



ENHANCE THE EFFICIENCY OF SYSTEMS ENGINEERING WITH A TAILORING OF SE PROCESSES AND ARCADIA METHOD

Capella Days – 15/11/2023

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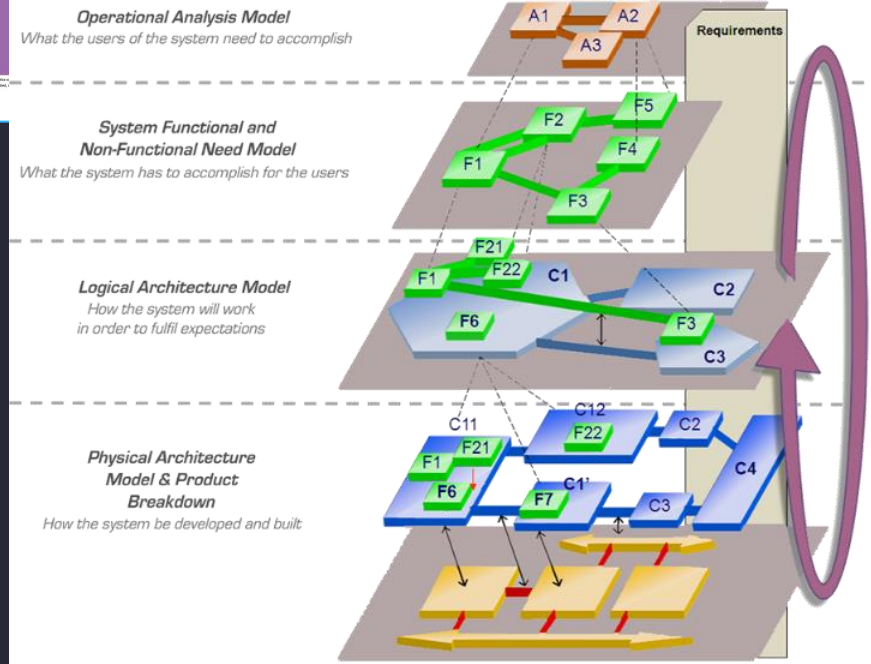
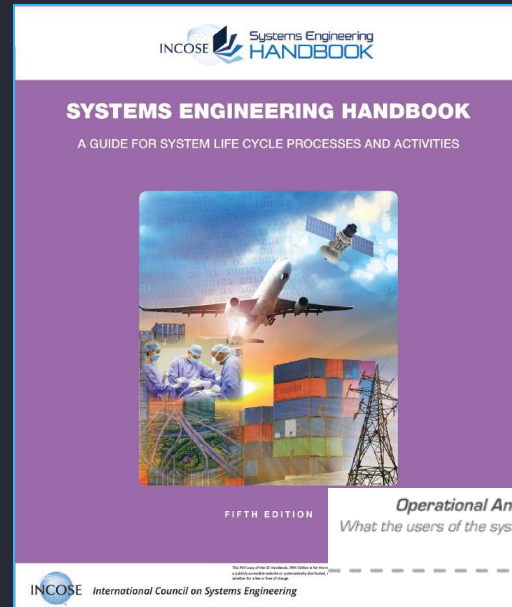
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AGENDA

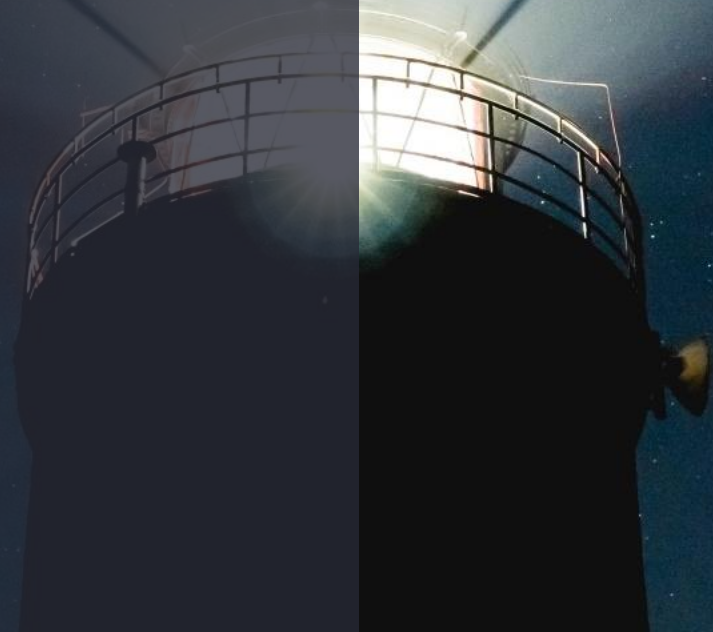
1. Capgemini Systems Engineering & Architecture
2. Tailoring ?
3. Tailoring of SE Processes
4. Tailoring of ARCADIA Method
5. Conclusion and way forward
6. Q&A





1

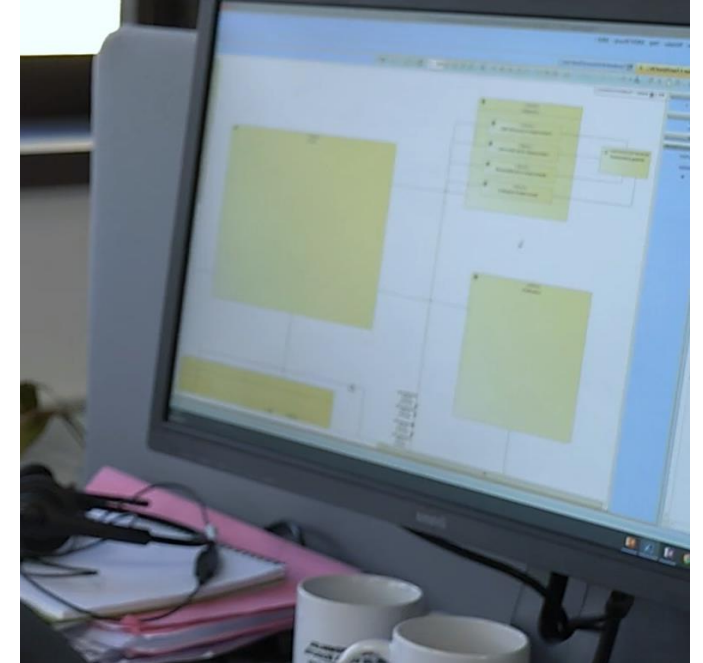
SYSTEMS ENGINEERING AND ARCHITECTURE





CAPGEMINI ENGINEERING

- SEA Team - Systems Engineering & Architecture
- Multi-industries & multi-clients
- SE Activities (including MBSE with ARCADIA/CAPELLA)
- Research & Innovation project « ECSE »
Efficient and Connected Systems Engineering



AN END-TO-END SE/MBSE VISION WITH CAPGEMINI ENGINEERING



SE SETUP

Addressing « MBSE pilots », Capgemini Systems Engineering Expertise Center SETUP **MBSE process, methods and tools**, define **Roadmap** with MBSE pilots based on a cross-fertilization approach.



SE DEPLOYMENT

Addressing « MBSE pilots », Capgemini Systems Engineering Expertise Center DEPLOY MBSE best-in-class practices by **Training & Coaching** based on a cross-fertilization approach.



SE OPERATION

Addressing « Architects and Systems Designers », Capgemini architects and designers teams are designing Systems, Products, Manufacturing or Services by **operating MBSE in their day-to-day design** work.

Examples: ADAS, Connectivity, Train, Power Plant, Industrial Systems, Avionic satellite systems, ATAs, aircraft, car, ...



MBSE
Experts



MBSE
practitioners

A CROSS-FERTILIZATION HISTORY FOR SE & MBSE

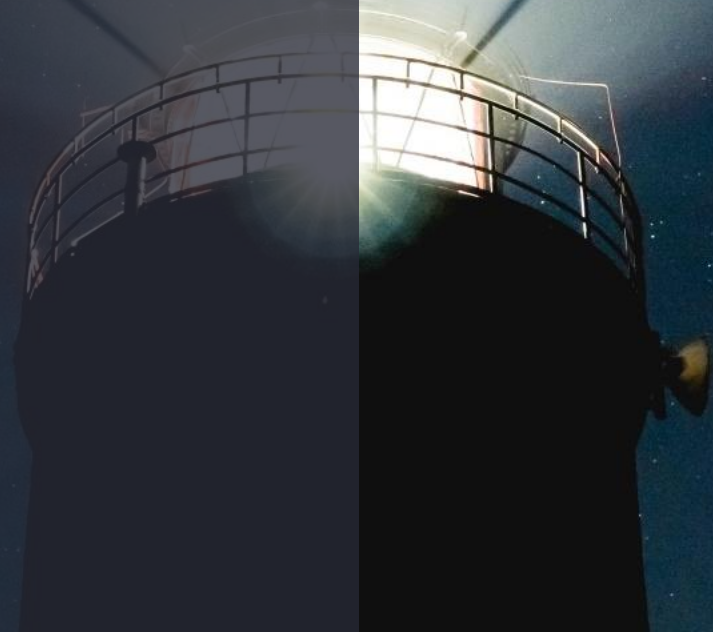


<p>STELLANTIS</p> <p>MAN</p> <p>BOSCH</p> <p>SOFTWARELABS GROUPE RENAULT</p> <p>HONDA</p> <p>Continental</p> <p>VW</p> <p>Mazda</p>	<p>AIRBUS</p> <p>BOMBARDIER AEROSPACE</p> <p>AIRBUS HELICOPTERS</p> <p>SAFRAN</p> <p>LIEBHERR</p> <p>ATR</p> <p>dgac</p> <p>THALES AVIONICS</p> <p>ZODIAC AEROSPACE</p> <p>Honeywell</p>	<p>ThalesAlenia Space</p> <p>cnes</p> <p>arianeGROUP</p> <p>AIRBUS DEFENCE & SPACE</p> <p>JAXA</p>	<p>BOMBARDIER TRANSPORTATION</p> <p>ALSTOM</p> <p>SNCF</p> <p>NetworkRail</p> <p>CAF</p> <p>HYPERLOOP TT</p> <p>DB</p>	<p>edf</p> <p>AREVA</p> <p>orano</p> <p>iter</p> <p>GE</p> <p>SBI OFFSHORE</p> <p>cea</p> <p>TotalEnergies</p> <p>Schneider Electric</p> <p>hager</p>	<p>MBDA MISSILE SYSTEMS</p> <p>AIRBUS DEFENCE & SPACE</p> <p>BECKER AVIONICS</p> <p>RUAG</p> <p>THALES</p> <p>NAVAL GROUP</p> <p>DGA</p>	<p>OLYMPUS</p> <p>ASML</p> <p>orange</p>



2

TAILORING? WHY AND ADDED VALUE





TAILORING ?

Definition (INCOSE Handbook) :

*“**Adapt** the processes to ensure that they **meet the needs** of an organisation or a project”*

Keywords :

- Realistic
- Efficiency
- Value oriented
- Shared
- Applicable
- Translate into client language
- Models are means not objectives

Means :

- Focus on value
- Focus on risky topics
- Focus on innovations
- Focus on interfaces
- ...

'One size fits all'
doesn't always fit

GENERIC vs REALISTIC ?



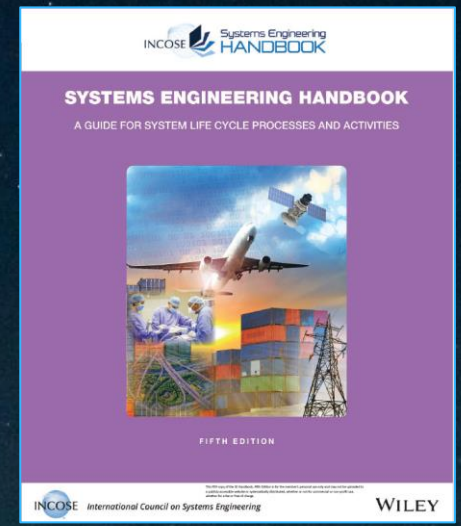
Level	Generic	Steps of the Tailoring Framework				Concrete application on a projet
Process	SE Processes (ISO15288 & INCOSE Handbook)	P01 Complexity grid	P02 BPMN SE processes model	P03 Versatile SE Data Model	P04 SEMP template	SEMP of the project
Method	ARCADIA method (AFNOR XP Z 67-140)	M01 Layer cartography	M02 Concepts cartography	M03 Views cartography	M04 MBSE method template	MBSE method for the project
Tool	<ul style="list-style-type: none"> - CAPELLA embedded user manual - Standards plugins 	<i>Not covered in the presentation</i>				<ul style="list-style-type: none"> - User guidelines and sheets for the project - Specific plugins

CAPGEMINI TAILORING FRAMEWORK
(transition from « generic » to « applicable » on a specific project)



3

TAILORING OF SYSTEMS ENGINEERING PROCESSES

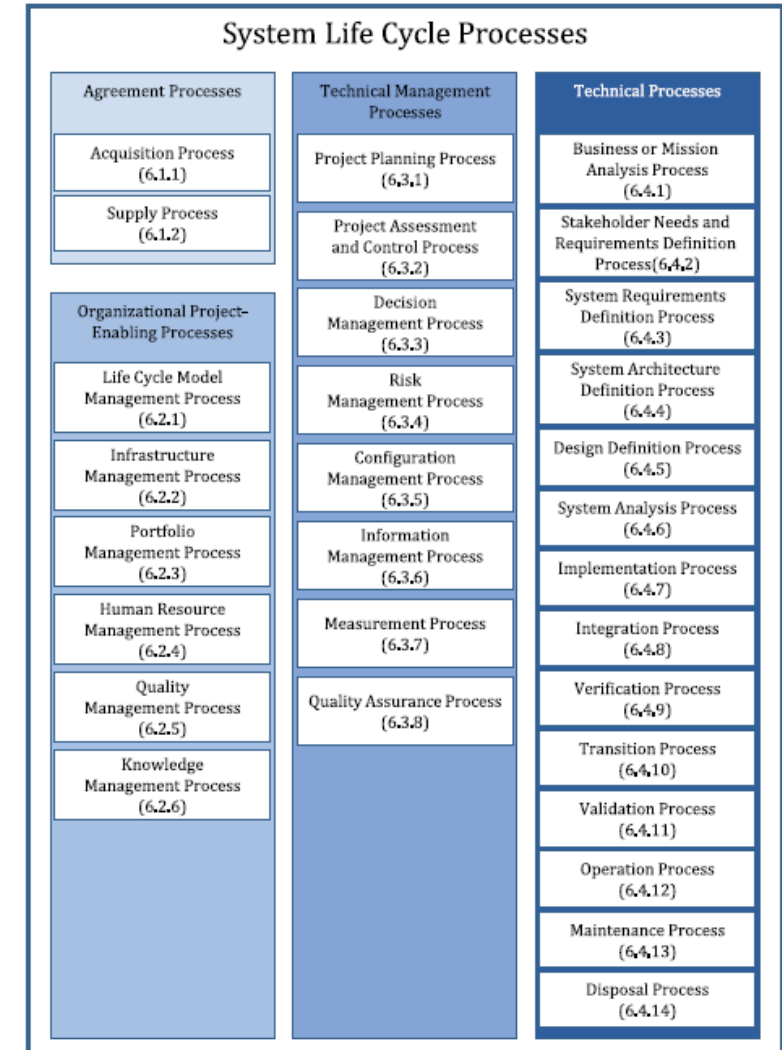
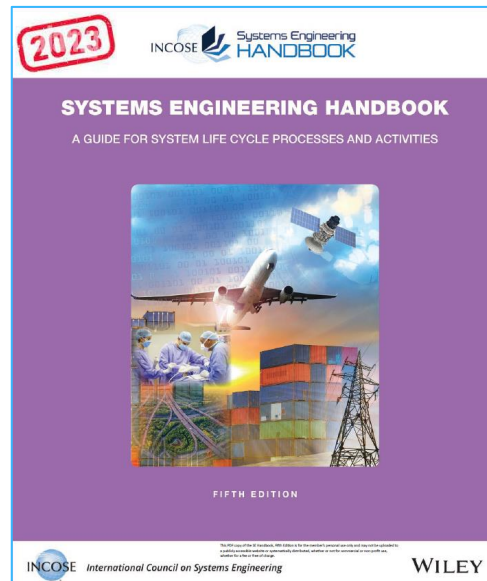
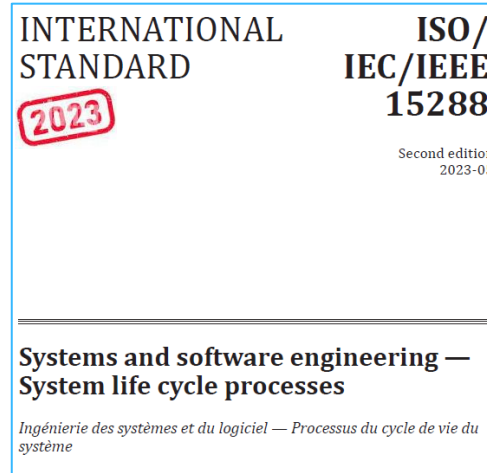




TAILORING OF SE PROCESSES

CURRENT STATUS OF SE PROCESSES

- Major SE International standards updated in 2023
- INCOSE Handbook 2023 (Version V5) in line with ISO15288-2023
- Generic and multi-industries processes
- Large source of knowledge for SE projects



TAILORING OF SE PROCESSES

FINDINGS ON CURRENT SE PROCESSES DESCRIPTION

- Large volume of knowledge :
 - ISO15288 :
 - 120 pages
 - 30 processes
 - 111 activities
 - 447 tasks
 - INCOSE Handbook :
 - 345 pages
- Inputs / Outputs at process level only
- Textual description of tasks for each activity

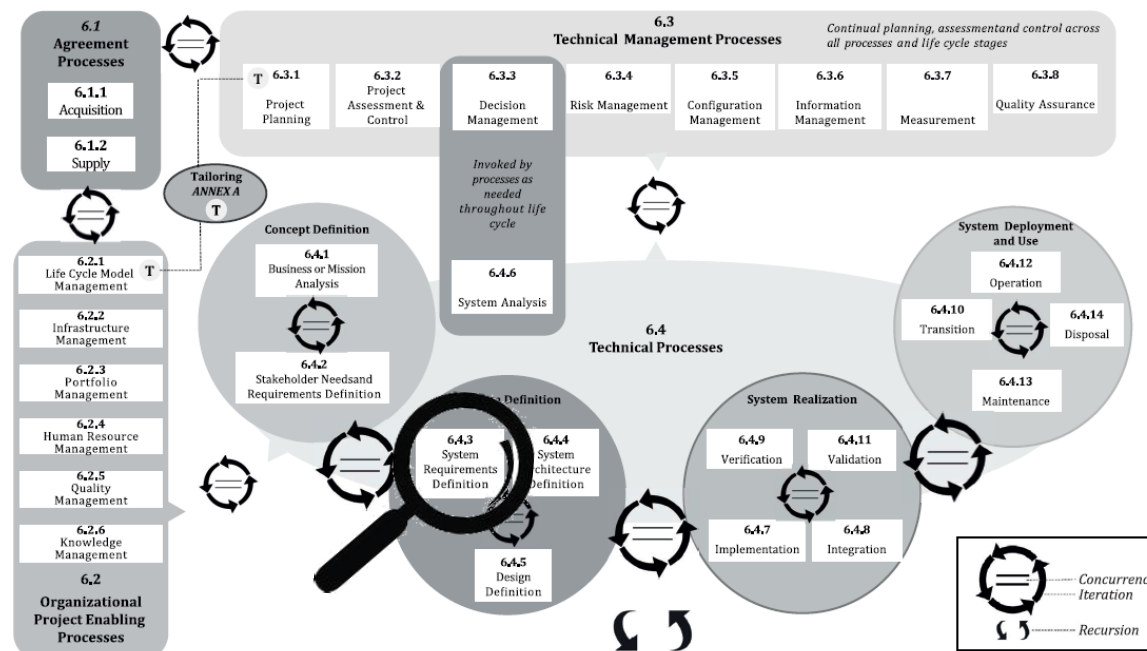
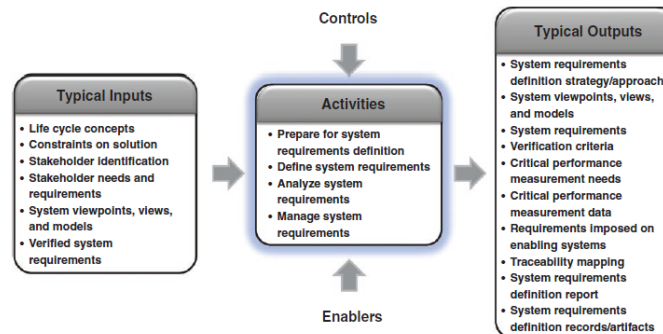


Figure 5 — Interrelationships between processes



System Requirements Definition Process

Process Activities. The System Requirements Definition process includes the following activities:

- Prepare for system requirements definition.
 - Establish the strategy/approach for system requirements definition.
 - Plan for the necessary enabling systems or services needed through the life cycle for system requirements definition. Enabling systems include tools for elicitation of requirements, life cycle concepts, recording drivers and constraints, defining risks, analysis, recording system needs, recording system requirements, and providing traceability.
 - Ensure enabling system or service access needed to support system requirements definition.
- Define system requirements.
 - Define the functional boundary of the system in terms of the behavior and properties to be provided.
 - Identify the life cycle concepts and stakeholder requirements from which the system requirements will be transformed and then define each function and associated performance.



TAILORING OF SE PROCESSES

OBJECTIVES OF THE TAILORING OF SE PROCESSES

WHY ?

- Adapt generic and large cartography of processes
- Prepare concrete deployment of SE on a project
- Ensure efficiency of SE on a project
- Gain membership of project team

Raison to tailor processes for a system :

- Innovation or recurrent
- Concept only or go down to the production of a final system
- Same need, new solution (obsolescence, re-engineering)
- Retro-engineering
- ...



TAILORING OF SE PROCESSES

P01 Complexity grid	P02 BPMN SE processes model	P03 Versatile SE Data Model	P04 SEMP Template
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MEAN PROVIDED BY THE TAILORING FRAMEWORK

Complexity grid :

- Characterize system type
- Characterize system complexity
- Useful input for the tailoring of SE processes and SE activities (including MBSE with ARCADIA / CAPELLA)
- Allow comparisons between projects



CAPGEMINI Engineering - ECSE Project CHARACTERIZE SYSTEM TYPE SHEET	
System name :	
Criteria	Response
1 - Type of System	
System of Systems or standard System	
2 - Type of industry and enterprise	
Industry	
Enterprise	
3 - Type of context	
Level of deployment of SE by the enterprise	
- First project with SE	
- SE Recurring project	
No link with INCOSE, ISO15288, EIA632, ... or other framework	

SYSTEMEEEC - ECSE Project SYSTEM COMPLEXITY EVALUATION SHEET	
System name :	
Criteria	Quotation (0 to 4)
STK1 - Number of stakeholders	
	3
ORG1 - Presence of competition	
ORG2 - Level of industrial organisation	
ARC2 - Number of external and internal interfaces	
MIS1 - Cost and duration of project	

SYSTEM COMPLEXITY EVALUATION

Criteria	Score
STK1 - Number of stakeholders	4
MIS1 - Cost and duration of project	3.5
ARC2 - Number of external and internal interfaces	2.5
ORG1 - Presence of competition	1
ORG2 - Level of industrial organisation	0.5

TAILORING OF SE PROCESSES

P01	P02	P03	P04
Complexity grid	BPMN SE processes model	Versatile SE Data Model	SEMP Template

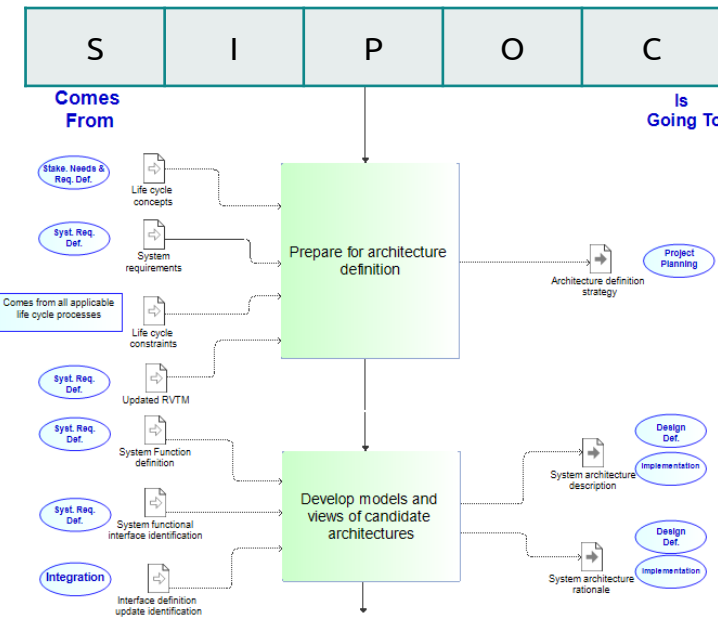
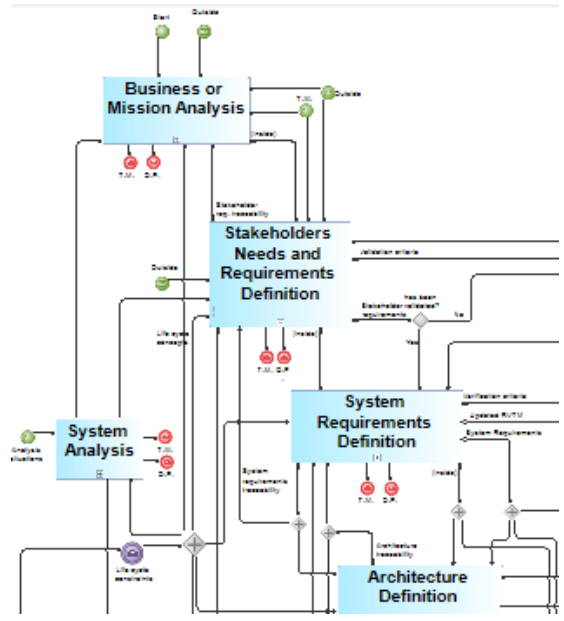
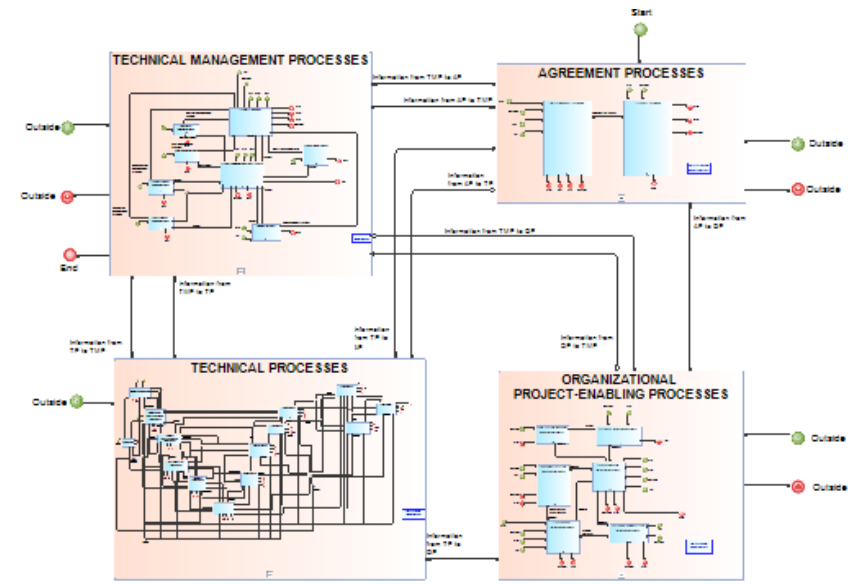


MEAN PROVIDED BY THE TAILORING FRAMEWORK

- BPMN SE processes model to support tailoring

From textual description of processes to graphical representation of processes, activities, tasks and input/output flows between tasks

- SIPOC for each activity
- Used to decide what SE processes, activities ... shall be deployed for the project



TAILORING OF SE PROCESSES

P01	P02	P03	P04
Complexity grid	BPMN SE processes model	Versatile SE Data Model	SEMP Template



MEAN PROVIDED BY THE TAILORING FRAMEWORK

VeSEDaM : Versatile SE Data Model

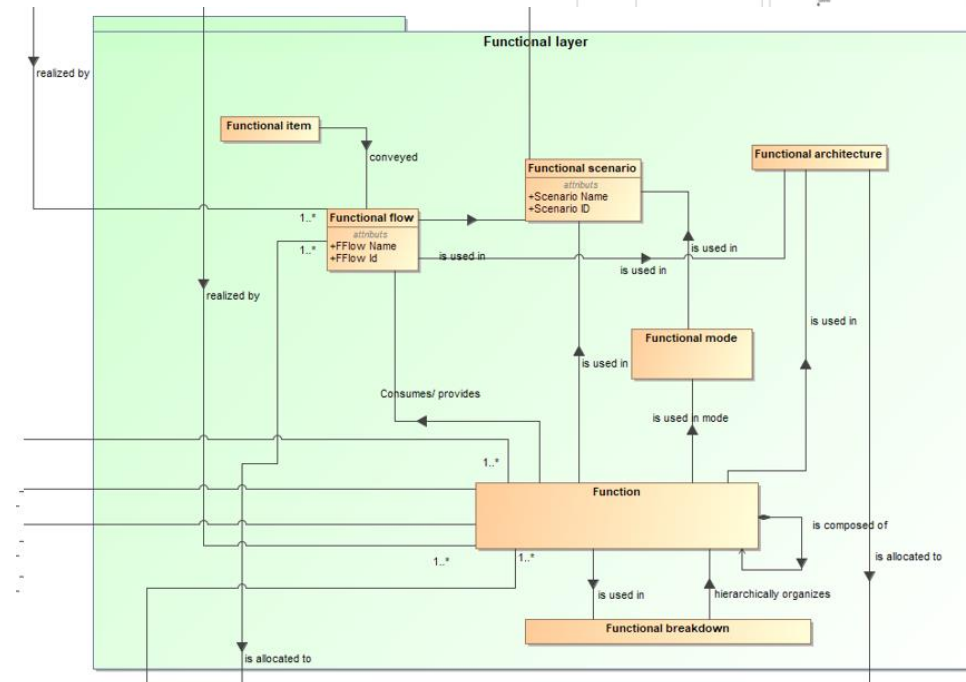
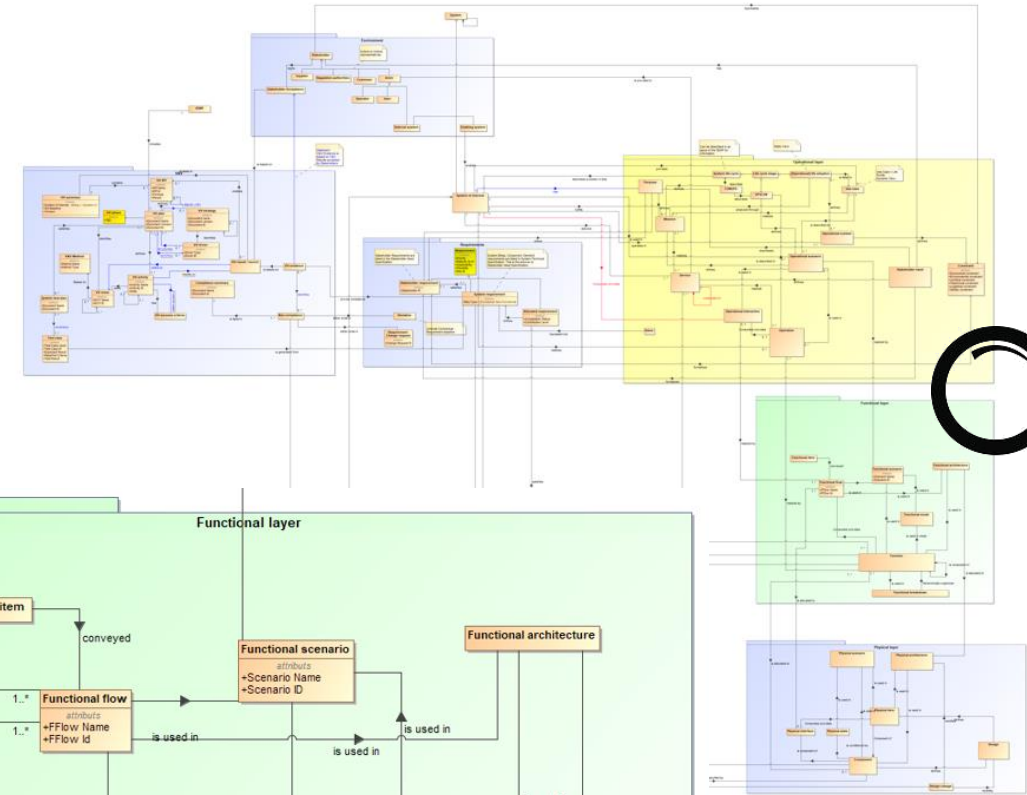
Bring a complete, state of the art, method to issue a useful data model on any Systems Engineering project.

Structure :

- Concepts
- Attributes
- Relationships (semantic, cardinality, ...)

Content :

- Environnement
- Requirements
- Operational layer
- Functional layer
- Physical layer
- V&V



TAILORING OF SE PROCESSES

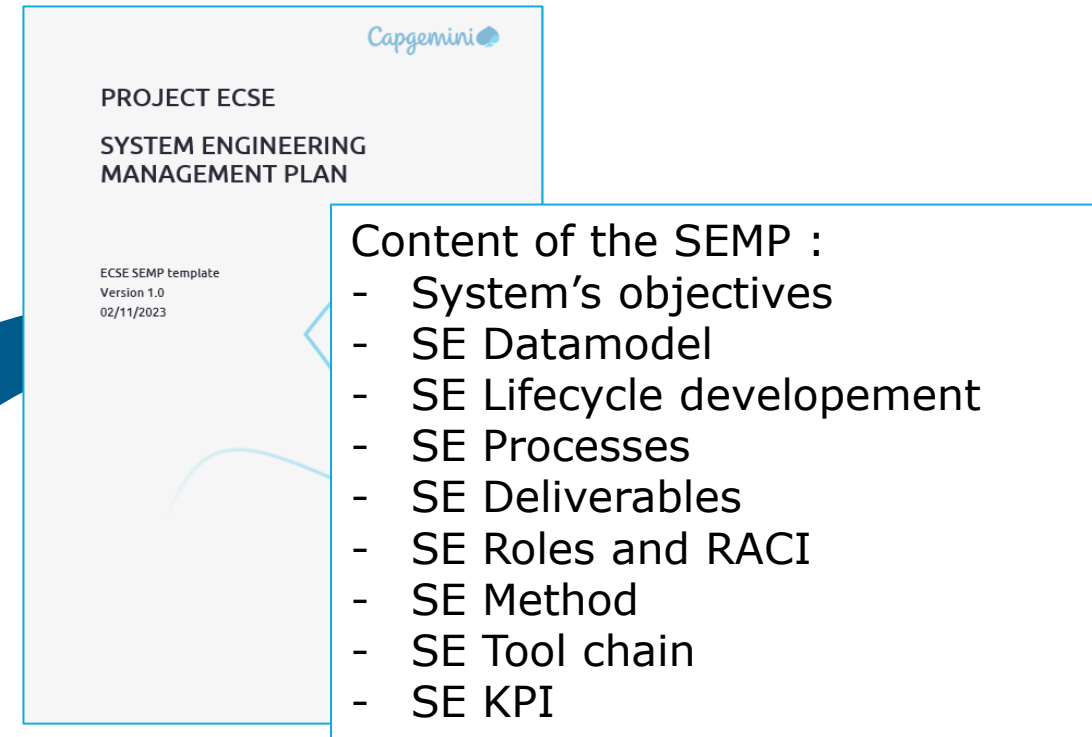
P01	P02	P03	P04
Complexity grid	BPMN SE processes model	Versatile SE Data Model	SEMP Template



RESULT OF SE PROCESSES TAILORING FRAMEWORK

SEMP (System Engineering Management Plan)

- Formalisation of SE processes tailoring results into a SEMP document
- Transition from « generic » to « applicable » on a specific project
- Concrete information for a specific project
- Simple, clear and applicable content by the project team





4

TAILORING OF MSBE ARCADIA METHOD



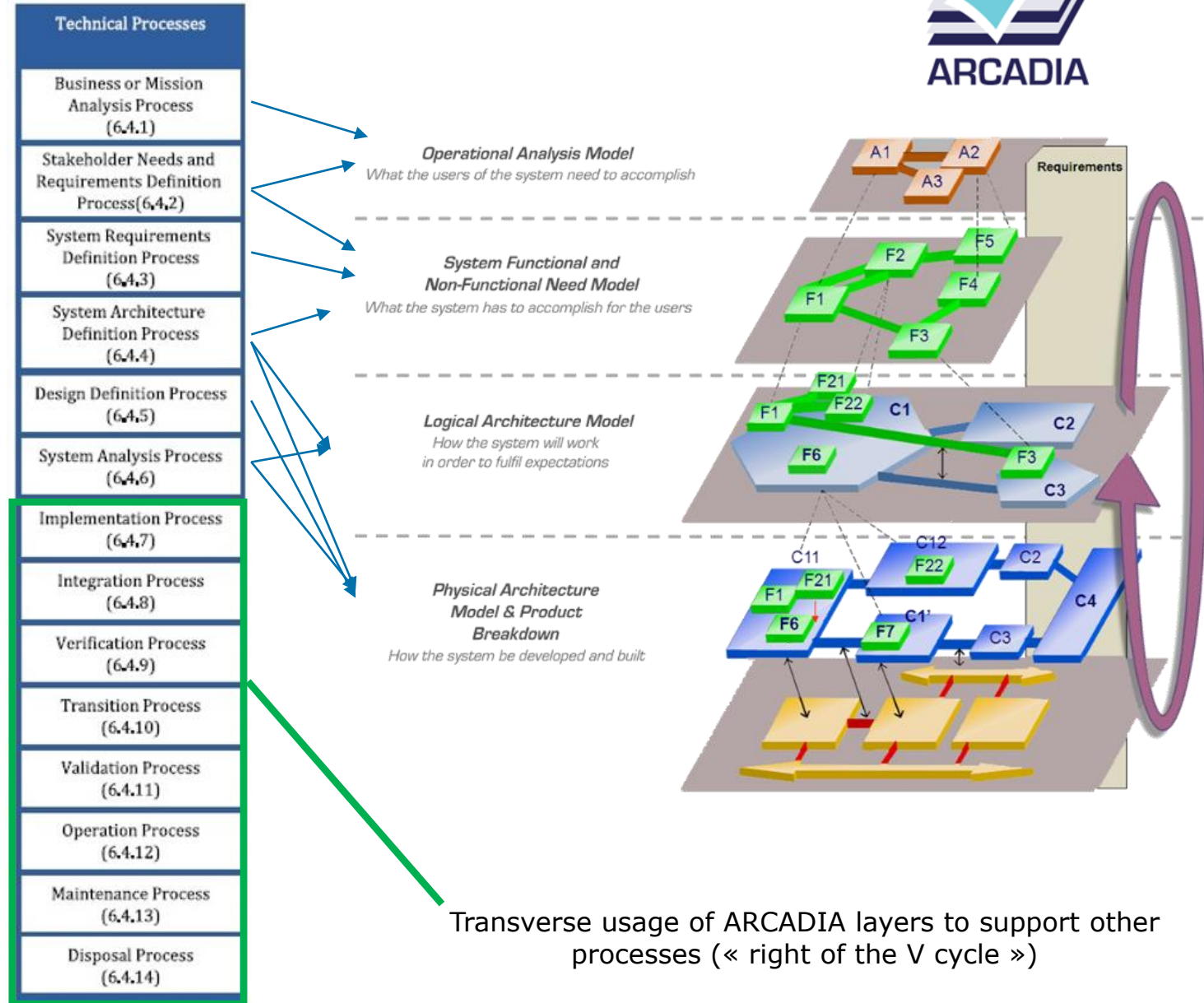
TAILORING OF ARCADIA METHOD



OBJECTIVES OF THE TAILORING OF ARCADIA METHOD

Objectives :

- Support tailored SE activities and deliverables by an efficient MBSE method
- Focus on what is expected by the project (defined into PMP and SEMP of the project)
- Define before modelize



TAILORING OF ARCADIA METHOD

CRITERIA FOR THE TAILORING OF ARCADIA METHOD

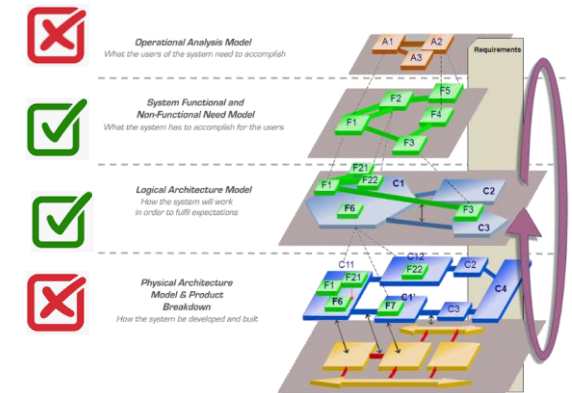
Criteria for ARCADIA tailoring :

- Maturity about SE
 - Reduced usage of Operational Arcadia layer
 - Black and / or White box approach (need / solution areas)
 - Static and / or behavior modeling
 - ...

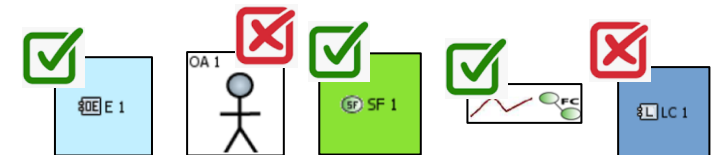
- Objective of the project
 - Capture needs
 - Architecting solution
 - Generate documents
 - System or Sub-systems level
 - ...

- Objectives of the model
 - Describe with low level formalism (« Visio like »)
 - Support communication
 - Prescriptive modeling
 - Documentation
 - ...

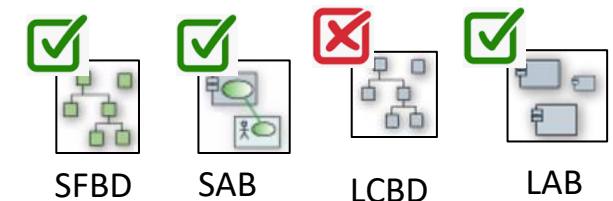
Layers



Concepts



Views



TAILORING OF ARCADIA METHOD

M01 Layer cartography	M02 Concepts cartography	M03 Views cartography	M04 MBSE method template
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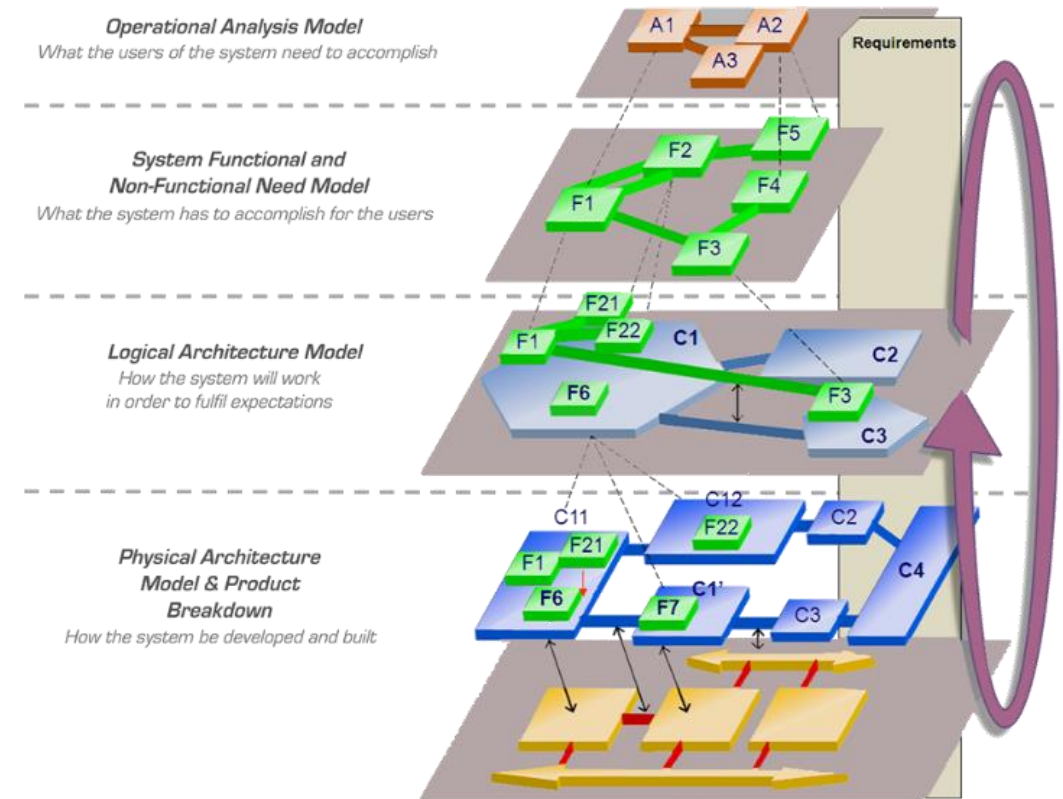


MEAN PROVIDED BY THE TAILORING FRAMEWORK



ARCADIA layers cartography :

- Select applicable ARCADIA layers for the project
 - Full operational analysis layer if SE maturity of the SE Team
 - Physical architecture layer if necessary to go down the physical formalization of the solution
 - EPBS
 - ...
- In line with SE objectives and deliverables defined in the SEMP



TAILORING OF ARCADIA METHOD

M01 Layer cartography	M02 Concepts cartography	M03 Views cartography	M04 MBSE method template
--------------------------	-----------------------------	--------------------------	-----------------------------



MEAN PROVIDED BY THE TAILORING FRAMEWORK



ARCADIA concepts cartography :

- List of available ARCADIA concepts per layer
- Select useful ARCADIA concepts for the project
- In line with MBSE objectives
- In line with selected layers

MBSE ARCADIA METHODOLOGY		Tailoring Sheet	
Project name :		Selection ?	
Operational Analysis - What the users of the system need to accomplish NO			
Concepts:	Operational Capability Operational Activity Operational Entity Operational Actor Operational Interaction Operational Process Operational Scenario		
Views:	[OEBD] Operational Entities [OCB] Operational Capabilities [OABD] Root Operational Activity (breakdown diagram) [OAB] Root Operational Activity (interaction diagram) [OAS] Operational Activity Scenario		
System Analysis - What the system has to accomplish for the Users YES			
Concepts:	System YES System Actor YES System Mission YES System Capability YES System Function YES Exchange and Port YES Functional Exchange YES Scenario YES State YES Mode YES		
Views:	[SFBD] Functional Breakdown Diagram YES [SAB] System Architecture YES [ES] Exchange Scenarios YES [MSM] Mode State Machine diagram YES		
Logical Architecture - How the system will work to fulfill operations YES			
Concepts:	Logical Function YES Logical Component YES Functional Exchange YES Component Exchange YES		
Views:	[LCBD] Logical Breakdown YES [LAB] Component Architecture YES [LFCD] Logical Functional Chain YES		
Physical Architecture - How the system will be developed and built NO			
Concepts:	Physical Function Physical Component		

TAILORING OF ARCADIA METHOD

M01 Layer cartography	M02 Concepts cartography	M03 Views cartography	M04 MBSE method template
--------------------------	-----------------------------	--------------------------	-----------------------------



MEAN PROVIDED BY THE TAILORING FRAMEWORK



ARCADIA views cartography :

- List of available ARCADIA views per layer
- Select useful ARCADIA views for the project
- In line with MBSE objectives
- In line with selected layers and concepts

The screenshot displays the 'MBSE ARCADIA METHODOLOGY Tailoring Sheet' with the following sections and their selection status:

- Operational Analysis - What the users of the system need to accomplish:** Selection status is 'No'. Views listed include [OEED] Operational Entities, [OCB] Operational Capabilities, [OABD] Root Operational Activity (breakdown diagram), [OAI] Root Operational Activity (interaction diagram), and [OAS] Operational Activity Scenario.
- System Analysis - What the system has to accomplish for the Users:** Selection status is 'Yes'. Views listed include [SFBD] Functional Breakdown Diagram, [SAB] System Architecture, [ES] Exchange Scenarios, and [MSM] Mode State Machine diagram.
- Logical Architecture - How the system will work so as to fulfil expectations:** Selection status is 'Yes'. Views listed include [LCBD] Logical Breakdown, [LAB] Component Architecture, and [LFC] Logical Functional Chain.
- Physical Architecture - How the system will be developed and built:** Selection status is 'No'.

TAILORING OF ARCADIA METHOD



M01	M02	M03	M04
Layer cartography	Concepts cartography	Views cartography	MBSE method template

MEAN PROVIDED BY THE TAILORING FRAMEWORK

MBSE method template :

- Applicable MBSE method by project team on the project
- Concrete application of tailored ARCADIA as the MBSE method for the project
- In line with MBSE objectives
- In line with selected layers, concepts and views

The image displays two sets of tailored ARCADIA templates. The top set is for 'Operational Analysis' and the bottom set is for 'System Analysis'. Each set includes a 'USED VIEWS' section with a list of diagram types and their justifications, and an 'UNUSED VIEWS' section with a list of diagram types that are not applicable. Additionally, there are sections for 'Objectives of the layer' and 'CONCEPTS USED'.

Operational Analysis (1/2) - USED VIEWS:

- [OEDD]** : Operational Entity Breakdown Diagram
- [OCD]** : Operational Capabilities Diagram
- [OAI]** : Operational Activity Interaction Diagram
- [OABD]** : Operational Activity Breakdown Diagram
- [OASD]** : Operational Architecture Scenario Diagram
- [OES]** : Operational Entity Scenario

Operational Analysis (1/2) - UNUSED VIEWS:

- [ORD]** : Operational Role Diagram
- [OAS]** : Operational Activity Scenario

Operational Analysis (1/2) - Objectives of the layer « Operational Analysis »:

- Définir les besoins et l'environnement des parties prenantes
- Copier et consolider les besoins opérationnels des parties prenantes
- Définir ce que les utilisateurs du système doivent accomplir
- Identifier les entités, les acteurs, les rôles, les activités et les concepts

Operational Analysis (2/2) - CONCEPTS USED:

- Entité opérationnelle
- Acteur opérationnel
- Interaction opérationnelle
- Processus opérationnel

System Analysis (1/2) - USED VIEWS:

- [CSA]** : Contextual System Actions Diagram
- Mission and / or Capability Blank Diagram
- Matrice de traçabilité
- [FBD]** : Functional Breakdown Diagram
- [DFB]** : Functional Dataflow Blank Diagram
- [SAD]** : System Architecture Diagram
- [ES]** : Exchange Scenario
- [CED]** : Contextual External Interface Diagram of the System

System Analysis (1/2) - UNUSED VIEWS:

- [FS]** : Functional Scenario
- [CDI]** : Contextual Detailed Interfacier
- [IS]** : Interface Scenario

System Analysis (1/2) - Objectives of the layer « Sy »:

- Formaliser les exigences du système
- Identifier les limites du système
- Définir ce que le système doit accomplir
- Visualiser le flux de données fonctionnelles

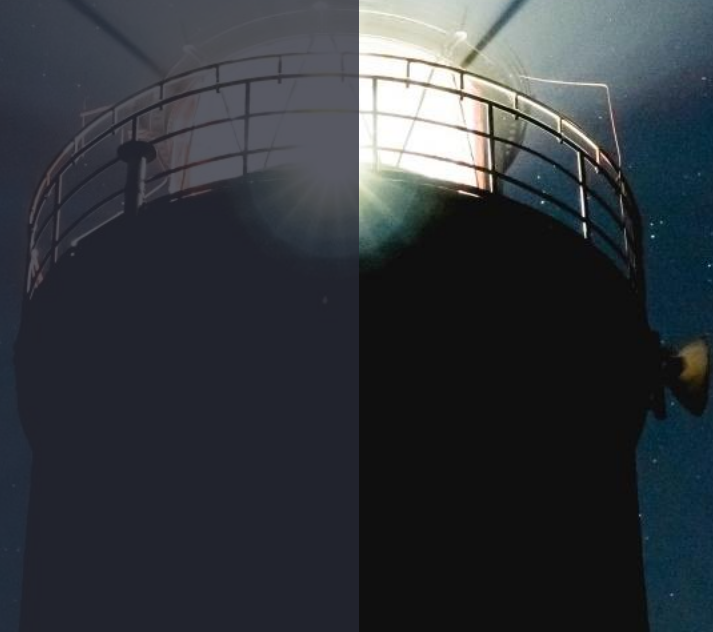
System Analysis (2/2) - CONCEPTS USED:

- Système
- Acteur système
- Mission
- Fonction système
- Échange et Port
- Chaîne fonctionnelle
- Interface



5

CONCLUSION AND WAY FORWARD





TAILORING OF SE PROCESSES AND ARCADIA MBSE METHOD CONCLUSION AND WAY FORWARD

CONCLUSION

- Be pragmatic
- Be applicable
- Adapt language to people
- MBSE is a mean for SE. SE is a mean for right system
- MBSE models are means and not objectives

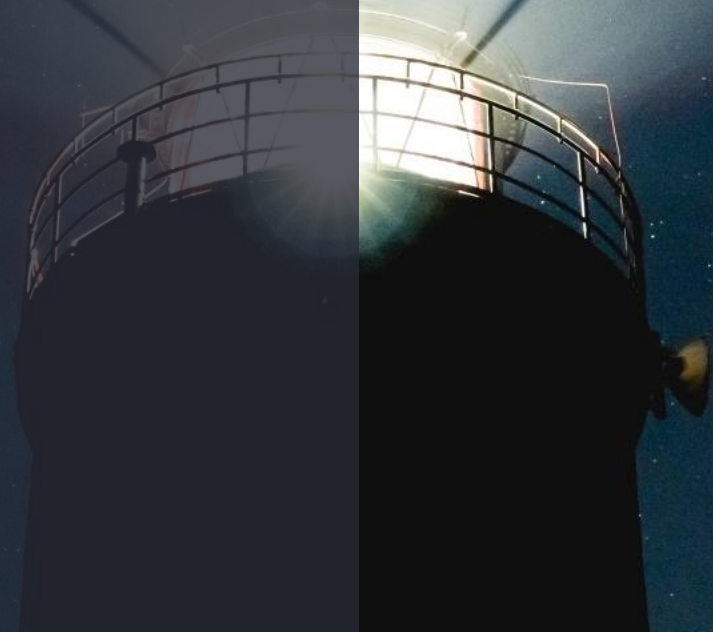
WAY FORWARD

- Update CAPGEMINI Tailoring Framework to be in line with ISO15288 and INCOSE Handbook 2023 versions
- Use more multi-industries and multi-projects return of experiences
- Extend tailoring to CAPELLA tool with plugins

LESS IS MORE



6 Q & A





**GET THE
FUTURE
YOU WANT**



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