment of this value?

**Description:** Most of the time sustainable aspects are not considered when value engineering approach are deployed, neither in 'Needs Satisfaction Level' nor in 'Usage of Resources'. For developing more sustainable products/services, the integration of such perspectives is obviously needed as soon as possible in the development lifecycle through Value engineering activities.

**Solution & benefits:**

- Extension of 'classical' Design to Cost/Design for Value approach
- Integration of Sustainable aspects through (1<sup>st</sup> step) Environmental impacts indicators
- Connection with System model
- Compliance for Integrating Social aspects

**Uses Cases:**

Use case description 1: MANTA Project, as a starting point for incorporating Environmental aspects through Value engineering approach.

Use case description 2: Assisted Bike: simple & pedagogical application case. Used as proof-of-concept.

Use case description 3: Aeronautical application case with realistic data. Status of demonstrator of feasibility (model + integration of Value engineering embedding Environment aspects).

**Horizontal & Technologies:** Sustainability, Lifecycle Assessment, Value Engineering, Model Based Systems Engineering, CAE/DOE

**Primary industries of use ?** Automotive, Finance & Public Sector, Industry, Healthcare, Telecom & Media, Energy, Rail, Spatial & Defence, Aero

**Status:** Identification, Co-Value, Data, Impact, Complete

### Co-Architecture / Contribution of enabling systems to lifecycle phases

From R&I Program : Future of Engineering | R&I Project : CORAC OneVoice

**Pitch:** How to consider the Enabling systems in the 'classical' System models in order to describe the correct level of information for assessing their contribution to lifecycle phases of the System itself?

**Description:** All lifecycle phases of Systems should be considered during development but, in fact, it is rarely the case. Moreover, the connection (and associated modeling) with Enabling Systems is not obvious, and associated calculation rules need to be defined.

**Solution & benefits:**

- Methodology for modeling needed information in Enabling Systems models & for linking the different models together.
- Calculation rules for assessing the contributions of Enabling Systems to associated lifecycle phase of System. Focused on Manufacturing phase/ Industrial System. Could be extended to other phases.

**Uses Cases:**

Use case description 1: Assisted Bike: simple & pedagogical application case. Used as proof-of-concept. Industrial System was partially modeled for embedding information allowing the Lifecycle Assessment.

**Horizontal & Technologies:** Sustainability, Model Based Systems Engineering for Systems & Enabling Systems, Architecture, Lifecycle Assessment

**Primary industries of use ?** Automotive, Finance & Public Sector, Industry, Healthcare, Telecom & Media, Energy, Rail, Spatial & Defence, Aero

**Status:** Identification, Co-Value, Data, Impact, Complete

### Architecture Principles for improving environmental impacts

From R&I Program : Future of Engineering | R&I Project : CORAC OneVoice

**Pitch:** How to architect more sustainable solutions (Products/Services) ?

**Description:** For developing better solutions (Products/Services), several practices exist: exploring, optimizing, guidance, principles... We focused on principles aspects for architecting better solutions in terms of environmental impacts. Nevertheless, a global analysis considering all the lifecycle of the developed solution is needed for confirming what Architecture principles suggest.

**Solution & benefits:**

- Methodology for developing & using a portfolio of Architecture Principles for improving Environmental impacts
- Portfolio of Architecture principles
  - Distributed by lifecycle phases
  - With targeted layers of MBSE Frameworks + order of magnitude on different values

**Uses Cases:**

Use case description 1: 1<sup>st</sup> releases of methodology + Architecture principles portfolio.

**Horizontal & Technologies:** Sustainability, Model Based Systems Engineering, Architecture, Lifecycle Assessment, Ecodesign approaches (LDS Wheel, Circular Economy, Ecodesign practices, CFC, Nature's principles...)

**Primary industries of use ?** Automotive, Finance & Public Sector, Industry, Healthcare, Telecom & Media, Energy, Rail, Spatial & Defence, Aero

**Status:** Identification, Co-Value, Data, Impact, Complete

### Biomimicry

Projects : INSEI, AIRCOP

**Pitch:** How to identify more sustainable solutions through Nature's inspiration ?

**Description:** For proposing better solutions in terms of sustainability, several inspirations exist. Nevertheless, one of the biggest one & oldest one is Nature.

**Solution & benefits:**

- Methodology for integrating biomimicry approach
- Collaboration with CEEDIS under discussion

**Uses Cases:**

Use case description 1: INSEI: Aerodynamics & bioinspiration for trucks

**Horizontal & Technologies:** Biomimicry, Sustainability, Model Based Systems Engineering, Architecture, Lifecycle Assessment, Ecodesign approaches (LDS Wheel, Circular Economy, Ecodesign practices, CFC, Nature's principles...)

**Primary industries of use ?** Automotive, Finance & Public Sector, Industry, Healthcare, Telecom & Media, Energy, Rail, Spatial & Defence, Aero

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### Connecting Model Based Systems Engineering (MBSE) & Lifecycle Assessment (LCA)

From R&I Program : Future of Engineering | R&I Project : CORAC OneVoice

**Pitch:** How to share consistent information between MBSE & LCA, domains that are supported by models and that are sharing common concepts like e.g. Systems, Lifecycle, Function... When? What for?

**Description:** MBSE & LCA are domains sharing some key concepts like Systems or Lifecycle. Nevertheless they are working in silos and their respective studies are, most of the time, not consistent. So we need a way to ensure consistency between those domains and a way to share pertinent information at the right granularity level, at the right moment in the development lifecycle.

**Solution & benefits:**

- Description of methodology connecting MBSE & LCA including
  - Activities of both domains with inputs/outputs
  - Information exchanged described through meta-model, ready for migration to ontology
- Application cases embedding data that can be exchanged between domains

**Uses Cases:**

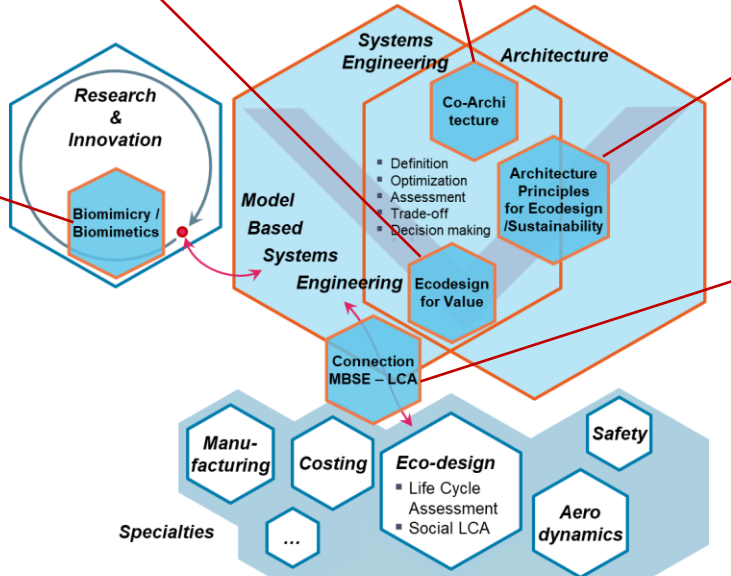
Use case description 1: Assisted Bike: simple & pedagogical application case. Used as proof-of-concept.

Use case description 2: Aeronautical application case with realistic data. Status of demonstrator of feasibility (model + integration of Value engineering embedding Environment aspects).

**Horizontal & Technologies:** Sustainability, Lifecycle Assessment, Model Based Systems Engineering

**Primary industries of use ?** Automotive, Finance & Public Sector, Industry, Healthcare, Telecom & Media, Energy, Rail, Spatial & Defence, Aero

**Status:** Identification, Co-Value, Data, Impact, Complete



# DESIGN FOR ENVIRONMENTAL VALUE ECO-DESIGN METHODOLOGY (VALUE & MBSE & LCA)

## CONTEXT

**CORAC** (COnseil pour la Recherche Aéronautique Civile) is an R&I program with funding from the French state, aimed at anticipating technological changes that will make it possible to decarbonize and ensure the competitiveness of the civil aviation industry

➤ We participate to this program in the frame of “**Design to Environment**” project: eco-design methodology combining value, MBSE and LCA for aeronautical usage

## OBJECTIVES

- **Definition of the Methodology**
  - Definition of the sustainability value and links with other values
  - System model embedding these values
  - Connection between MBSE & LCA models
  - Reference environmental assessment
  - Contributions of enabling systems to environmental assessment
  - Architecture Principles
  - Uncertainties management
- **Deployment with 2 cases:** Assisted bike + transposition in the aeronautic domain through realistic data

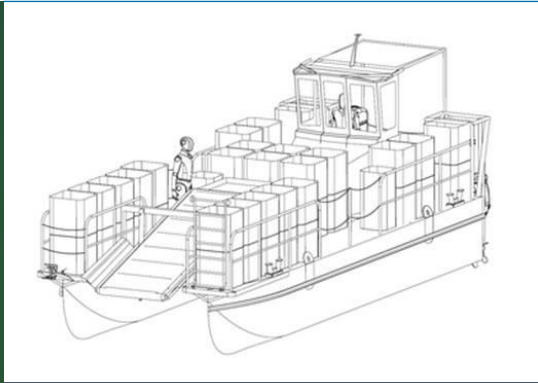
## SOLUTIONS:

- Value
- LCA (Life Cycle Assessment)
- MBSE (Model Based Systems Engineering)
- Eco-design methodology

## ACHIEVEMENTS

- **Different releases of methodology bricks:** Sustainable value, connection between Value – MBSE – LCA, contribution of enabling systems
- **Releases of system models,** for an Assisted bike with CAMEO tool + Aeronautical case

**AIRBUS** Capgemini engineering



## SOLUTIONS:



- LCA (Life Cycle Assessment)
- MBSE (Model Based Systems Engineering)
- Eco-design methodology & tool

## PARTNERS :



# ECOPLEX (ECO-DESIGN OF COMPLEX SHIPS) STANDARDIZED ECO-DESIGN TOOL (MBSE & LCA)

## CONTEXT

**EMC2** is an European competitiveness cluster for manufacturing technologies, aiming to support companies towards better and clean production, through collaborative innovation projects.

➤ **EcoPlex project** has been qualified by this cluster & funded by Bpifrance, the Bretagne region and the CIR: Methodology & eco-design tool, with digital continuity between the MBSE and the LCA, for use in the naval domain

## OBJECTIVES

- **Definition of an eco-design methodology**
  - Modular with generic parts and parts specific to naval domain
  - Digital continuity by connecting MBSE & LCA with integration of naval stakes
- **Specification dossier for software**
- **Tool development:** Capella add-on for MBSE to LCA digital continuity
- **Implementation in 3 pilot cases:** Mobula 8 & 10 + SDI boat
  - MBSE & LCA models
  - Usage of developed add-on for testing
  - Analysis results

## ACHIEVEMENTS

- Analysis of the **state of the art** in all areas, with a focus on the Naval domain
- **Releases of the methodology:** macro definition of naval engineering, MBSE and LCA development processes
- **Releases of tool specifications & plug in**
- **Releases of MBSE & LCA models** for the 1<sup>st</sup> pilot cases with export-import from System model to LCA model

*April 2021 – October 2022*



**GET THE  
FUTURE  
YOU WANT**