THALES

Arcadia and Capella: Rationale, status, and perspectives

WEBINAR – MAY 14TH, 2019

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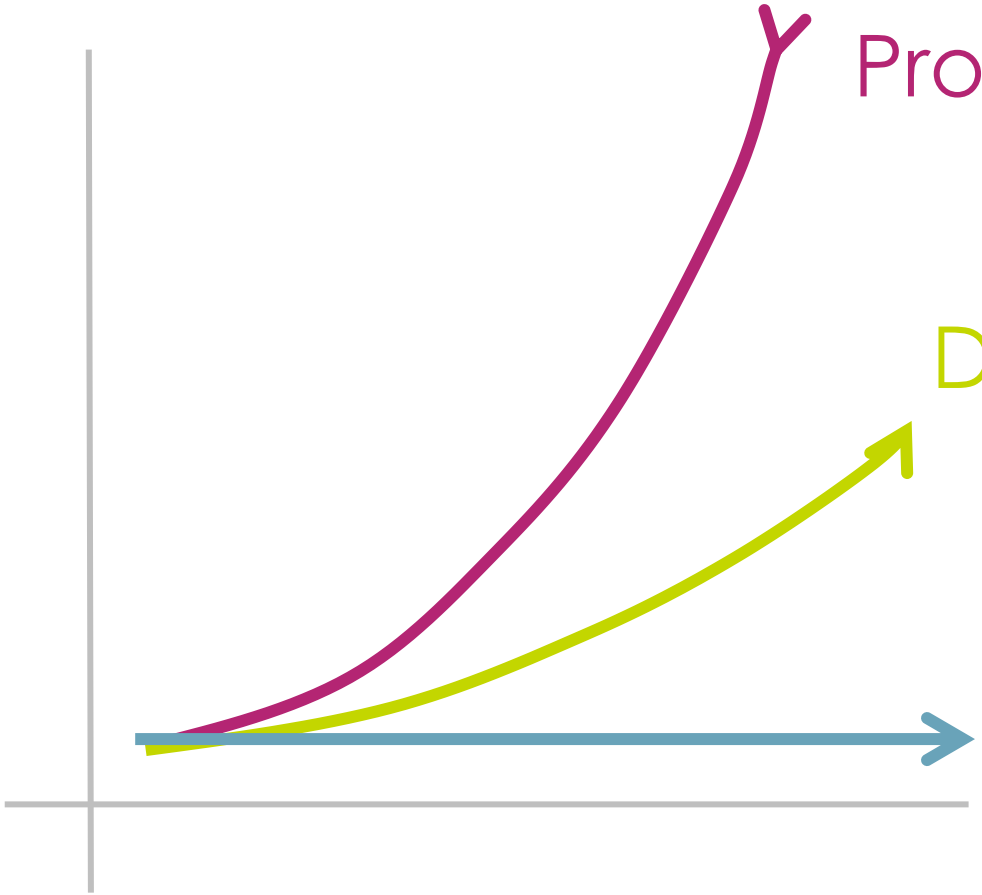
NAFEMS
Systems Modeling and Simulation Working Group

Preamble

Why MBSE, Arcadia, Capella

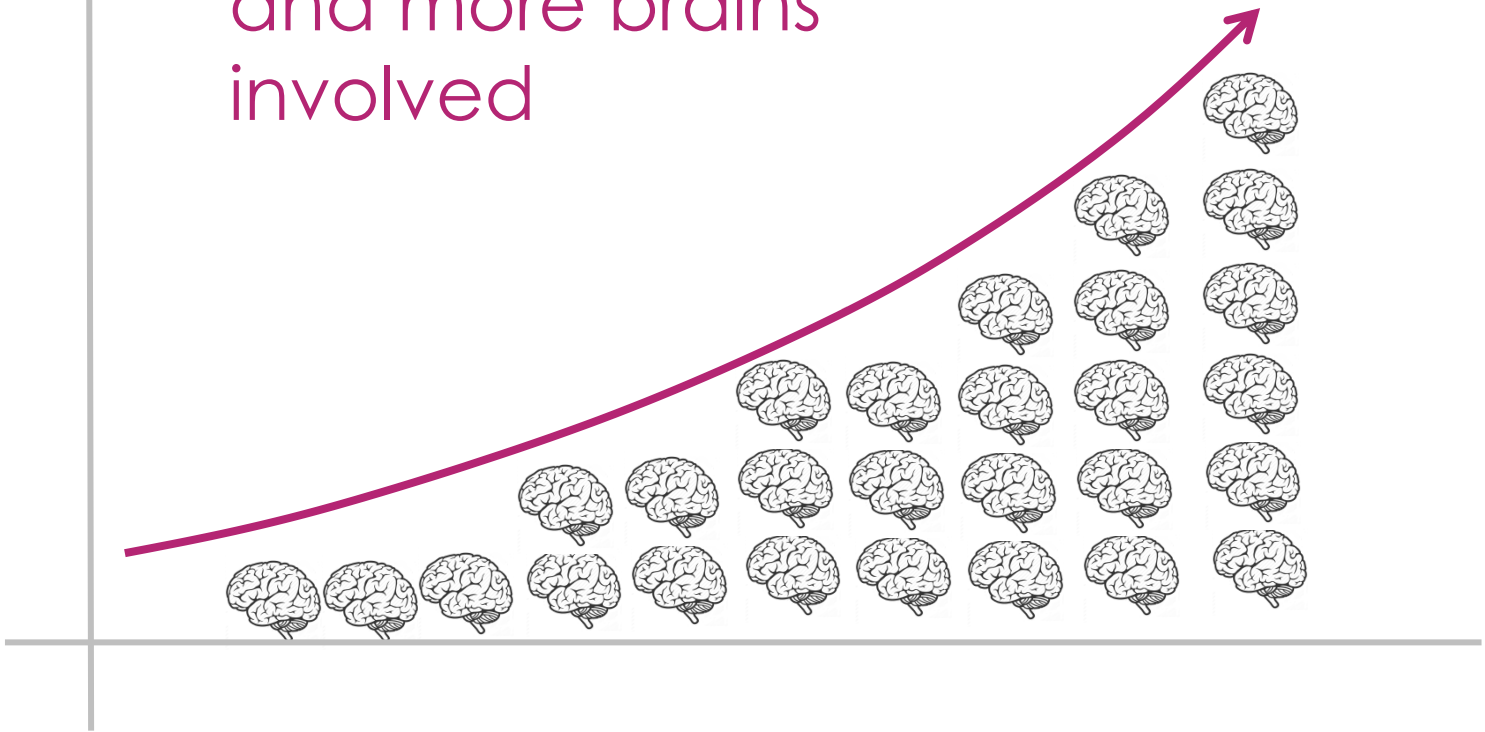


Project complexity

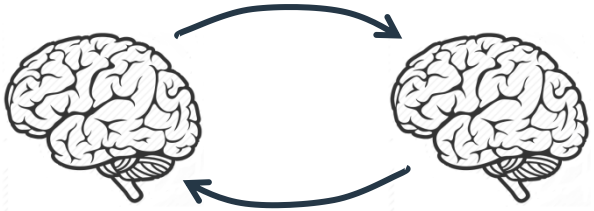
Disciplines

The brains of engineers

Complexity: more and more brains involved

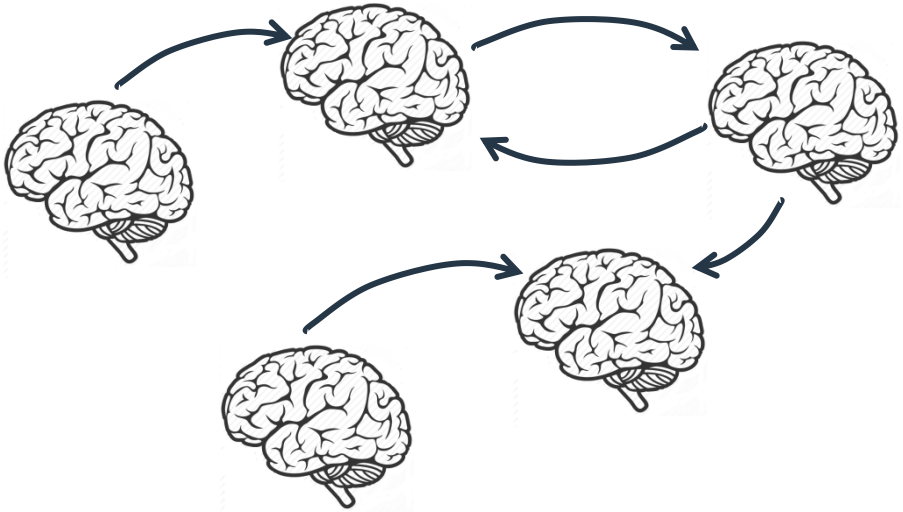


Doing more, with more constraints and less time



Coping with very demanding customers

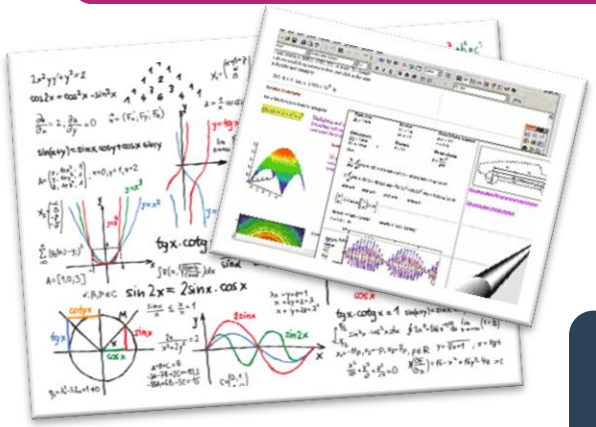
Interacting with more peers



Communication and information management problem

Languages

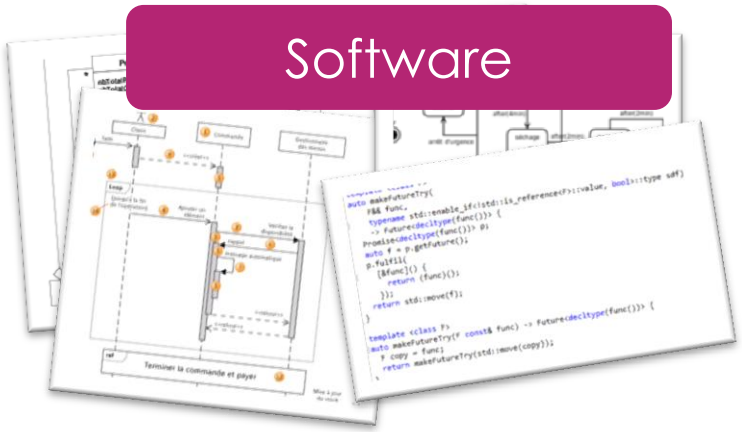
Mathematics



Construction

Electronics

Software



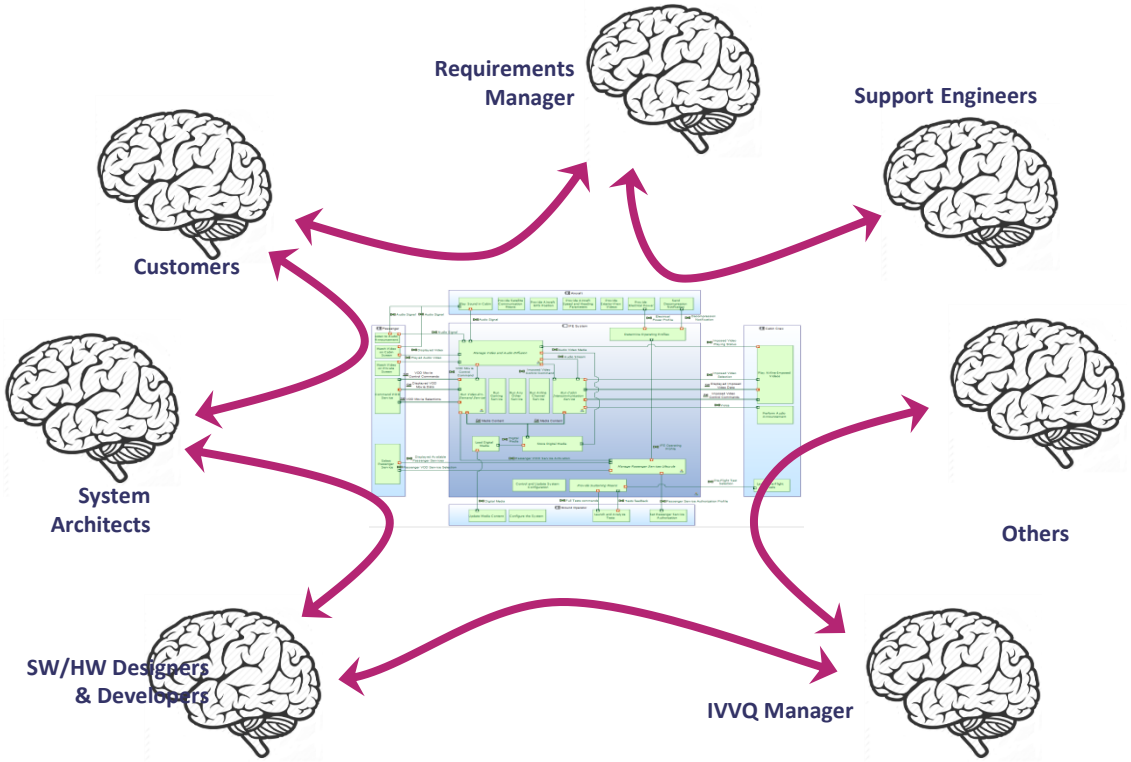
Engineering pratices

Natural language text,
ad-hoc spreadsheets,
textual requirements,
a pinch of traceability,
etc.

Common language

Shared models with multiple views

Collaborative workflow and unique reference



Which purposes for a model?

SHARE

Improve communication and reduce ambiguities

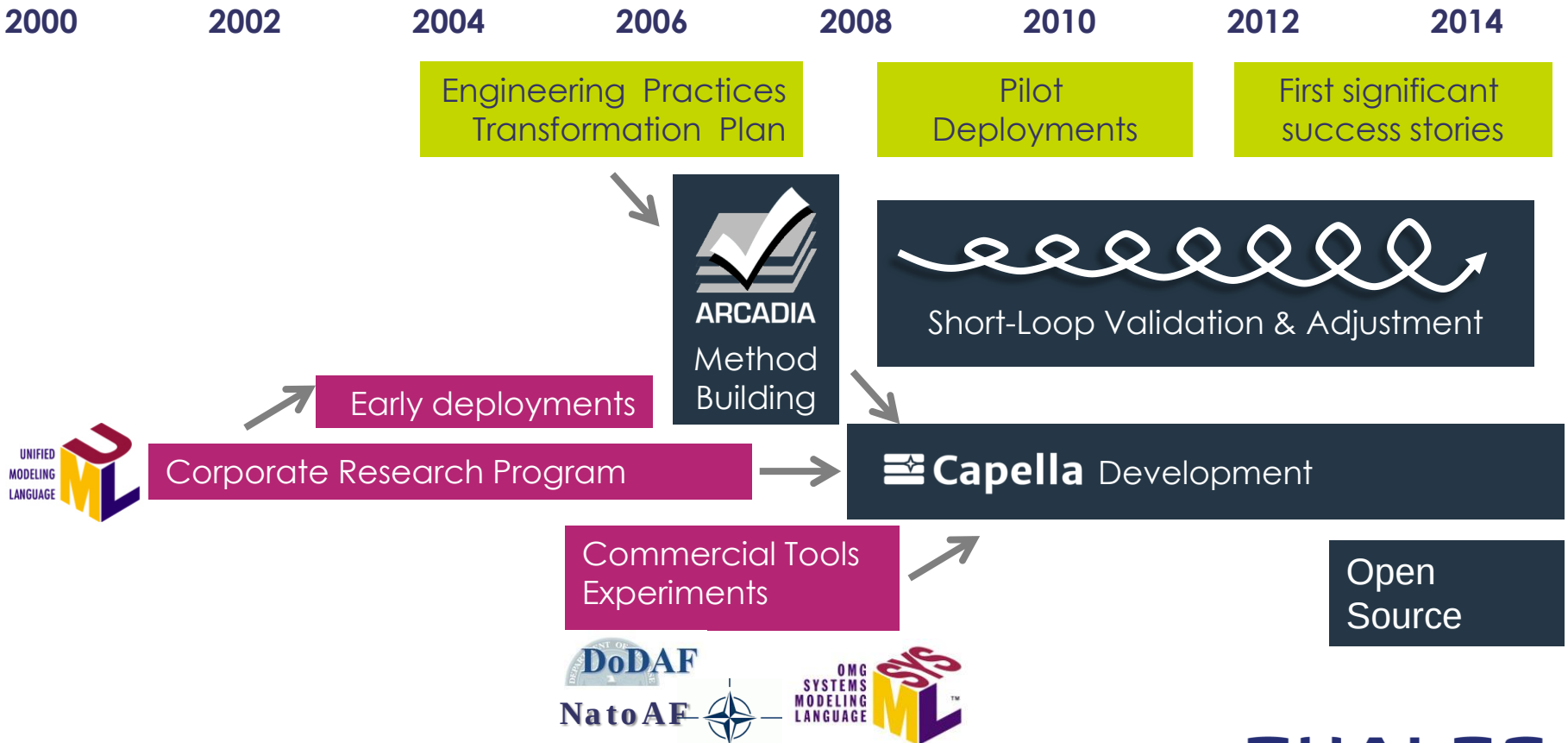
MASTER

Analyze and evaluate to secure design, drive engineering activities

AUTOMATE

Generate documentation, code, models, etc.

The Thales MBSE Odyssey



Scope

Enterprise Architecting (operational capabilities and need, orientations, etc.)

Multi-physics: 3D, power models, thermal models, etc.

Algos, Real-time Analysis, NF, Etc.

System Architectural Design

SW/HW/FM Architectural Design

V&V

Detailed design, development

Scope

Enterprise Architecting (operational capabilities and need, orientations, etc.)

Multi-physics: 3D, power models, thermal models, etc.

Algos, Real-time Analysi NF, Etc.

Method

Workbench

V&V

Detailed design, development

Arcadia

The method

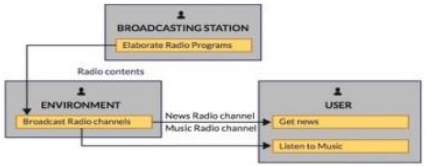
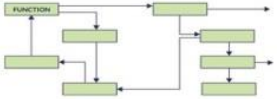
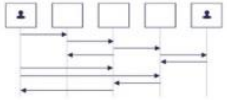
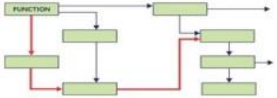
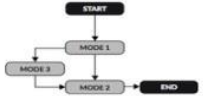
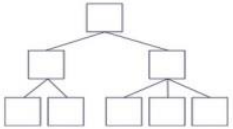
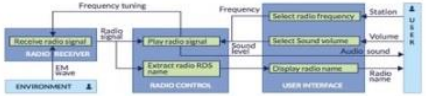
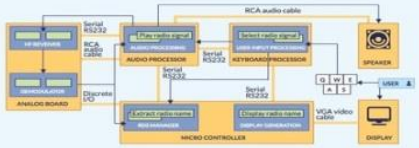
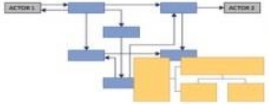
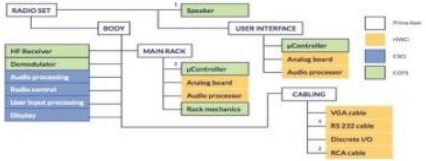
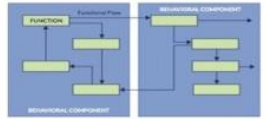
Understand the real user/customer needs

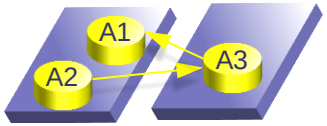
Define and share the solution among stakeholders

Secure SYS/SW/HW engineering, prepare subcontracting

Early evaluate and justify architectural design

Prepare and master V&V

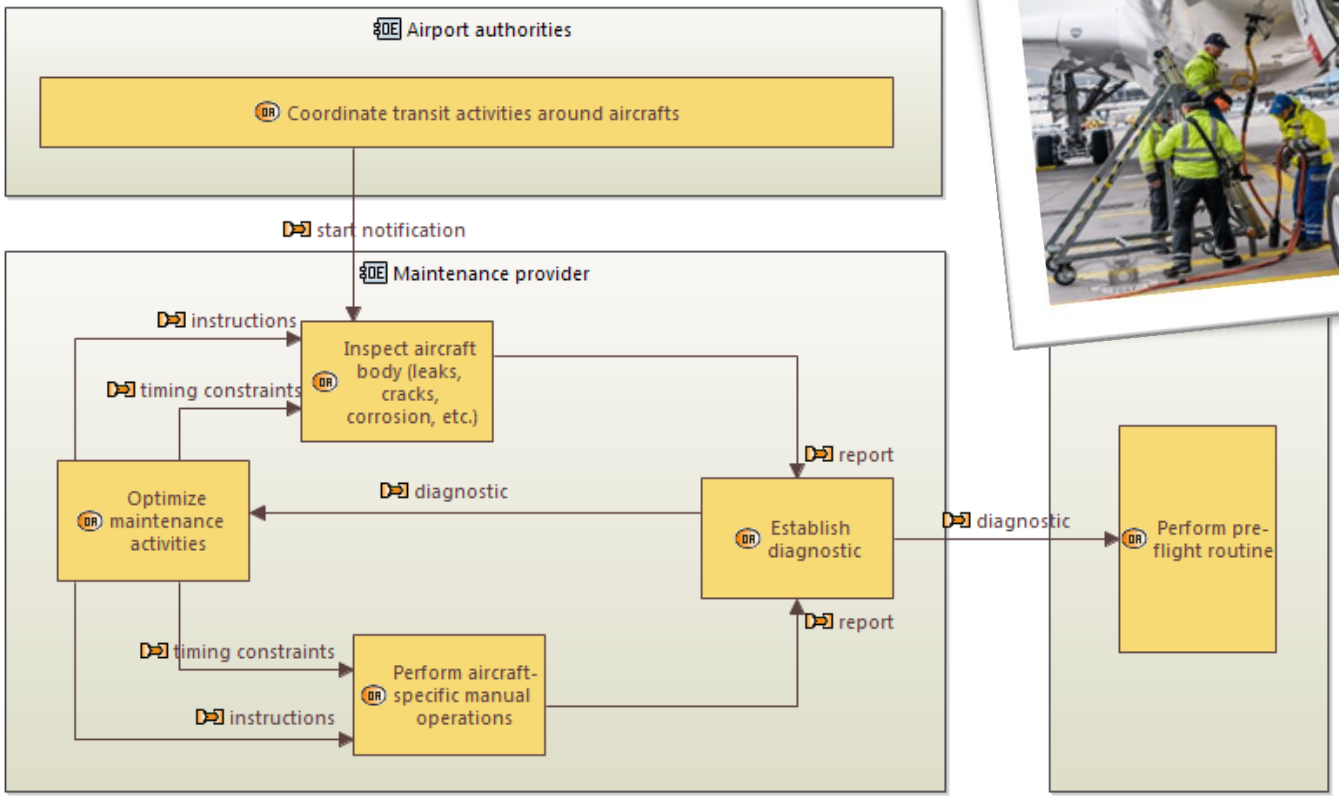
METHOD STEPS	TASKS	SAMPLE MODEL	CONCEPTS	DESCRIPTION MEANS
NEED				
Customer Operational Need Analysis What the users of the system need to accomplish	✓ Define operational capabilities ✓ Perform an operational need analysis		- Operational capabilities - Actors, operational entities - Actor activities - Interactions between activities & actors - Information used in activities & interactions - Operational processes chaining activities - Scenarios for dynamic behaviour	 **Dataflow**: functions, op. activities interactions & exchanges  **Scenarios**: actors, system, components interactions & exchanges
System/ SW/HW Need Analysis What the system has to accomplish for the Users	✓ Perform a capability trade-off analysis ✓ Perform a functional and non-functional analysis ✓ Formalise and consolidate requirements		- Actors and system, capabilities - Functions of system & actors - Dataflow exchanges between functions - Functional chains traversing dataflow - Information used in functions & exchanges, data model - Scenarios for dynamic behaviour - Modes & states	 **Functional chains, operational processes** through functions & op. activities   **Modes & states** of actors, system, components
SOLUTIONS				
Logical Architecture Design How the system will work so as to fulfil expectations	✓ Define architecture drivers and viewpoints ✓ Build candidate architectural breakdowns in components ✓ Select best compromise architecture		*SAME CONCEPTS, PLUS :* - Components - Component ports and interfaces - Exchanges between components - Function allocation to components - Component interface justification by functional exchanges allocation	**Breakdown** of functions & components
Physical Architecture Design How the system will be developed & built	✓ Define architectural patterns ✓ Consider reuse of existing assets design a physical ✓ Design a physical reference architecture ✓ Validate and check it		*SAME CONCEPTS, PLUS :* - Behavioural components refining logical ones, and implementing functional behaviour - Implementation components supplying resources for behavioural components - Physical links between implementation components	**Data model**: dataflow & scenario contents, definition & justification of interfaces   **Component wiring:** all kinds of components
Development Contracts What is expected from each designer/ sub-contractor	✓ Define a components IVVQ strategy ✓ Define & enforce a PBS and component integration contract		- Configuration items tree - Parts numbers, quantities - Development contract (expected behaviour, interfaces, scenarios, resource consumption, non-functional properties...)	**Allocation** of op.activities to actors, of functions to components, of behav.components to impl.components, of dataflows to interfaces, of elements to configuration items 

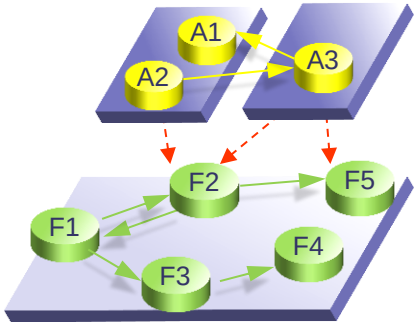


Operational Analysis

WHAT THE USERS/STAKEHOLDERS NEED TO ACCOMPLISH

Support of discussions with the customer, capabilities, scenarios and processes

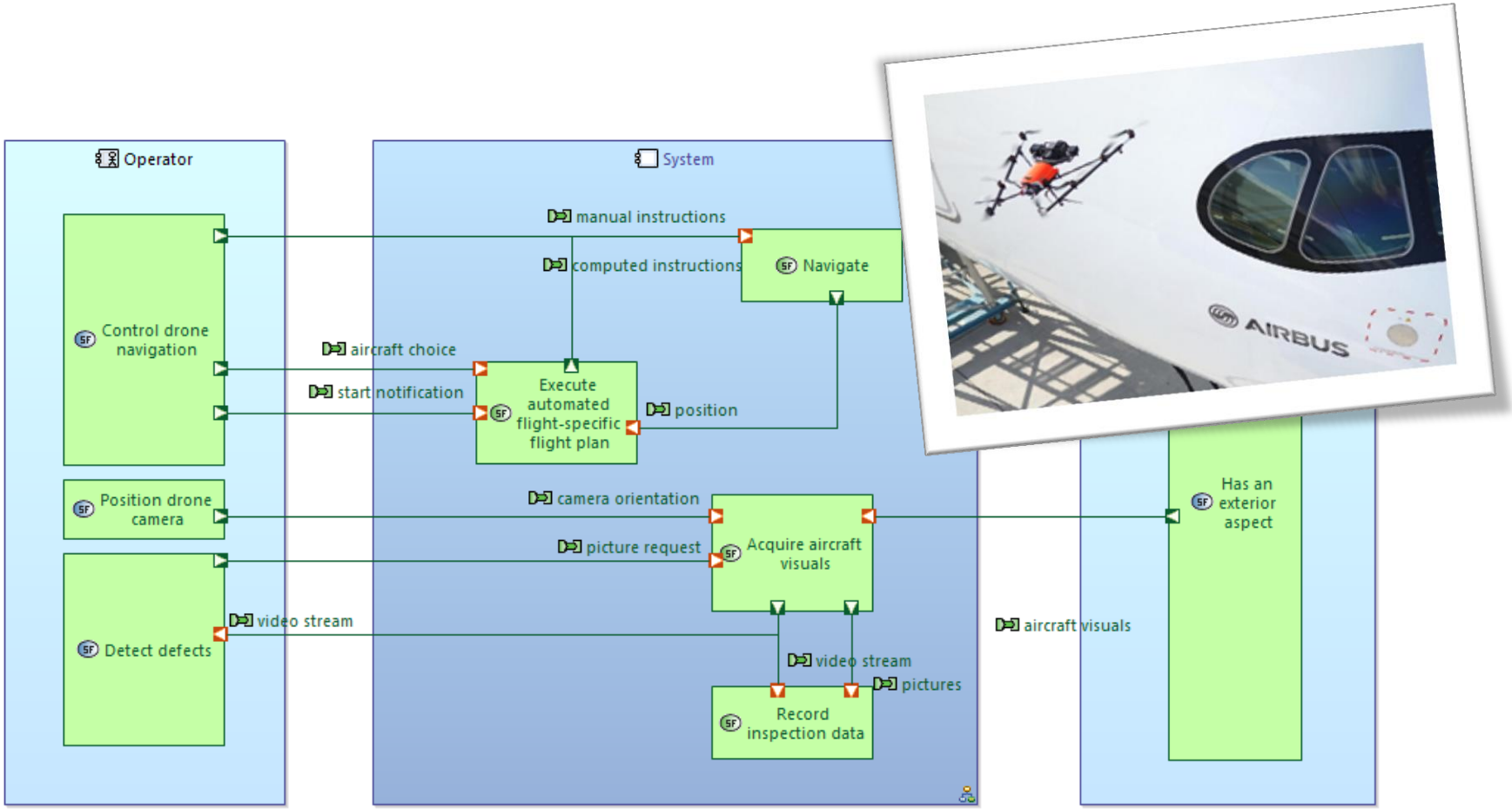


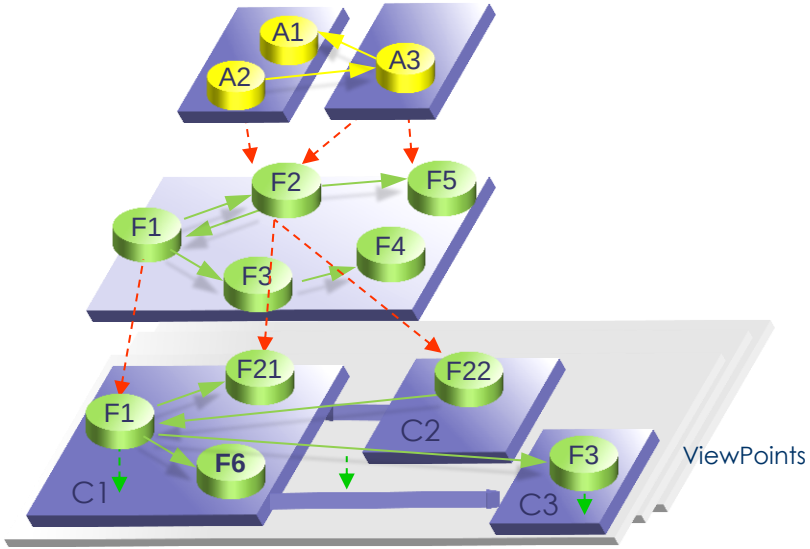


System Need Analysis

WHAT THE SYSTEM HAS TO ACCOMPLISH FOR THE USERS

Boundaries, external interfaces, specification, v&v procedures, feasibility of requirements



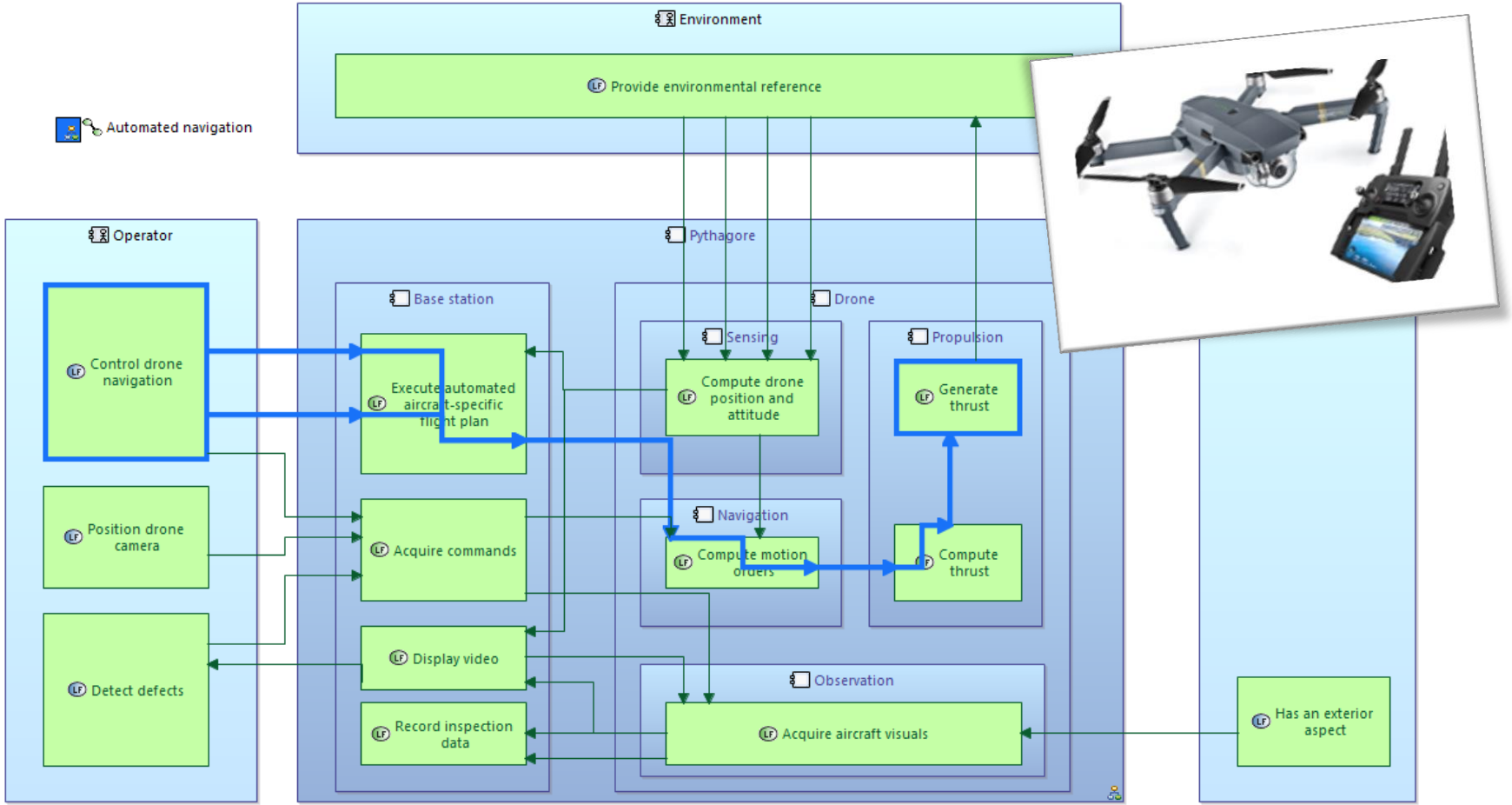


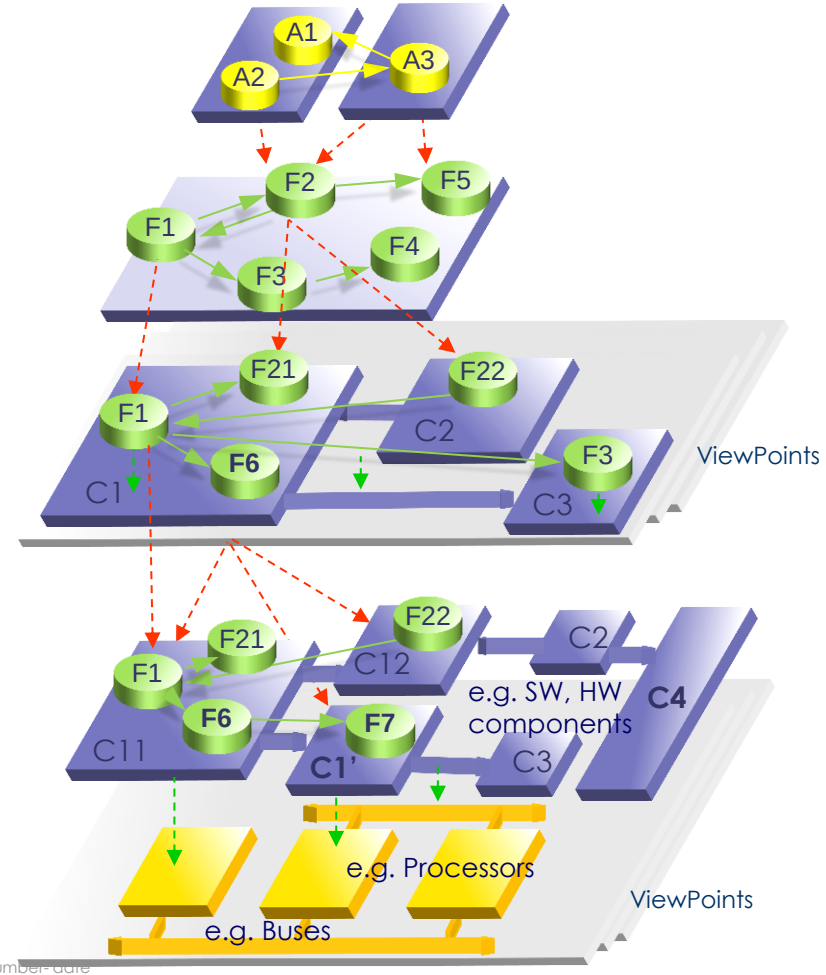
Logical Architecture

HOW THE SYSTEM WILL WORK SO AS TO FULFIL EXPECTATIONS

High-level architecture description, functional refinement, architectural drivers, functional allocation, first trade-offs,

modes and states analysis

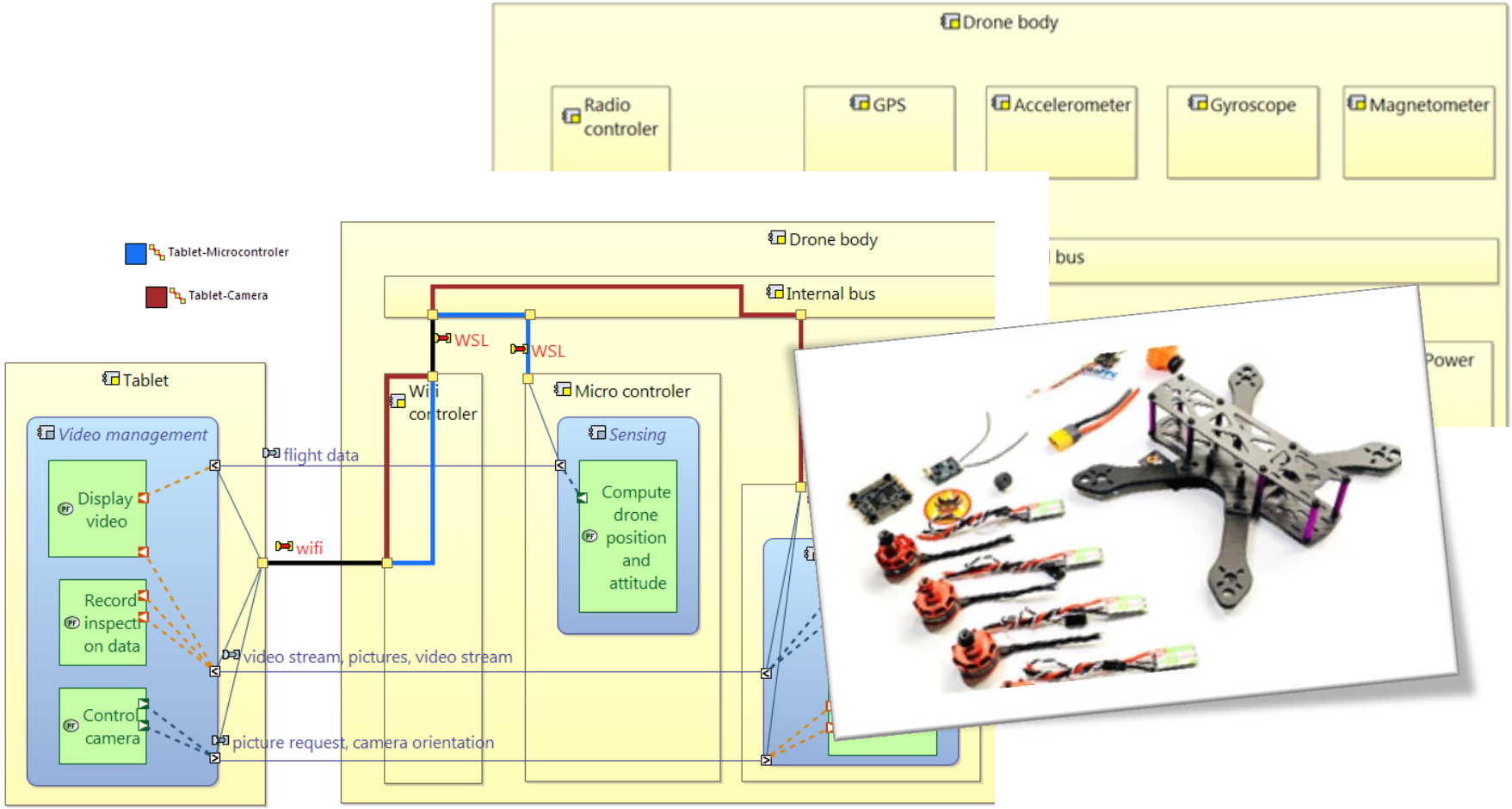




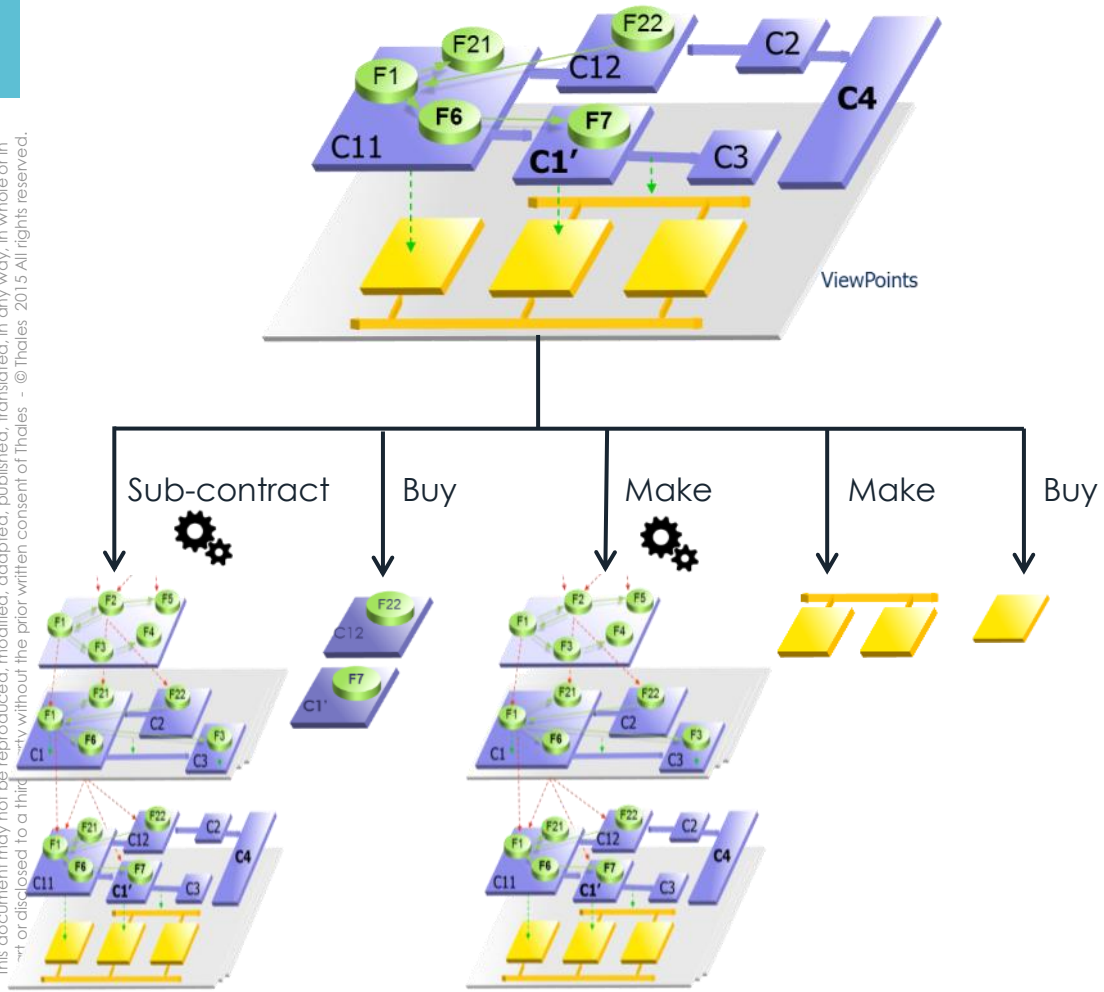
Physical Architecture

HOW THE SYSTEM WILL BE DEVELOPED AND BUILT

Implementation constraints, reuse, refined trade-offs, M/T/B strategy, finalized detailed interfaces



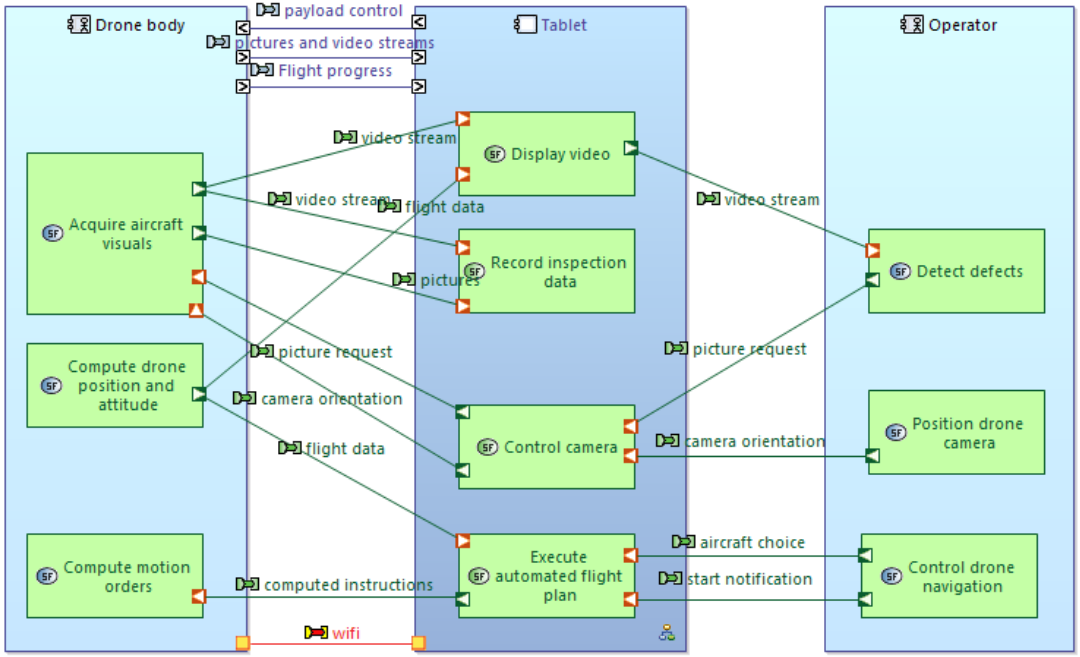
THALES



End-Product Break Down Structure

WHAT IS EXPECTED FROM EACH DESIGNER / SUB-CONTRACTOR

Definition of Configuration Items, definition of development strategy (make, buy, sub-contract)

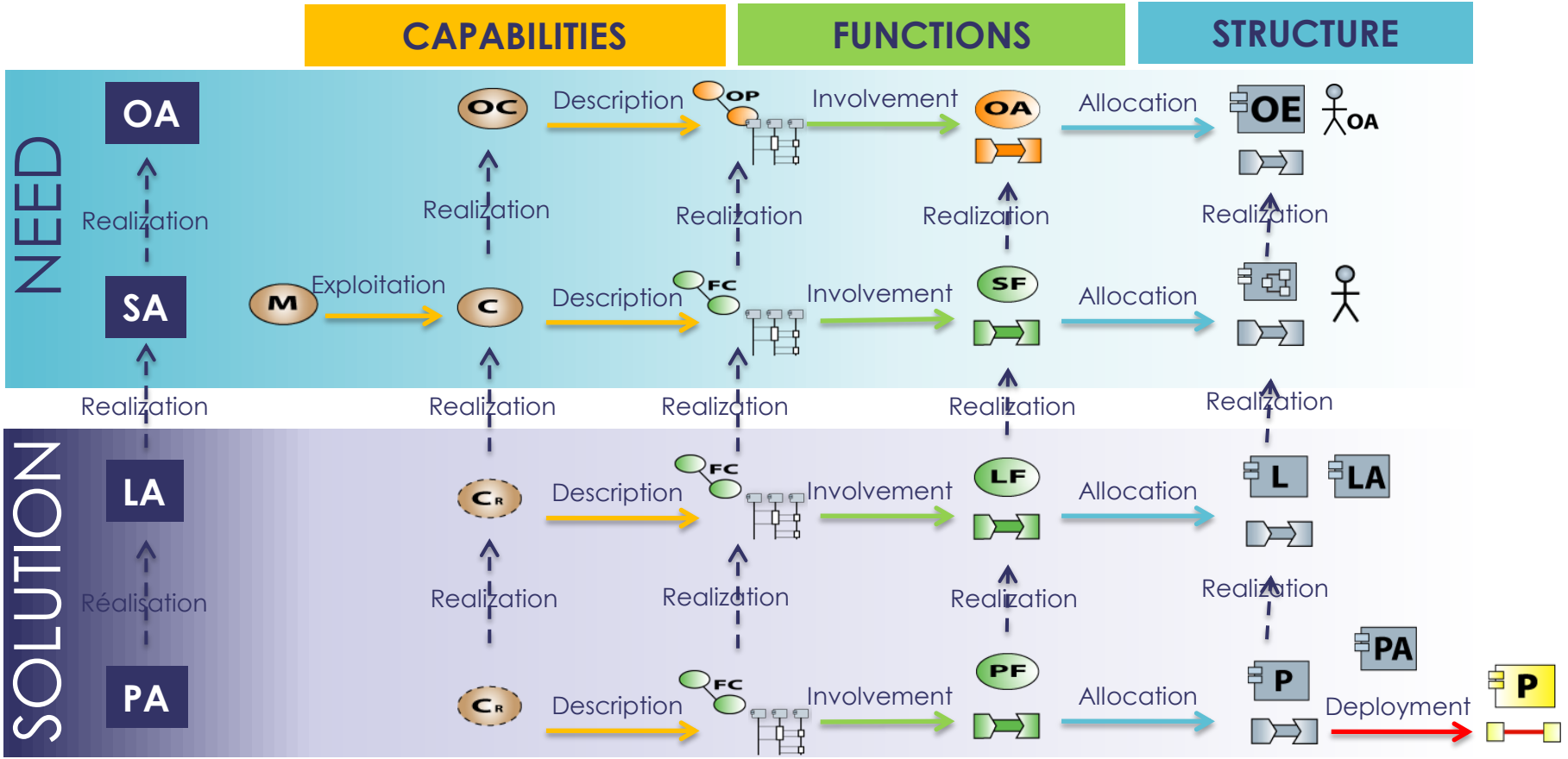


System Need Analysis

WHAT THE SYSTEM HAS TO ACCOMPLISH FOR THE USERS

Boundaries, external interfaces, specification, v&v procedures, feasibility of requirements

Summary of concepts



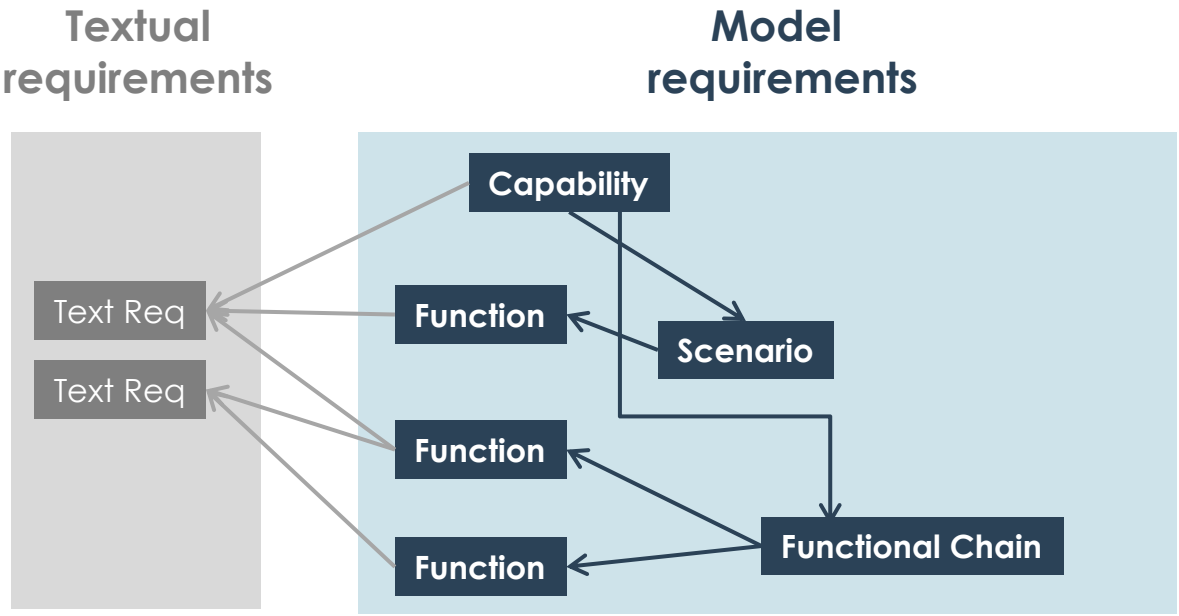
Requirements and models, a 3-legs stool

Textual requirements are at the heart of the current engineering practices

"Need" model helps formalize and consolidate customer and system requirements

"Solution" model helps validate feasibility and elicit/justify new requirements for the system or its subsystems

Textual and model requirements complete each other

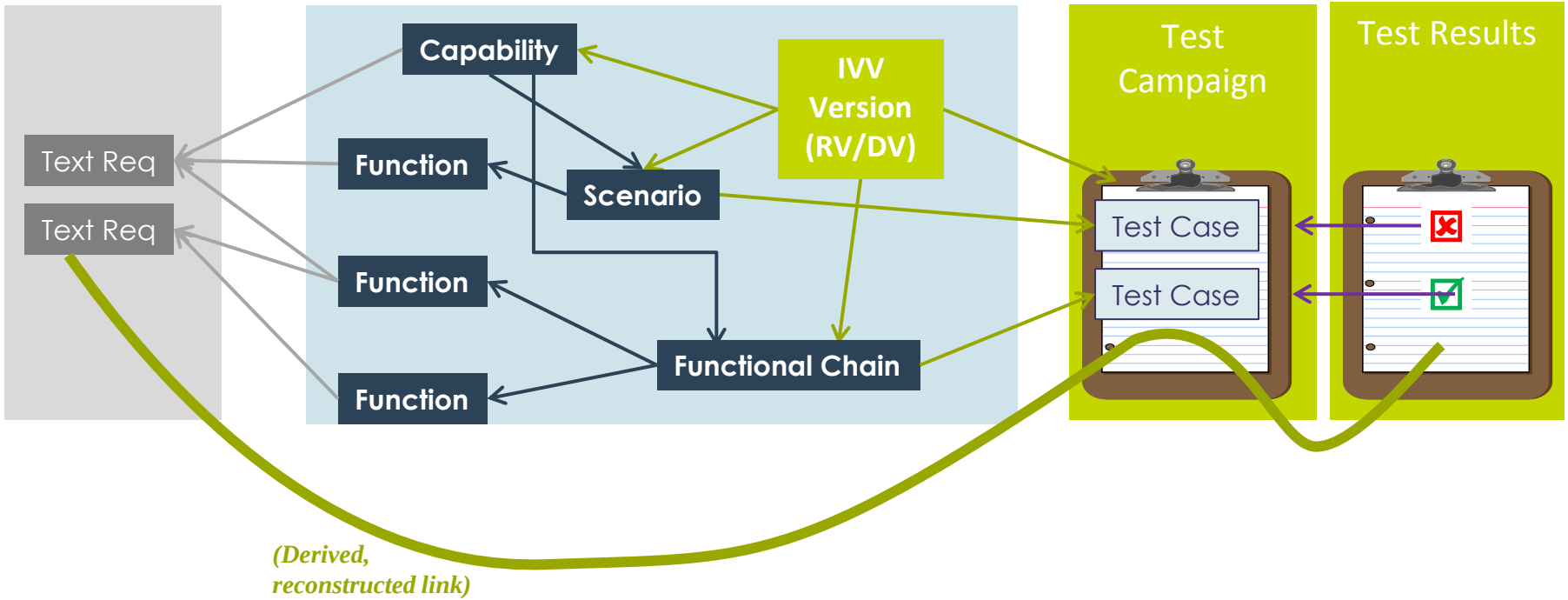


Not all expectations can be captured in a model (environmental constraints, applicable norms, required maintenance period, etc.)

Textual requirements

Model requirements

V&V



Arcadia-Capella

Tight coupling

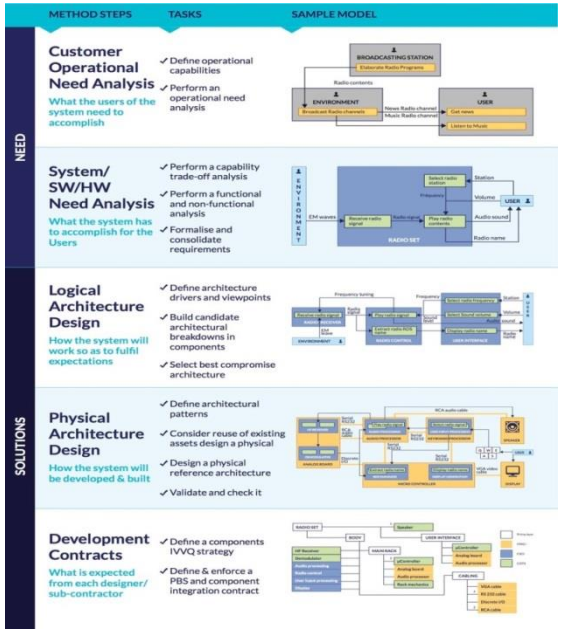
Tight coupling method/tool

Methodology + high level concepts and viewpoints

Purpose-built to provide the notation and diagrams fitting the Arcadia approach

Capella

Tight coupling method/tool



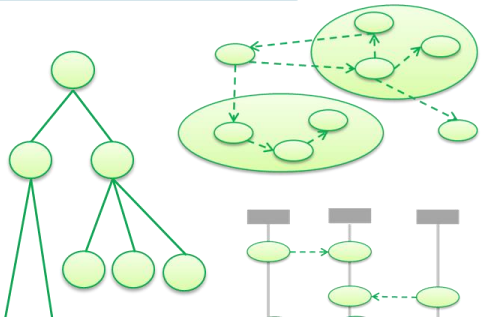
ARCADIA

Capella

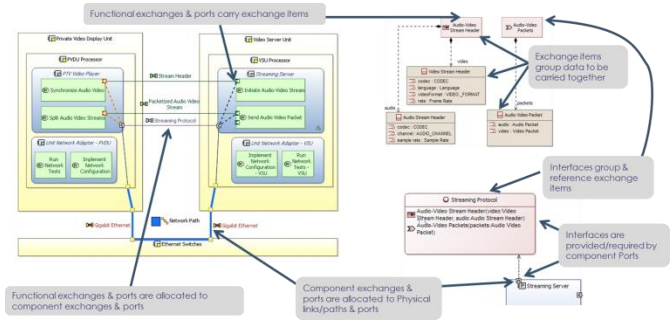
THALES

(Some of the) Key aspects of Capella

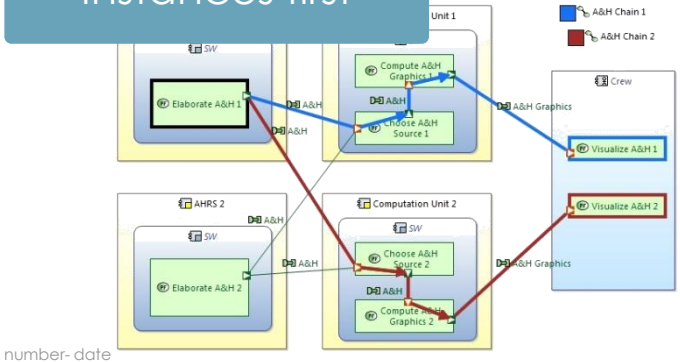
Functional analysis



(Functional) Interfaces



Instances first



Modeling accelerators

Complexity management

…

Demos on Youtube channel

1 Webinar - How is Capella different?
PolarSys Capella

2 [Webinar] What's new in Capella 1.3?
PolarSys Capella

3 [Webinar] Thales return on experience: usage of Capella in bid phase of railway signalling projects
PolarSys Capella

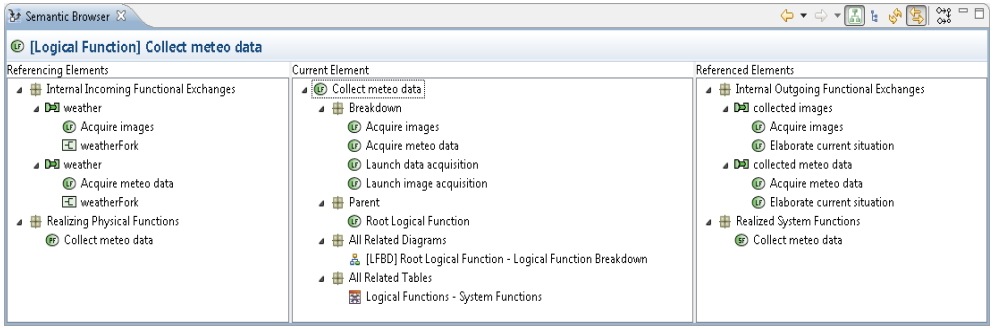
4 [Webinar] Easily enrich Capella models with your domain extensions
PolarSys Capella

5 [Webinar] Equivalences and differences between Arcadia/Capella and SysML
PolarSys Capella

User oriented productivity tools

Relations visualization

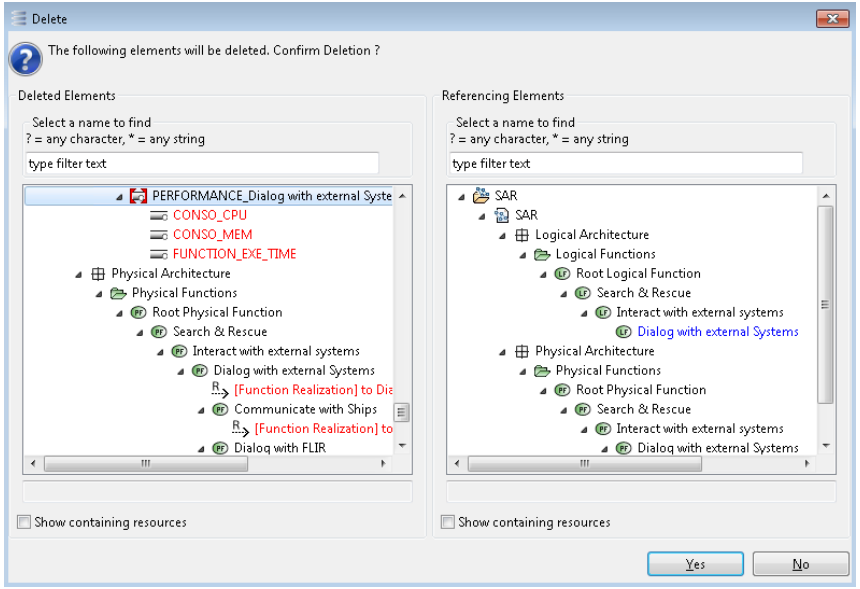
- Semantic browser



User oriented productivity tools

- **Relations visualization**
- **Semantic delete**

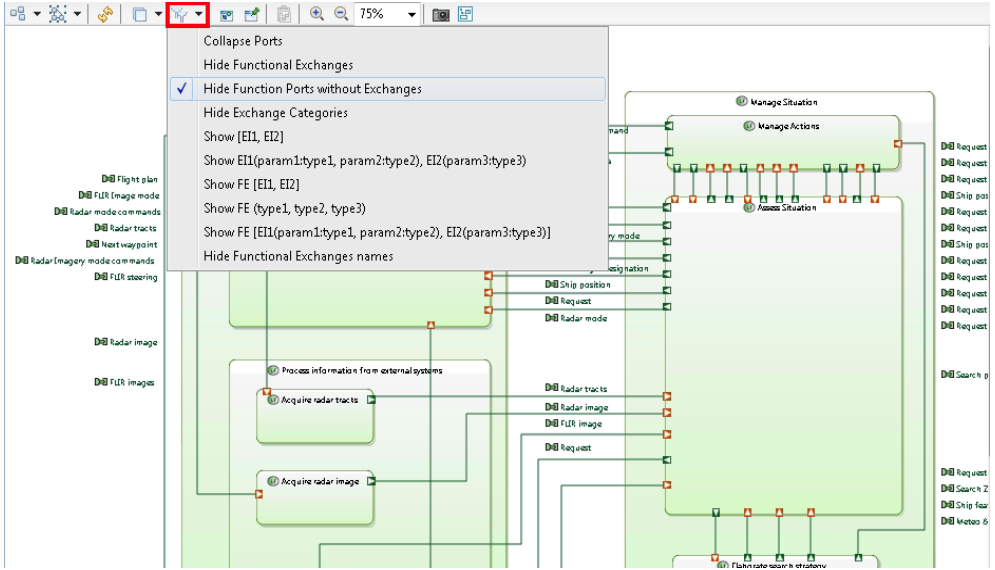
- Ensures datamodel consistency!



User oriented productivity tools

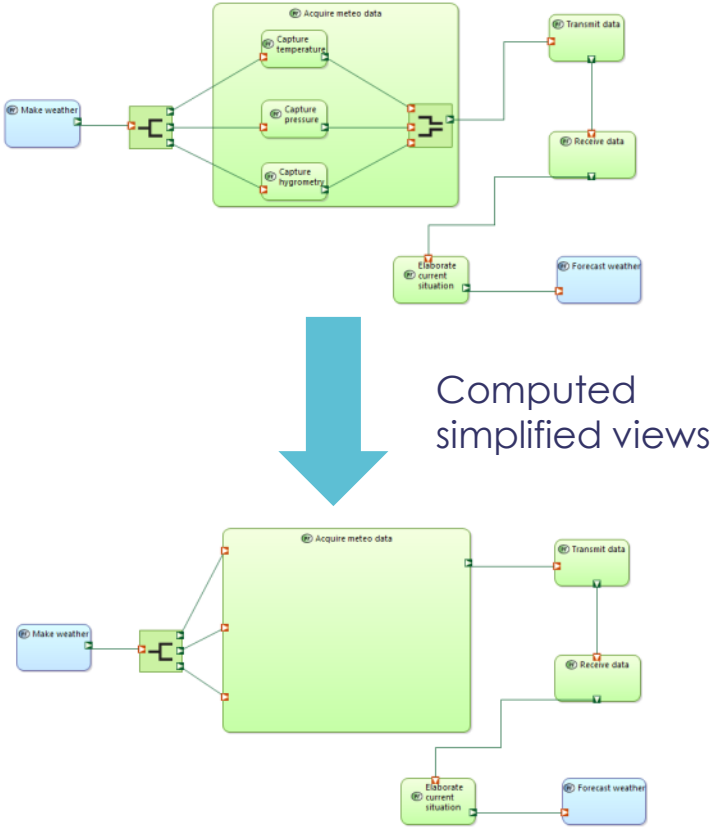
- **Relations visualization**
- **Semantic delete**
- **Management of filters**

- Hide graphical complexity



User oriented productivity tools

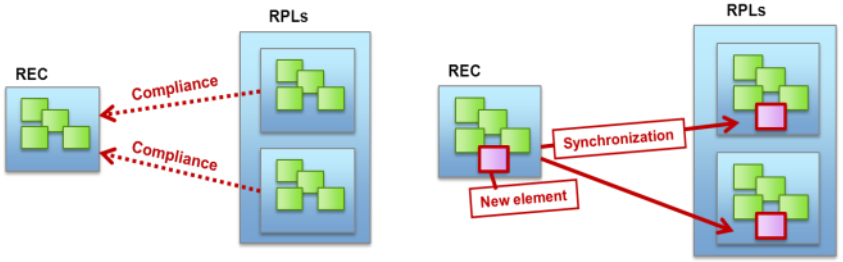
- Relations visualization
- Semantic delete
- Management of filters
- Complexity management



User oriented productivity tools

- **Relations visualization**
- **Semantic delete**
- **Management of filters**
- **Complexity management**
- **Reuse**

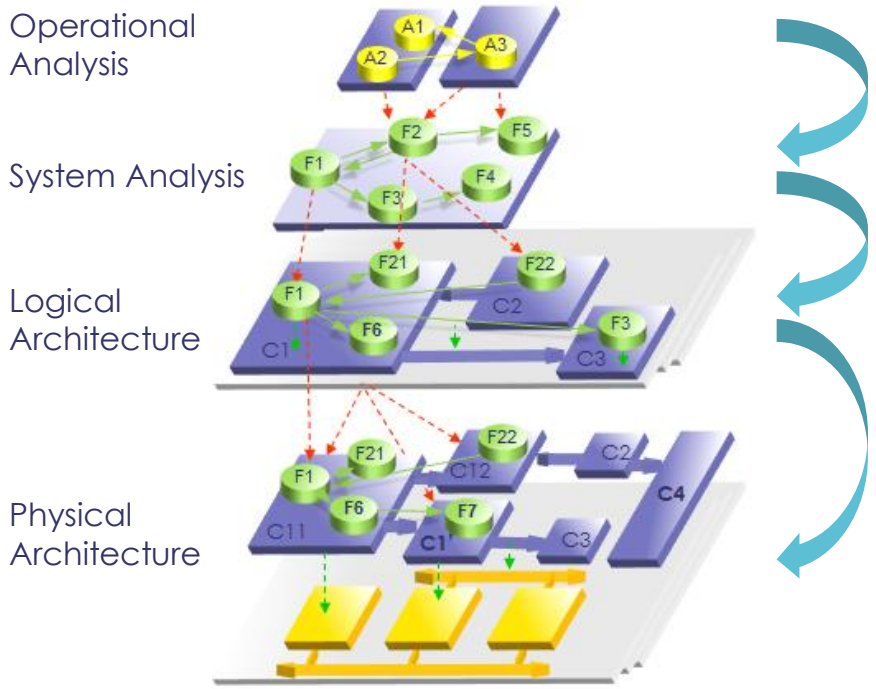
- Definition of replicable elements and multi-instanciation



- Definition of libraries for reuse in several projects

User oriented productivity tools

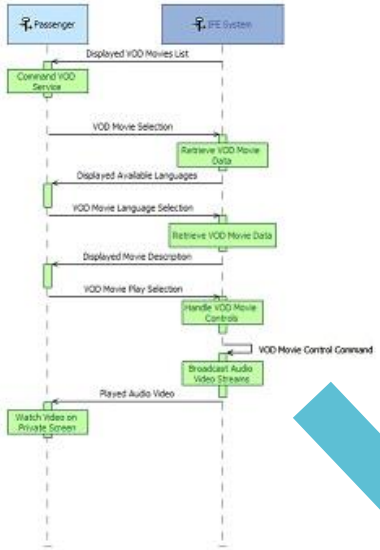
- Relations visualization
- Semantic delete
- Management of filters
- Complexity management
- Reuse
- Iterative transitions



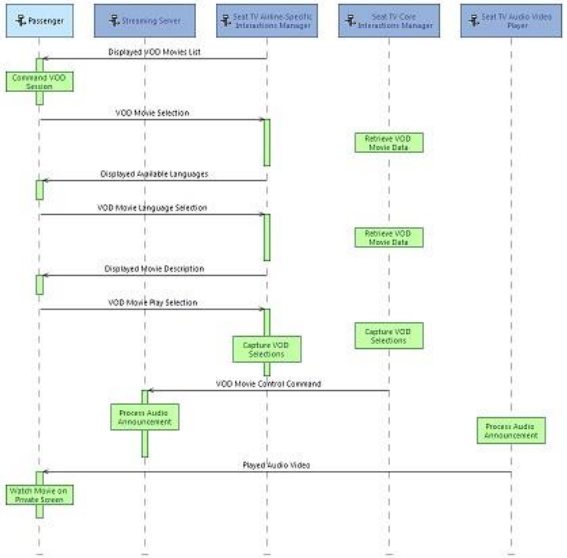
Iterative transitions between Arcadia steps and tracebability

User oriented productivity tools

- Relations visualization
- Semantic delete
- Management of filters
- Complexity management
- Reuse
- Iterative transitions
- Modeling Accelerators



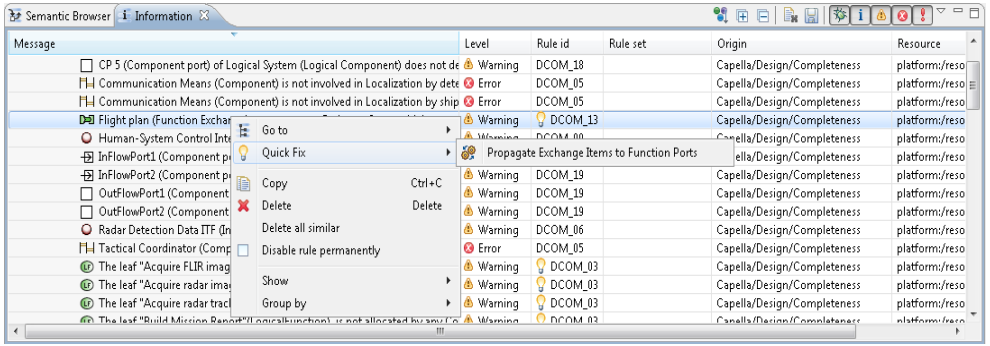
E.g. initialisation of Logical Architecture scenario from System Analysis scenario



User oriented productivity tools

- Relations visualization
- Semantic delete
- Management of filters
- Complexity management
- Reuse
- Iterative transitions
- Modeling Accelerators
- Model validations & quick fixes

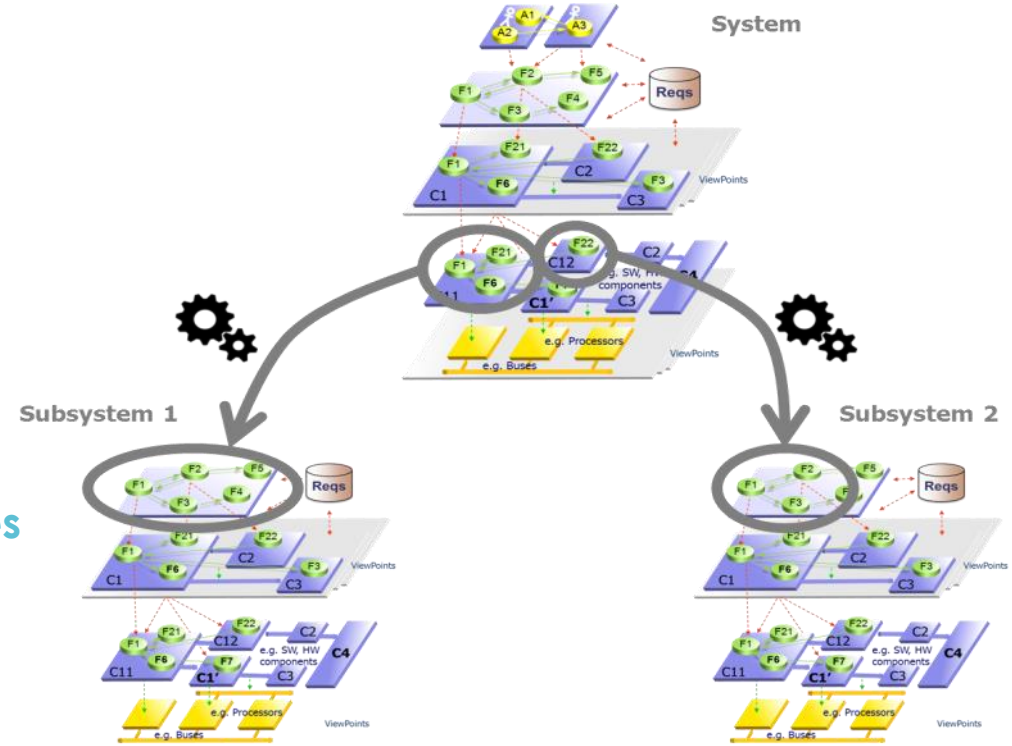
- Execution of validation rules
- Customization of validation rules
- Execution of quick fixes



User oriented productivity tools

- Relations visualization
- Semantic delete
- Management of filters
- Complexity management
- Reuse
- Iterative transitions
- Modeling Accelerators
- Model validations & quick fixes
- Transition to sub-systems

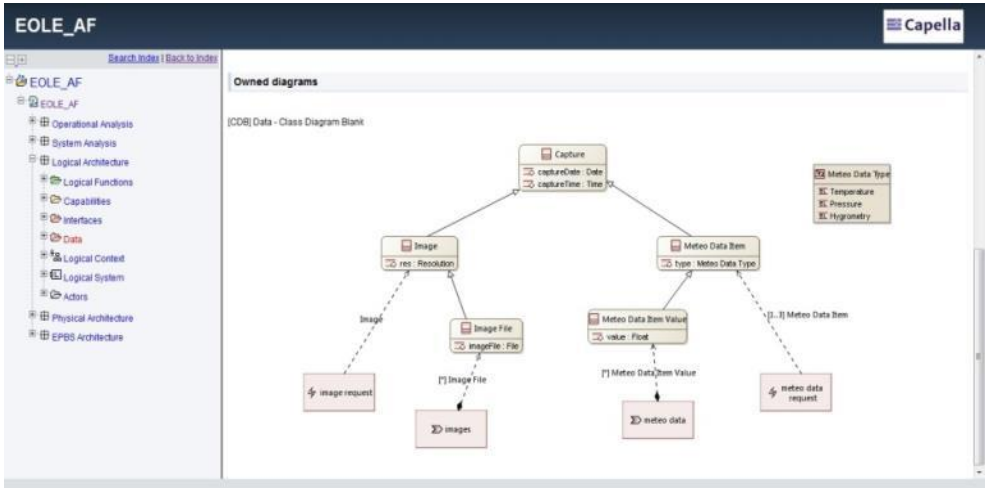
- Iterative generation of sub-systems specification based on super system architecture



User oriented productivity tools

- Relations visualization
- Semantic delete
- Management of filters
- Complexity management
- Reuse
- Iterative transitions
- Modeling Accelerators
- Model validations & quick fixes
- Transition to sub-systems
- HTML generation

- Generation of navigable documentation



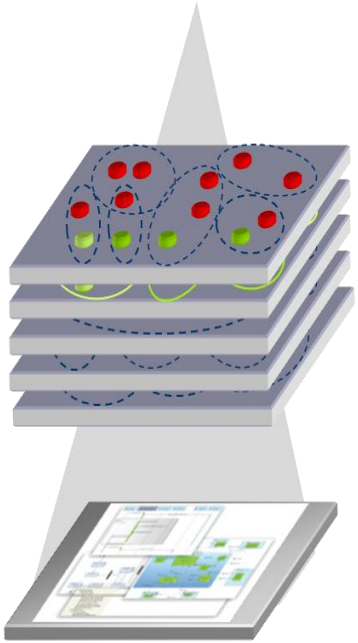
Architecture early evaluation

Performance

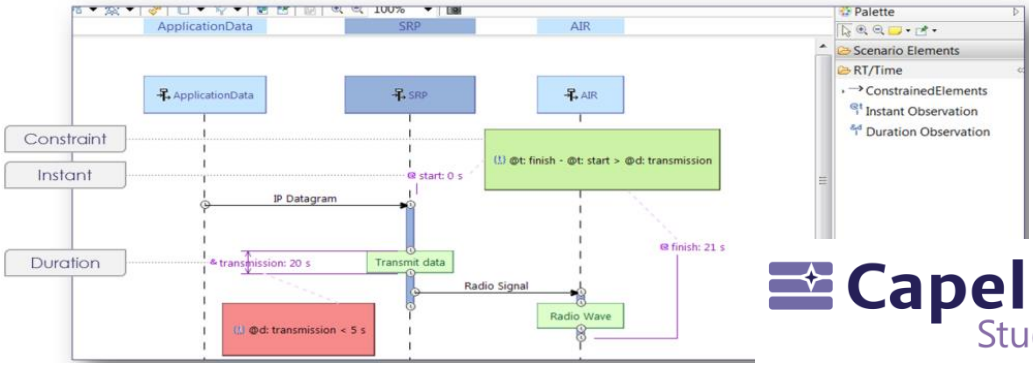
Mass

Safety

...

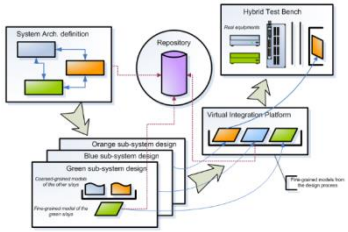


Autonomous viewpoints

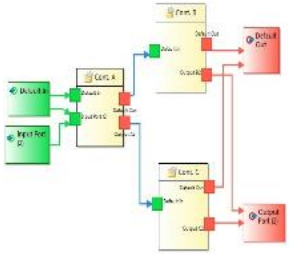


Capella Studio

Birectional coupling with specialty tools



Citrus simulation env.



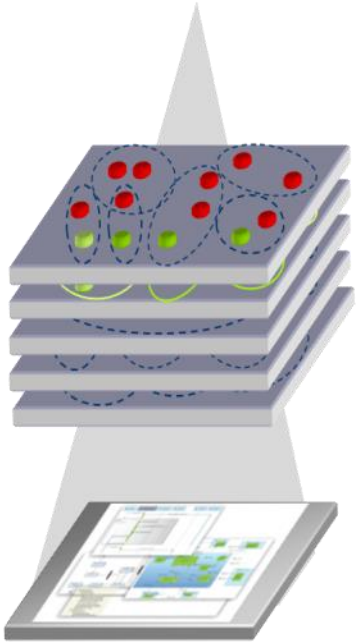
All4Tec Safety Architect

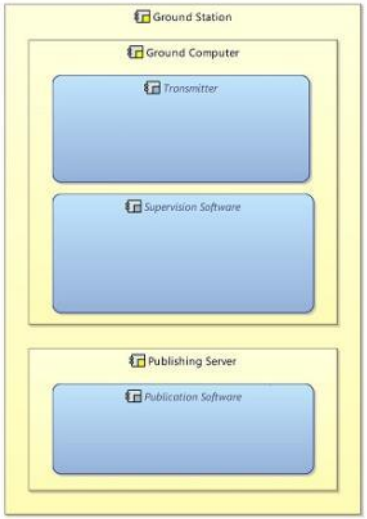
THALES

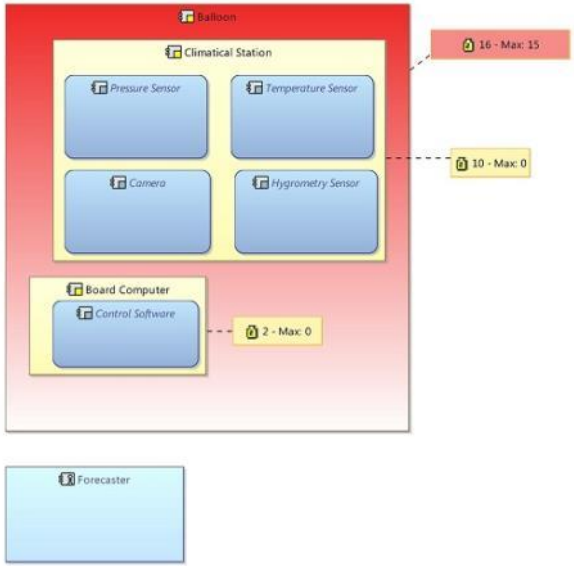
Architecture evaluation using domain viewpoints

Mass evaluation

- Performance
- Mass
- Safety
- ...







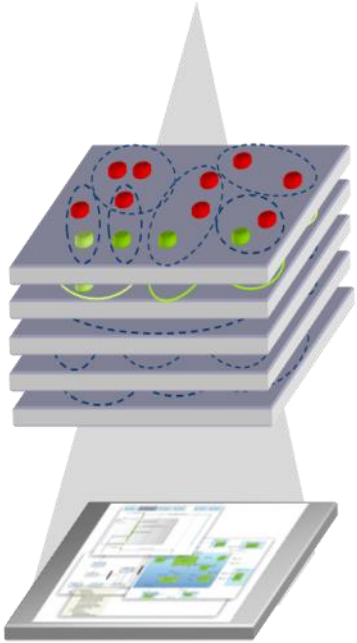
Architecture evaluation using domain viewpoints

Performance

Mass

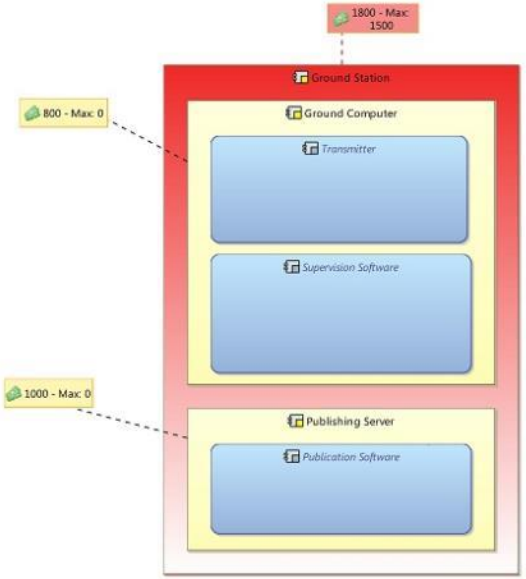
Safety

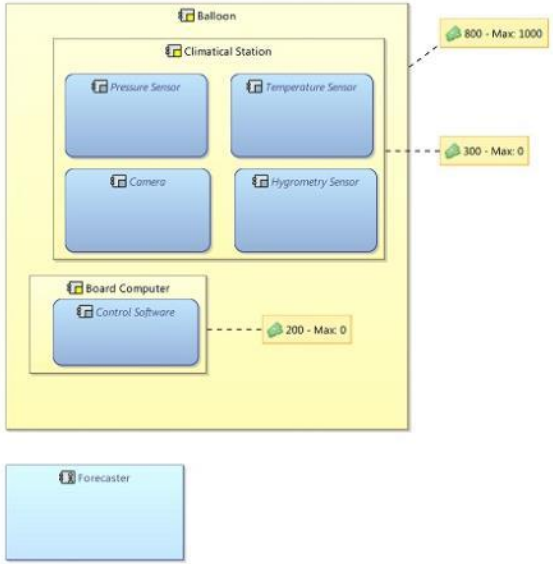
...



Mass evaluation

Price evaluation





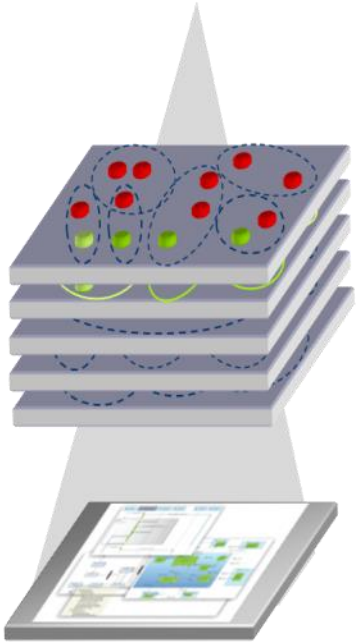
Architecture evaluation using domain viewpoints

Performance

Mass

Safety

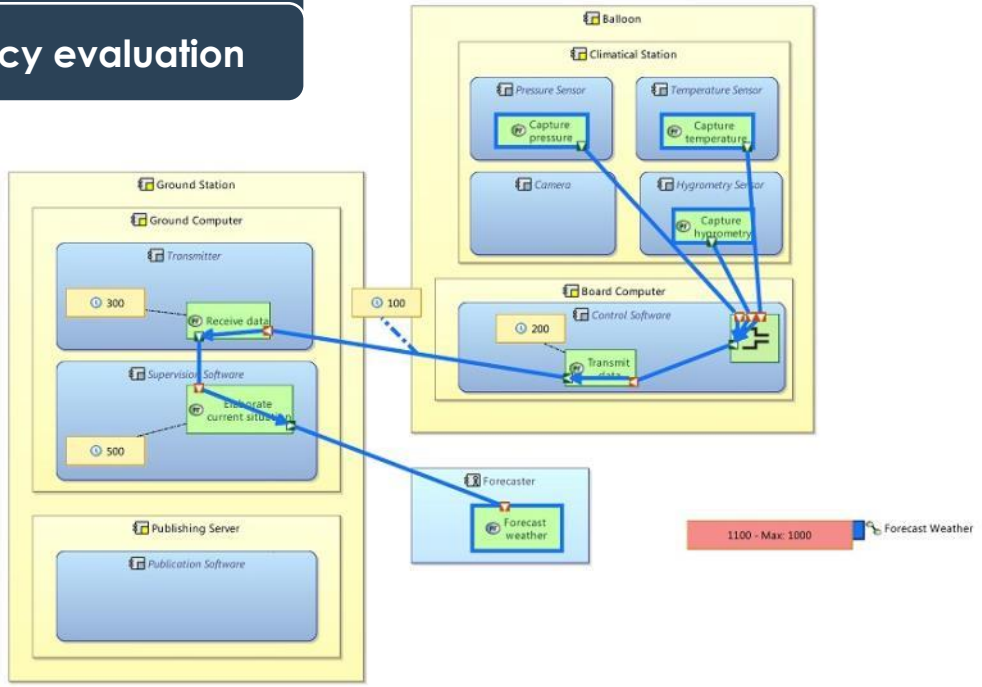
...



Mass evaluation

Price evaluation

Latency evaluation



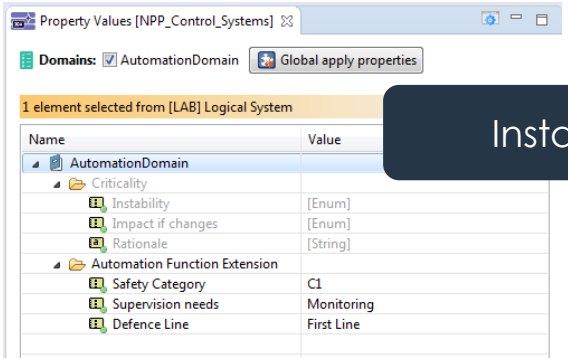
Ref number- date
Name of the company/ Template : 87204467-DOC-GRP-EN-002

THALES

User-level definition of extensions to Capella

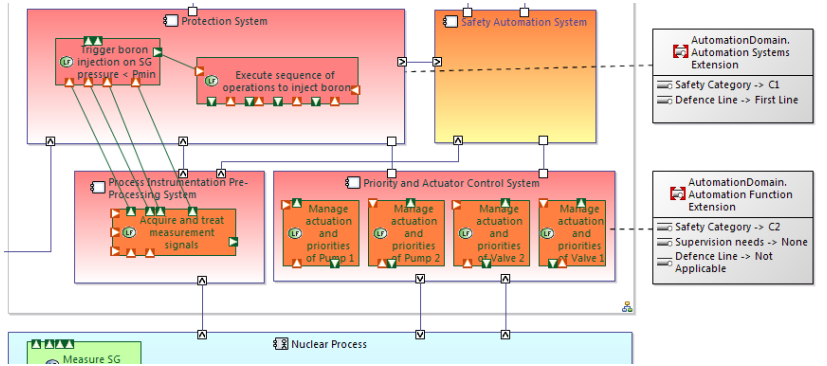
UI for definition of extensions

Name	Type	Default Value
Automation Domain		
SafetyCategoryEnum		
C1		
Background Color		
Label Color		
C2		
Background Color		
C3		
NC		
HMINeedsEnum		
DefenceLineEnum		
Automation Function Extension		
Scope	[SYSTEM, LOGICAL]	
Safety Category	SafetyCategoryEnum	NC
Supervision needs	HMINeedsEnum	None
Defence Line	DefenceLineEnum	Not Applicable
Automation Systems Extension		
Scope	[LOGICAL]	
Safety Category	SafetyCategoryEnum	NC
Defence Line	DefenceLineEnum	Not Applicable
Process Domain		
Technical Management Domain		



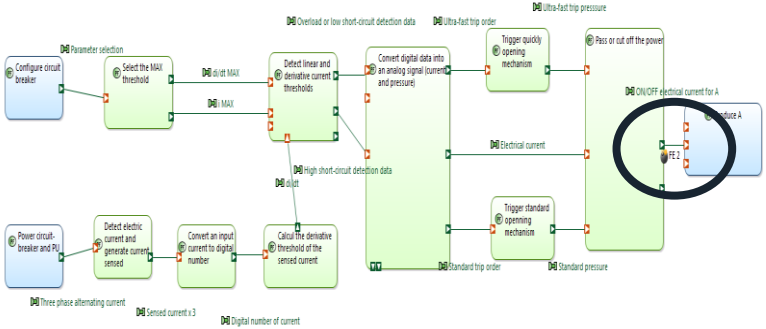
Instantiate

Visualize (automatic coloring)



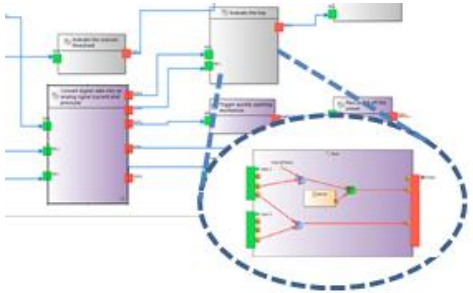
Example: Capella – Safety Architect (All4Tec)

Feared event added to Capella dataflows (viewpoint)

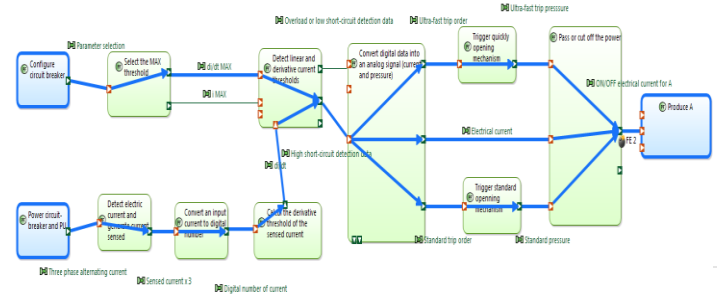


Functional Hazard Analysis (FHA)

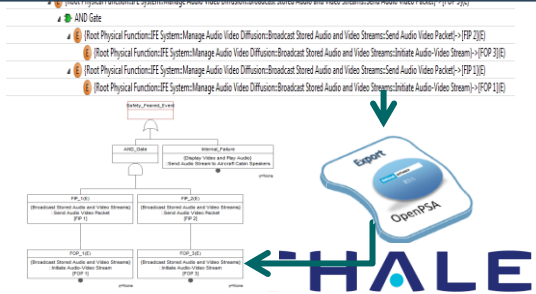
In Safety Architect, analysis of block local failure conditions



In Capella, visualization of fault trees as critical functional chains



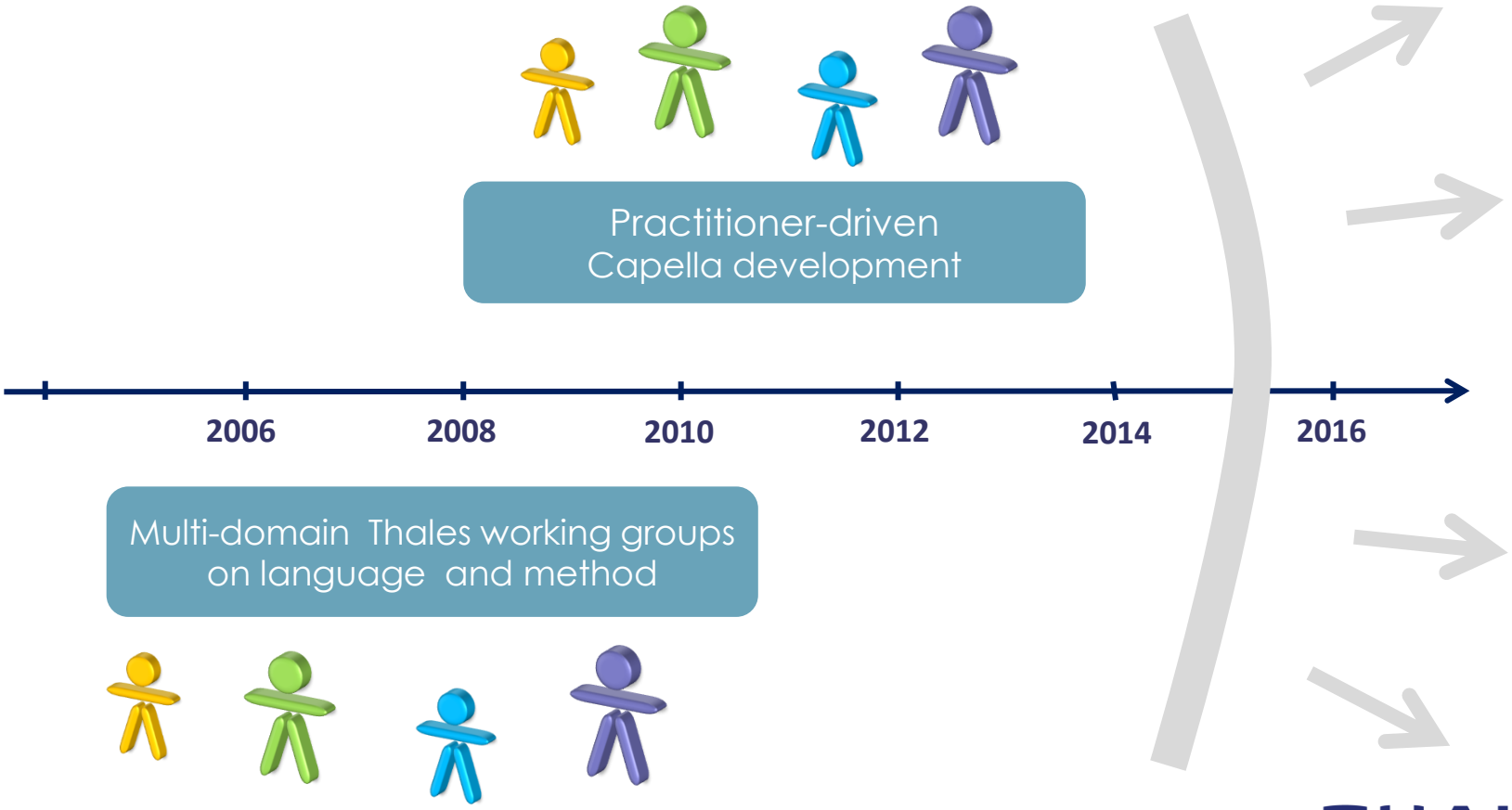
In Safety Architect, automated generation of fault-trees



Open source

How Capella is developed

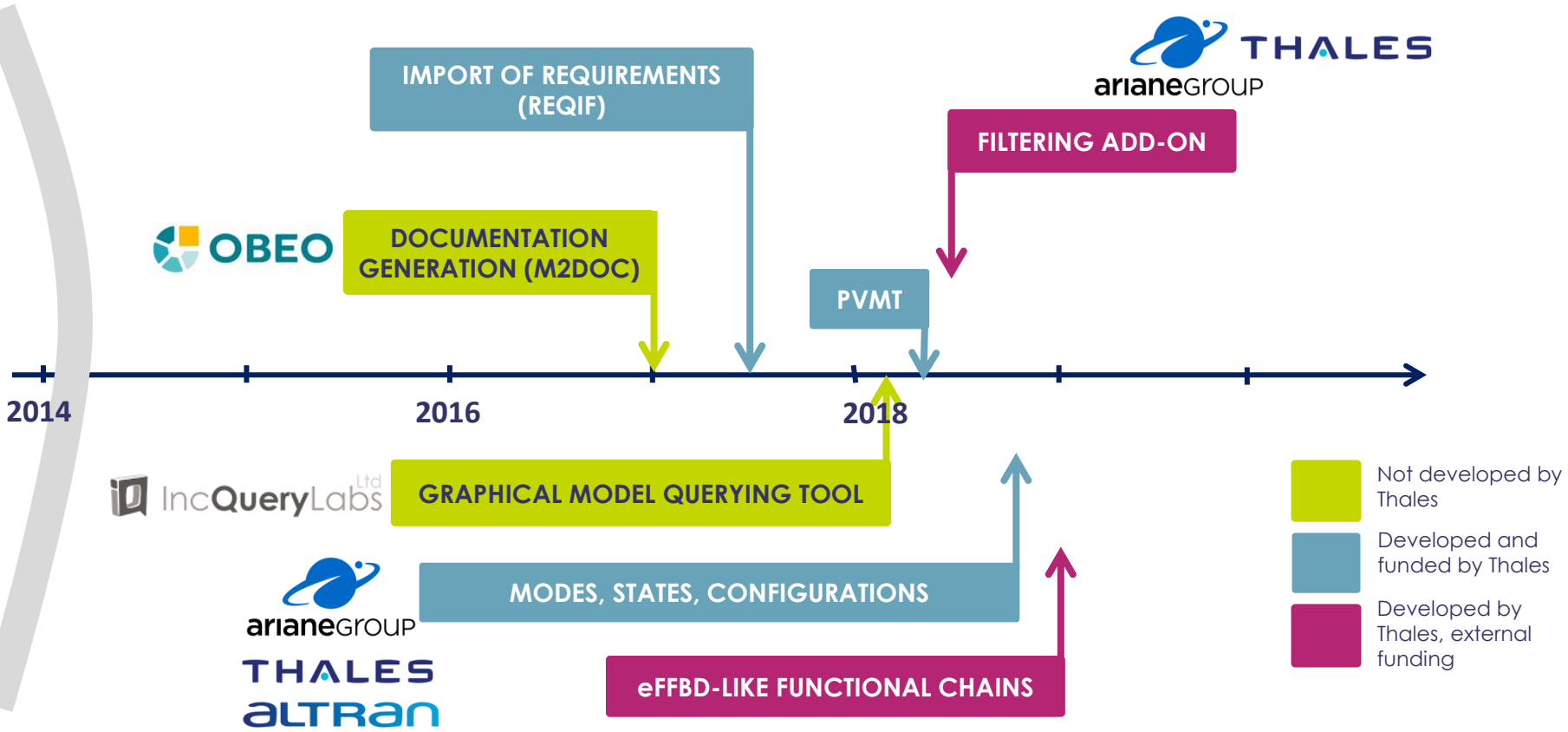
A practitioner-driven journey started in Thales



… and now open source

- Evolutions based on Thales internal need capture
- Public and private bugfixes
- Evolutions with non-Thales funding

… and now open source



The community is growing

The community is growing


Sprint ID	Start Date	End Date	Sprint Goal	Sprint Details	Demo Attendees	Demo comments
#55	13 Mar 2017	24 Mar 2017	**Validation campaigns and delivery of next Melody Patches (4.1.4, 4.2.1)**	Agile Development of Capella		> See Agile page for 4.1.4 & 4.2.1 release note, and 2017 WN page. > TTS Germany Action Diagram feedback required (colors etc..): pending.
#54	27 Feb 2017	10 Mar 2017	**Freeze of next Melody Patches (4.1.4, 4.2.1)**	Agile Development of Capella		> ELE->It would be nice to package migration tools for administrators and be able to run them in command line on a set of projects for migration and cleaning. => Nice feature, to prioritize. A first step has been done: 2017 What's new in Melody Advance 4.3 ?#2017What%27snewinMelodyAdvance4.3?-MELODY-7831
#53	13 Feb 2017	24 Feb 2017	**Delivery of first Prototype Melody Requirements VP and preparation of next Melody Patches (4.1.4, 4.2.1)**	Agile Development of Capella		> ELE->Team: Add more information in related WN (MELODY-7820) / context and results interpretation > Team-> IVV Sys: a first RC of 4.1.4 and 4.2.1 is available for tests (perf & bugfix)
#52	30 Jan 2017	10 Feb 2017	**Delivery of first Prototype Melody Requirements VP and preparation of next Melody Patches (4.1.4, 4.2.1)**	Agile Development of Capella	NA	
#51	16 Jan 2017	26 Jan 2017	**Gold5.6: delivery of Melody Connector for and RC of new Addon Melody Requirements VP integrated LM**	Agile Development of Capella		> Delivery of Prototype 0.5.0 => #52 Operational feedback is required to go further on this feature. > Nice to have: xhtml export of allocated Capella requirements => to plan in MDK CCB
#50	02 Jan 2017	13 Dec 2016	**Migration of addons for Melody 4.2 and first Release Candidate of new Addon Melody Requirements VP**	Agile Development of Capella		Location of requirement traces & bugs => #51
2016...						
#49	05 Dec 2016	23 Dec 2016	**Addons for Melody 4.2 - Orchestra 5.6**	Agile Development of Capella		

Personnes

Historique des constructions

Relations entre les projets

Vérifier les empreintes numériques

Disk usage

File d'attente des constructions

Pas de construction en attente.

État du lanceur de construction

Status 3/4

En construction capella-v1.1.x #118

En construction capella-gerrit #3043

En construction capella-studio-gerrit #404

Jobs Status

Capella

Bugzilla Gerrit Sonar

All | **Capella Addons** | Capella Studio | Capella Viewpoints | Capella-master | Capella-v0.8.x | Capella-v1.0.x | Capella-v1.1.x

S	W	Tâche ↓	Dernier succès	Dernier échec	Dernière durée	Console
		capella-addon-docgen-master	2 mo. 27 j (#736)	10 h (#821)	6 mn 49 s	
		capella-addon-docgen-v0.8.x	9 mo. 18 j (#130)	N/A	4 mn 27 s	
		capella-addon-docgen-v1.0.x	10 h (#479)	1 j 10 h (#478)	5 mn 32 s	
		capella-addon-docgen-v1.1.x	2 mo. 26 j (#8)	10 h (#92)	4 mn 22 s	
		capella-addon-transitionsystem2subsystem-gerrit-others	22 j (#28)	23 j (#27)	3 mn 3 s	
		capella-addon-transitionsystem2subsystem-gerrit-v0.8.x	4 mo. 17 j (#16)	4 mo. 17 j (#15)	2 mn 13 s	
		capella-addon-transitionsystem2subsystem-master	22 j (#468)	2 j 3 h (#469)	3 mn 27 s	
		capella-addon-transitionsystem2subsystem-v0.8.x	20 j (#459)	N/A	2 mn 42 s	
		capella-addon-transitionsystem2subsystem-v1.0.x	4 mo. 4 j (#94)	N/A	2 mn 52 s	
		capella-addon-transitionsystem2subsystem-v1.1.x	4 mo. 4 j (#6)	N/A	4 mn 25 s	
		capella-addon-xmlpivot-gerrit-others	3 mo. 23 j (#32)	N/A	4 mn 22 s	
		capella-addon-xmlpivot-gerrit-v0.8.x	N/A	N/A	N/A	N/A
		capella-addon-xmlpivot-master	3 mo. 23 j (#322)	N/A	3 mn 32 s	
		capella-addon-xmlpivot-v0.8.x	20 j (#122)	N/A	2 mn 57 s	
		capella-addon-xmlpivot-v1.0.x	4 mo. 11 j (#26)	N/A	2 mn 3 s	

Icône: S M L

Légende toutes les constructions tous les échecs pour les dernières constructions seulement

Arcadia SysML positioning

Equivalences, differences

Arcadia & SysML

Arcadia & SysML

Similarities

- Most diagrams: IBDs, BDDs, sequence diagrams, state machines, class diagrams, use cases, etc.

Differences

- Method vs Language
- Operational analysis
- Functional analysis: activity diagrams vs functional dataflows

- Instance-driven

Arcadia & Architecture frameworks

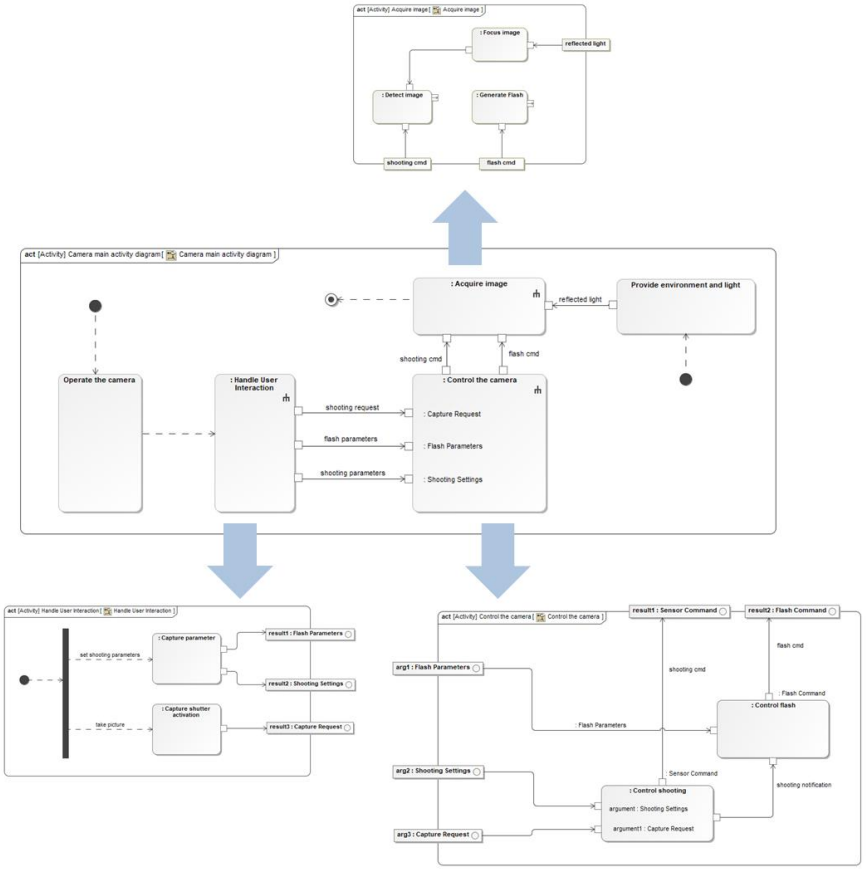
Similarities

- A subset of the diagrams such as OV2, OV4, OV5, OV6, OV7, SOV, SV1, SV2, SV4, SV5, SV10…

Differences

- Method vs Language
- Expected level of detail and rigor of the model

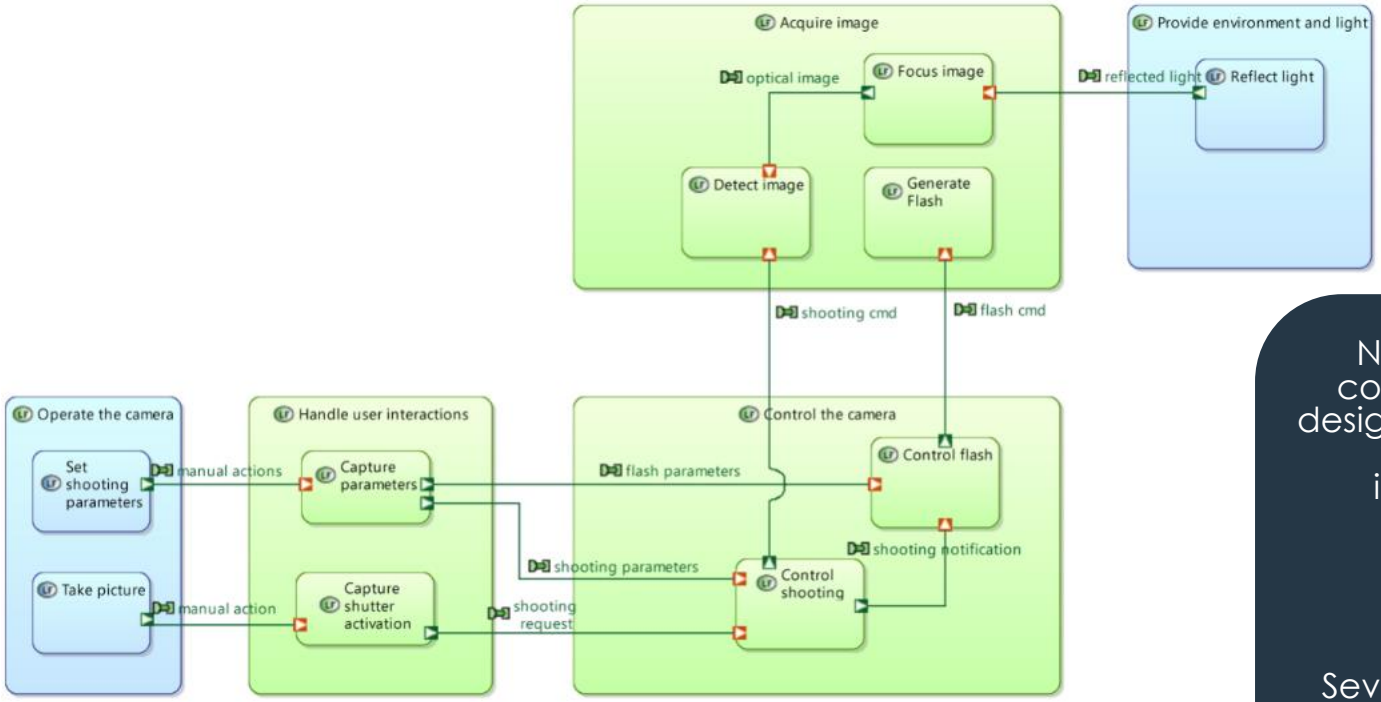
Functional analysis with SysML



Activities and several kinds of actions, parameters nodes connected to pins, strong delegation mechanism. Control and objects flows.

THALES

Functional analysis with Capella

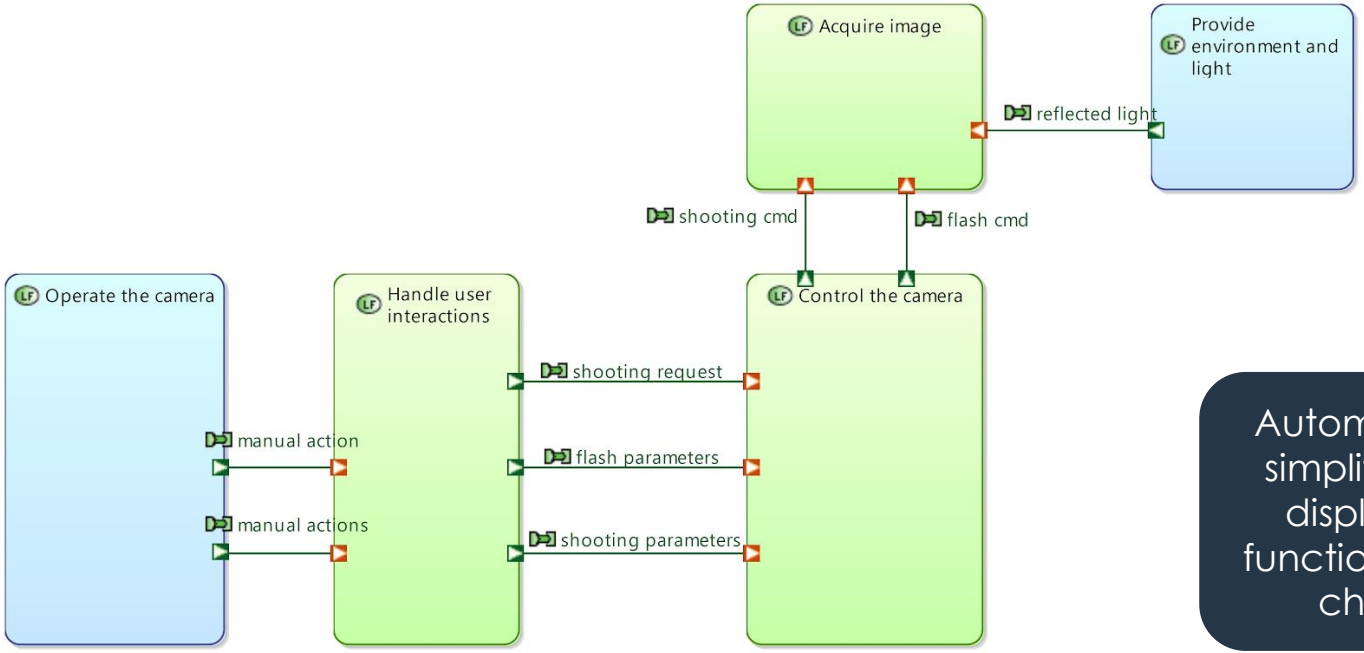


No delegation, direct containment. When the design is complete, only leaf functions are have incoming/outgoing exchanges.

Objects flow only

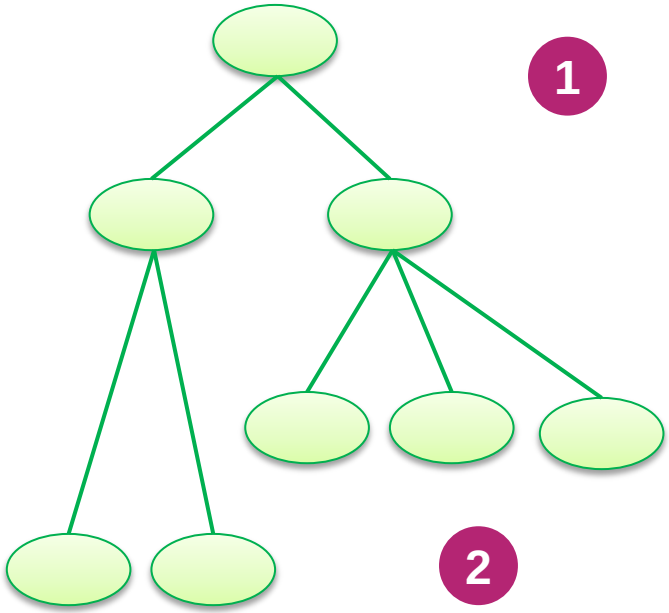
Several levels of functions can be displayed in the same diagram

Functional analysis with Capella



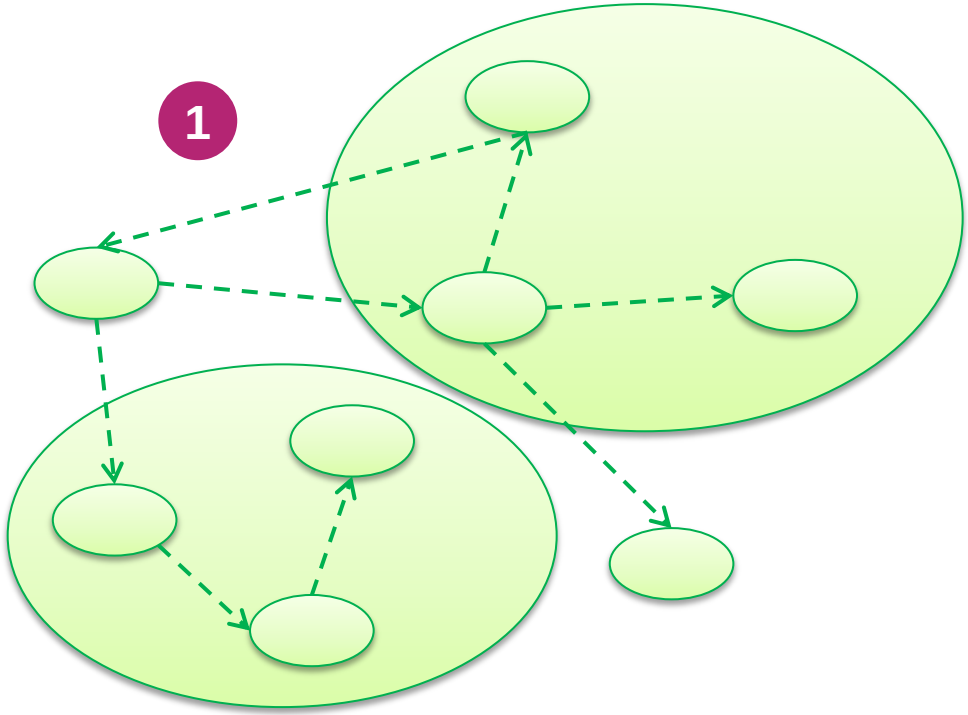
Automatically computed simplified view. Ports are displayed on non-leaf functions but still belong to children functions.

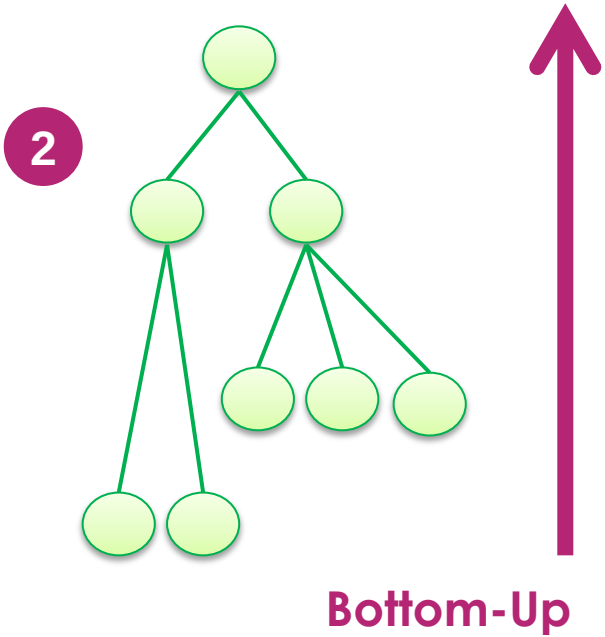
Rationale: Supporting multiple functional analysis workflows



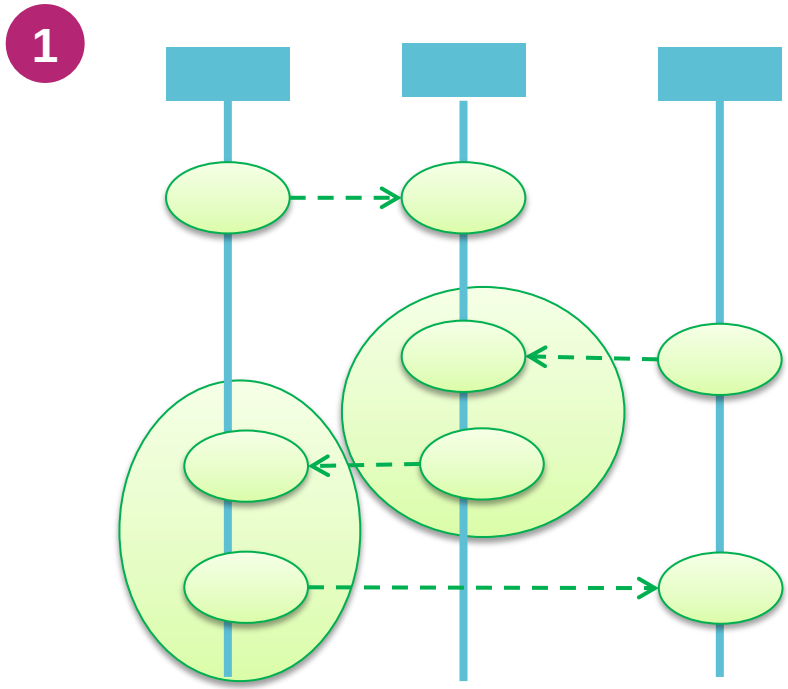
Top-down

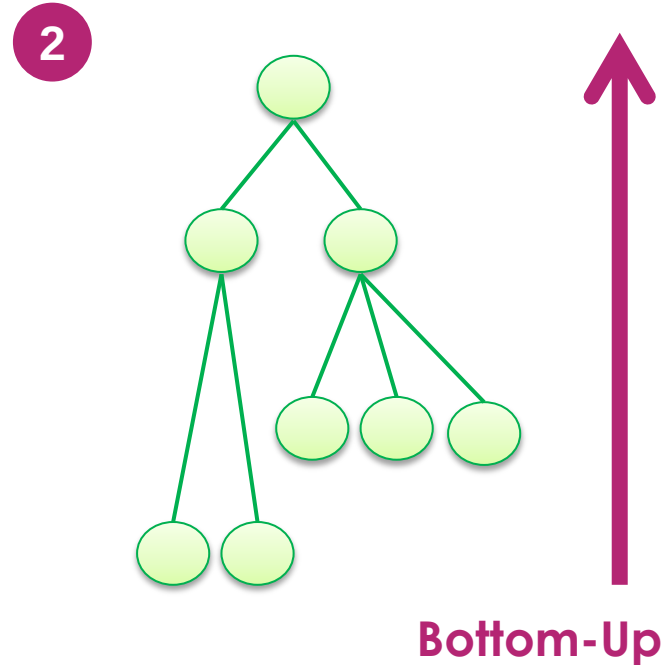
Rationale: Supporting multiple functional analysis workflows



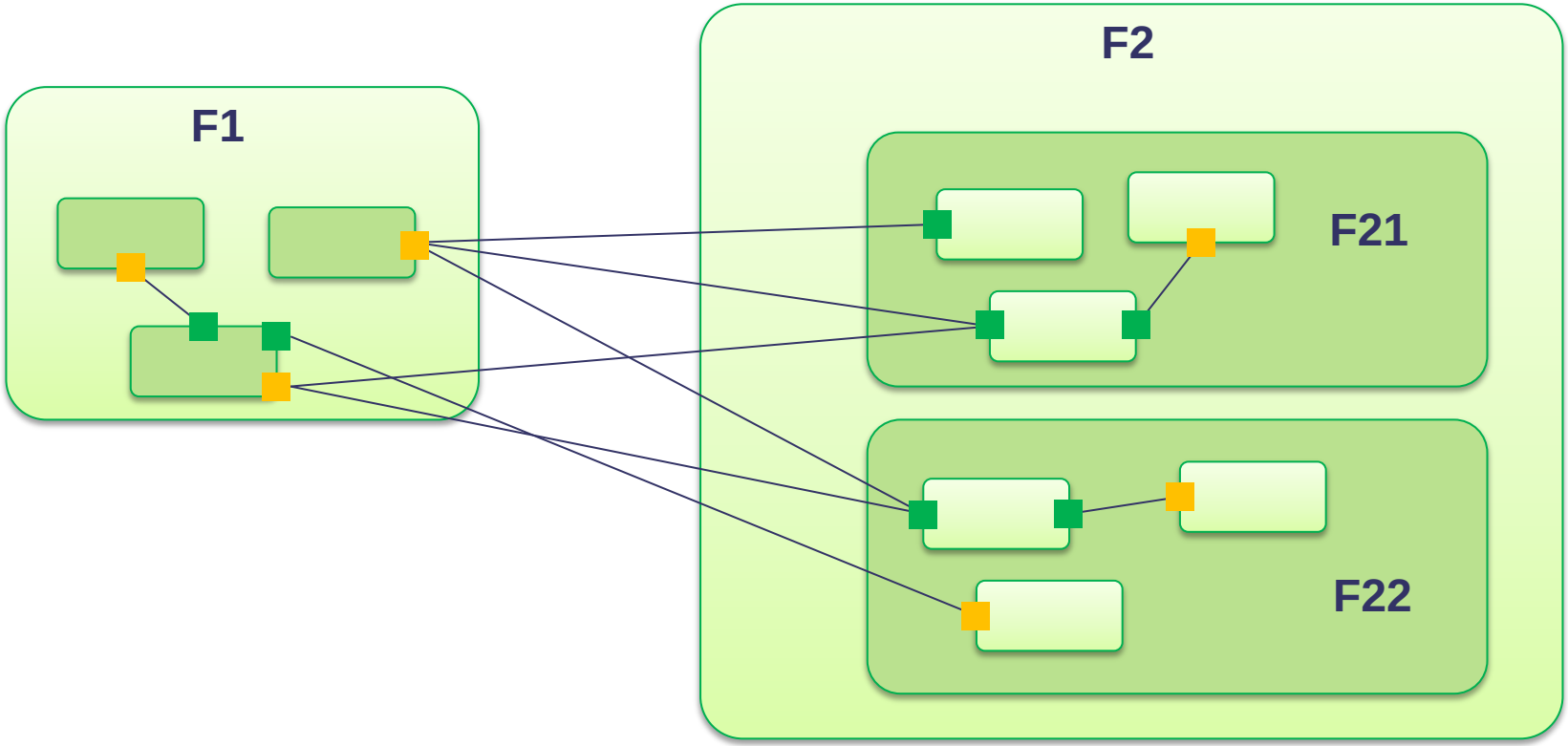


Rationale: Supporting multiple functional analysis workflows

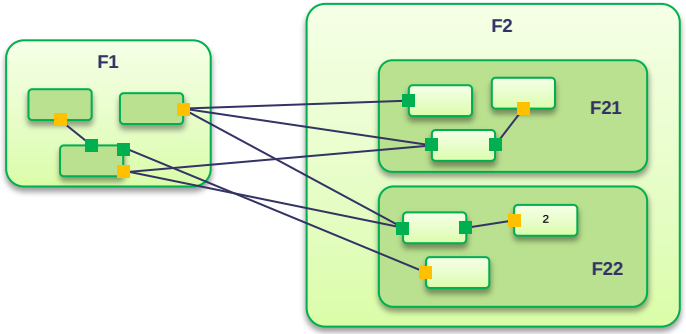




Functional Analysis with Capella



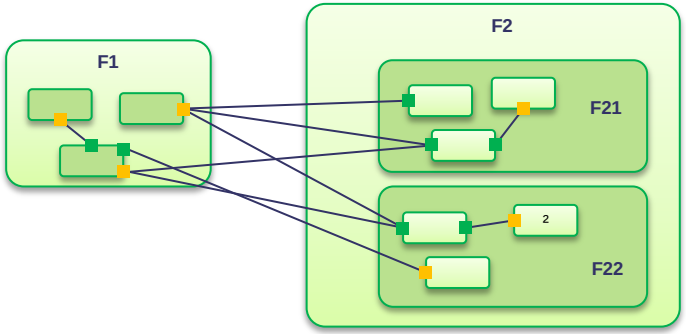
Functional Analysis with Capella

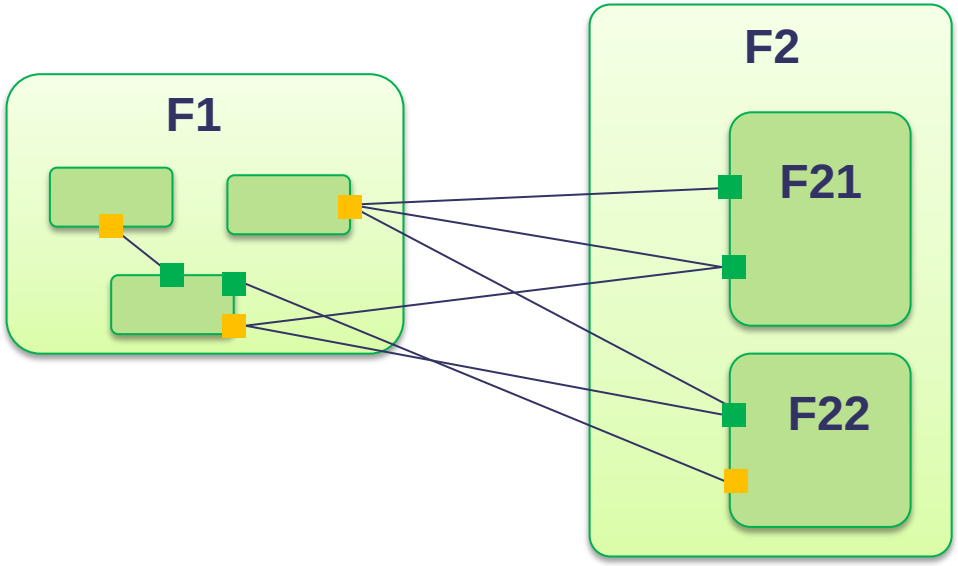


MODEL

VIEW

Functional Analysis with Capella

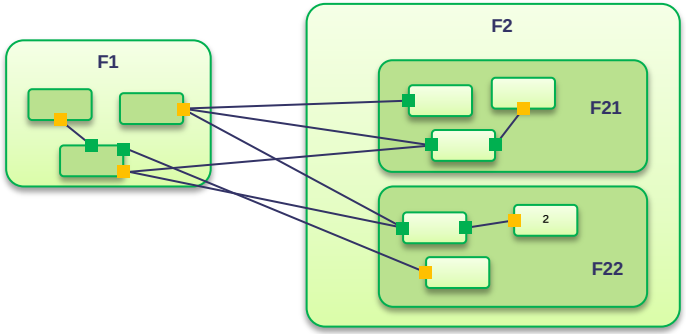


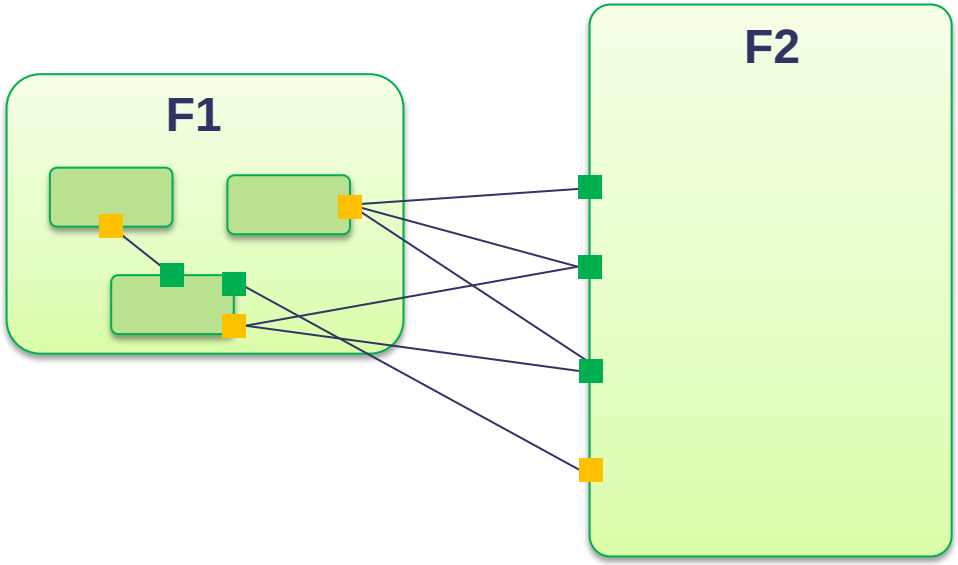


Graphical simplification: Ports on F21 and F22 do not actually « belong » to F21 and F22 but to their children functions.

MODEL **VIEW**

Functional Analysis with Capella

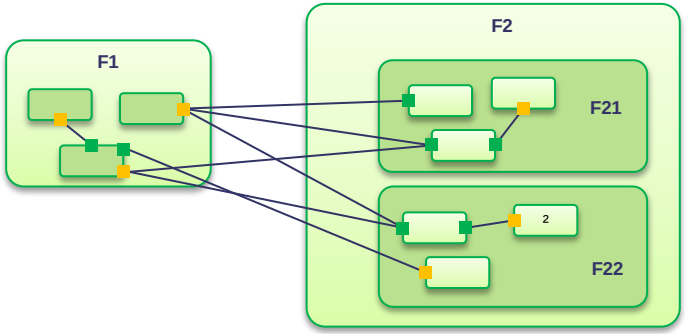


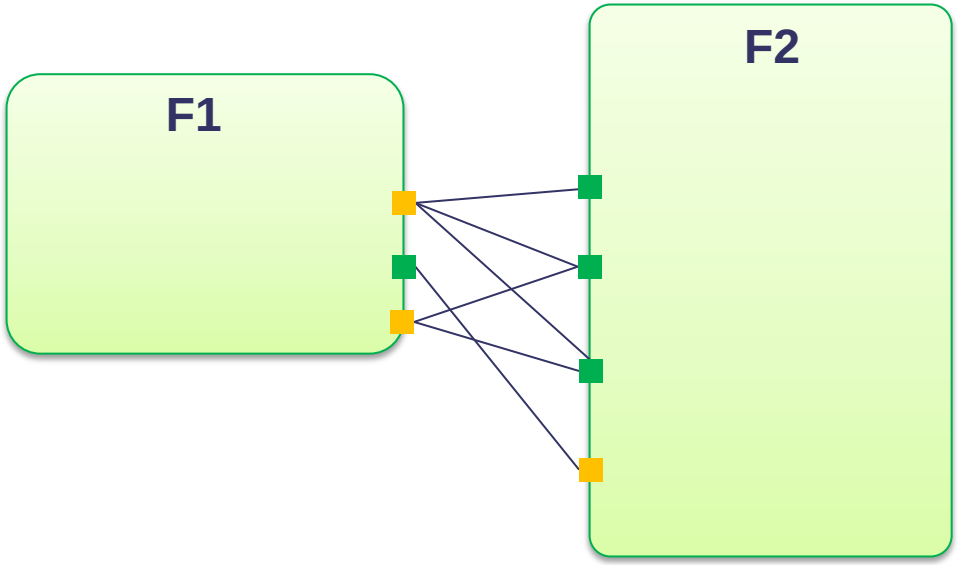


Graphical simplification: Ports on F2 do not actually « belong » to F2 but to its children functions.

MODEL **VIEW**

Functional Analysis with Capella

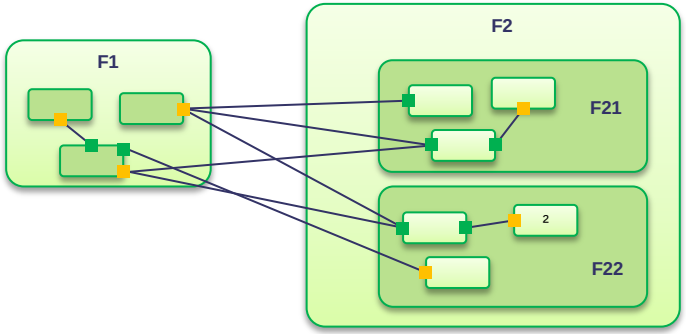


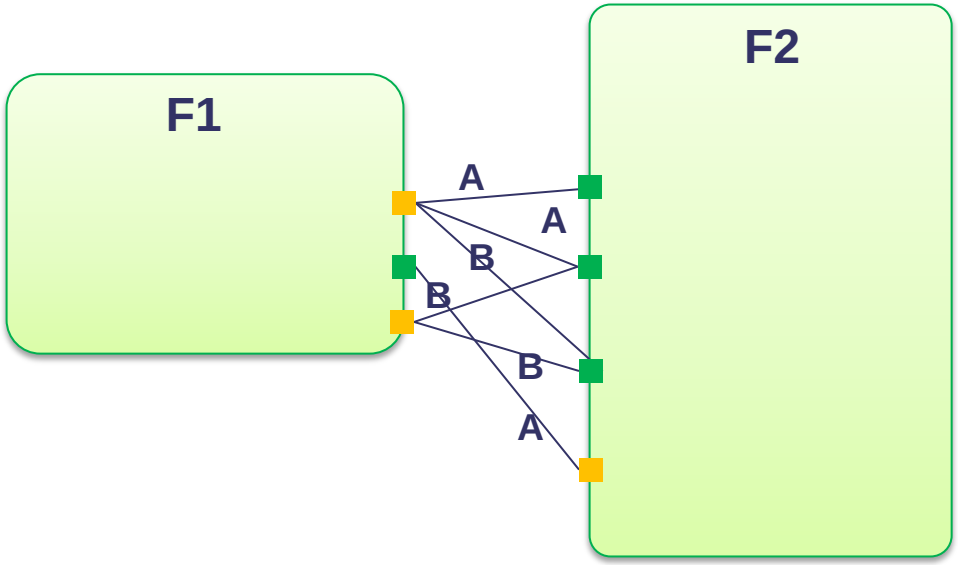


Graphical simplification: Ports on F1 and F2 do not actually « belong » to F1 and F2 but to their children functions.

MODEL **VIEW**

Functional Analysis with Capella



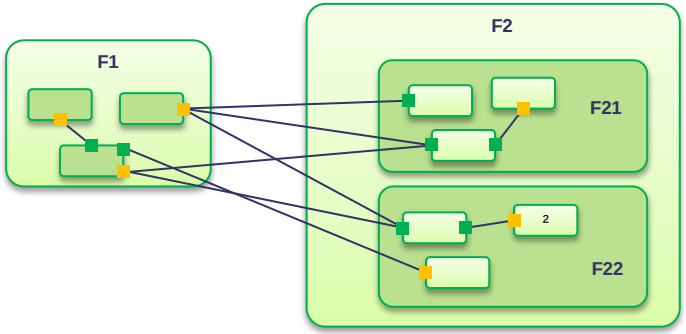


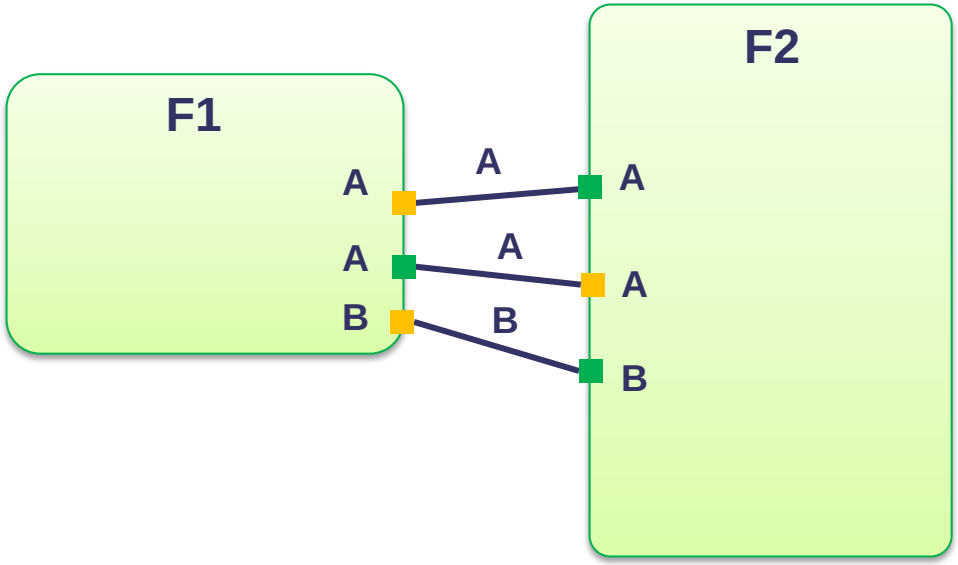
Introduction of the « Category » concept

MODEL

VIEW

Functional Analysis with Capella

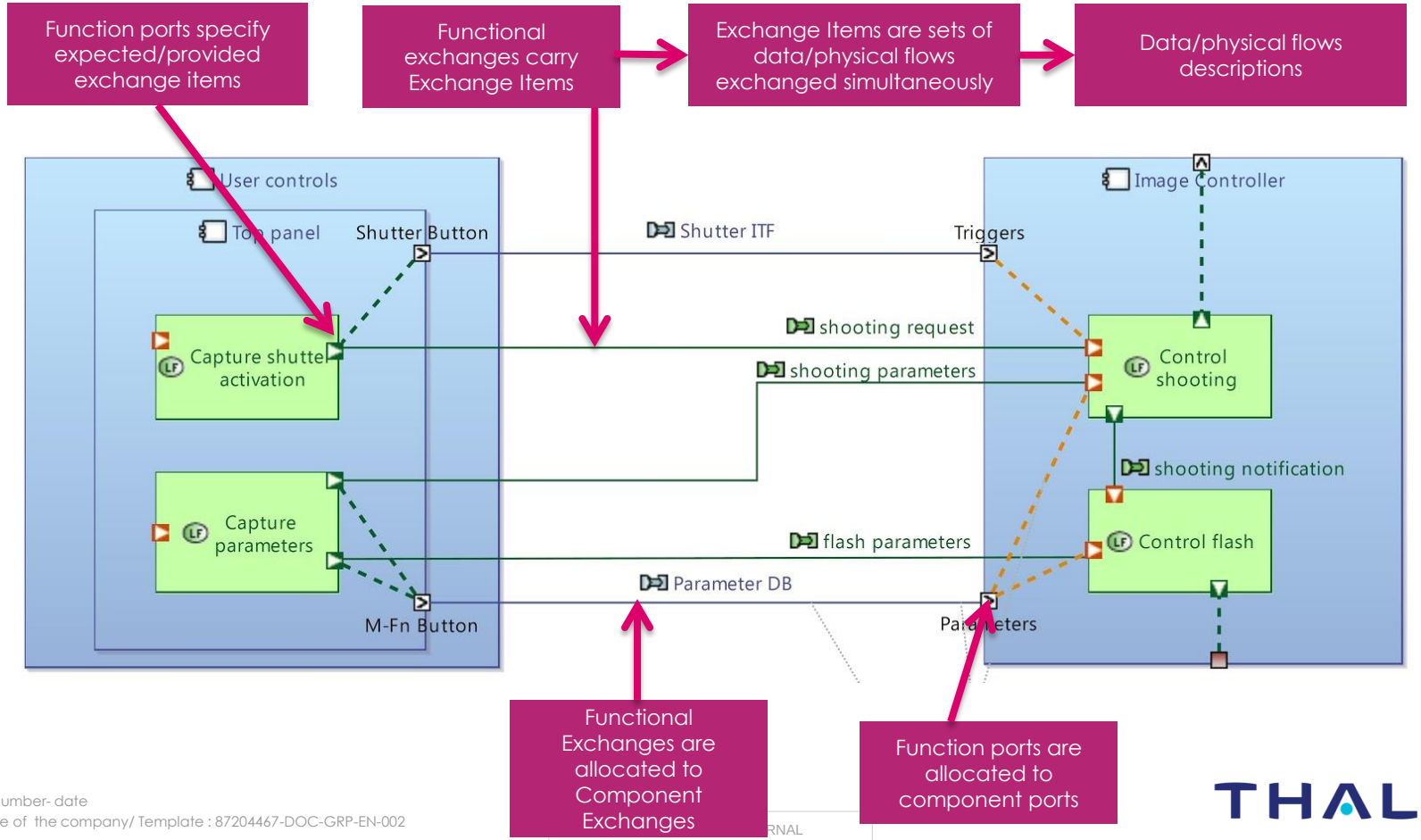




Graphical simplification based on the « Category » concept. Displayed ports are not the real ones anymore

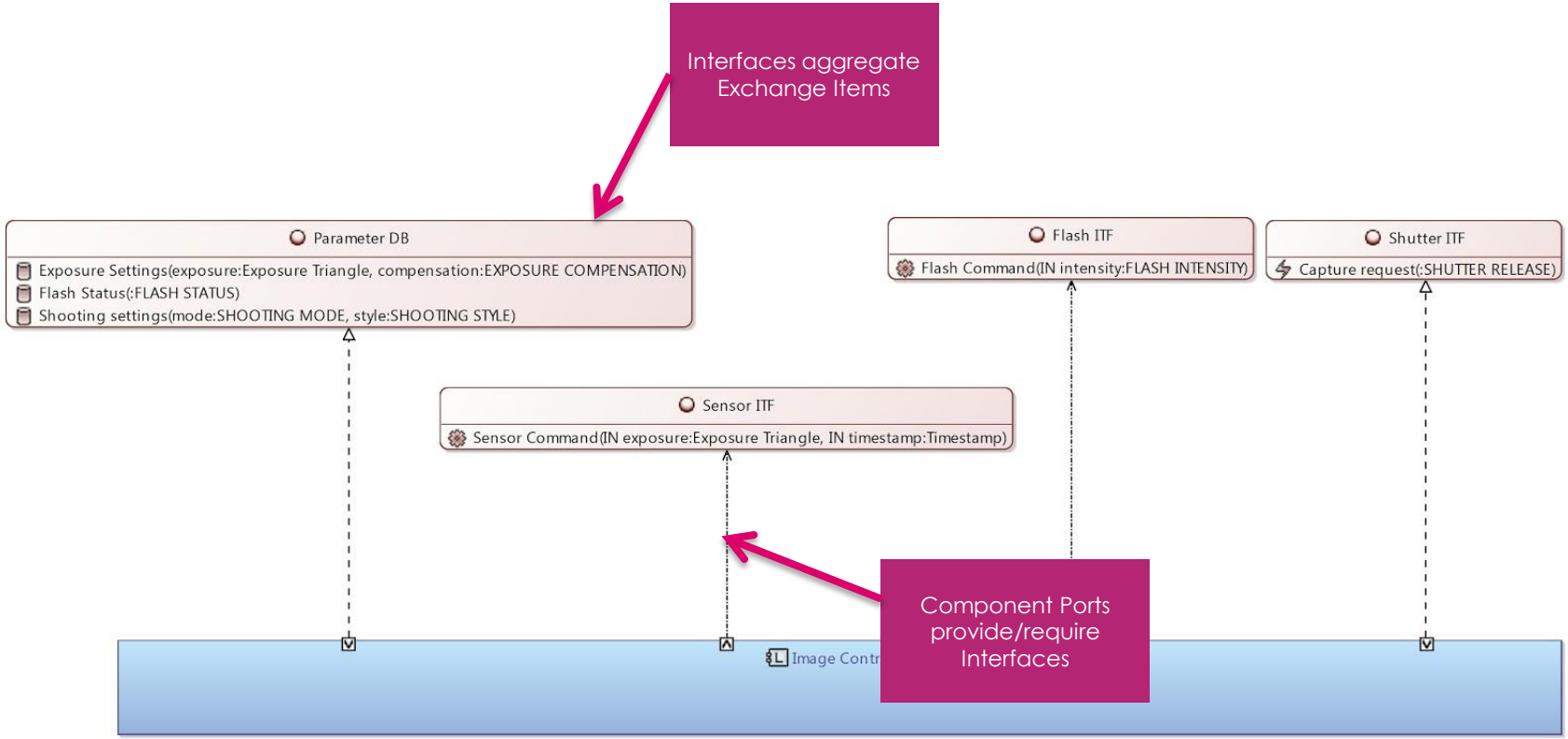
MODEL **VIEW**

Definition and functional justification of interfaces



THALES

Definition and functional justification of interfaces

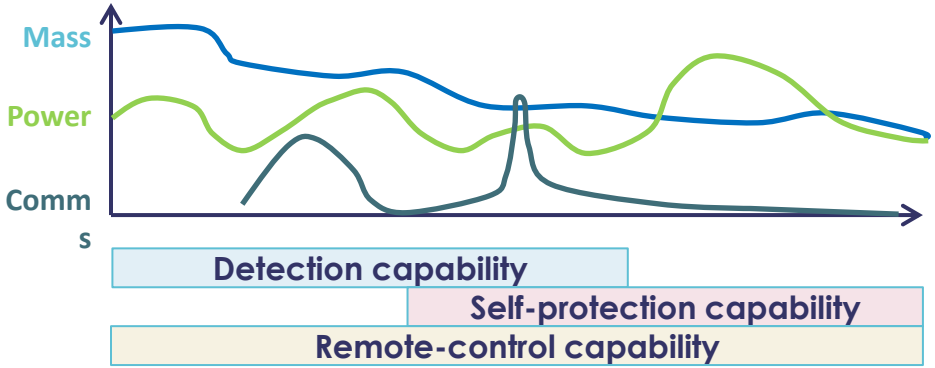


Current topics

Impact of modes and states on the system

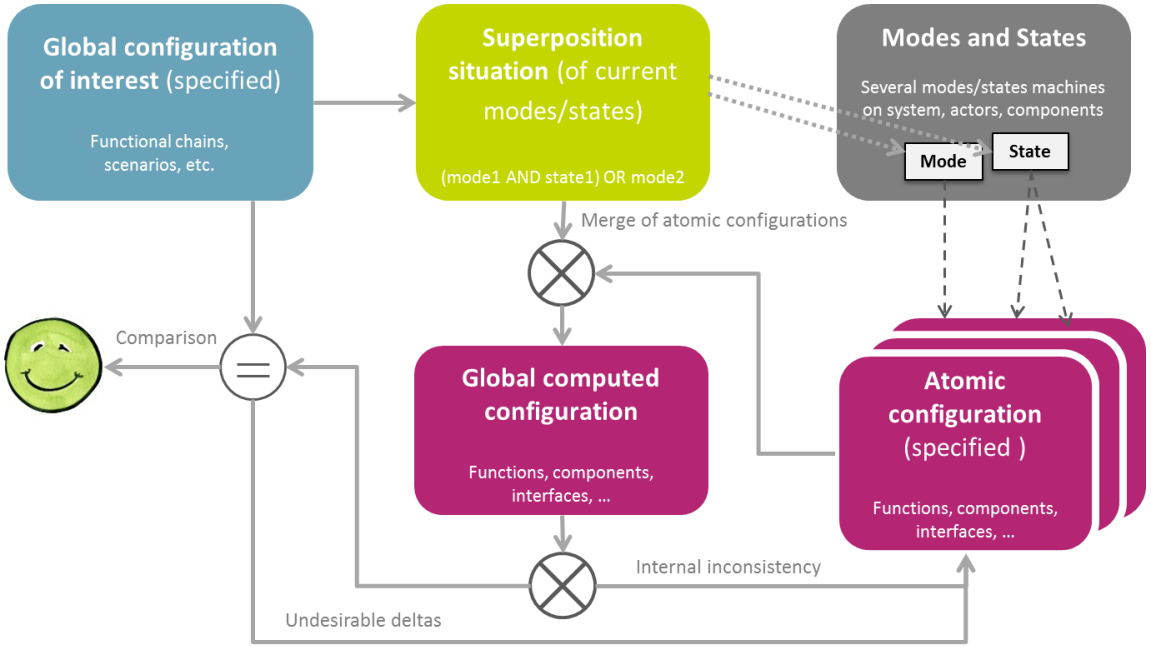
Modes, states, and their impacts on the system

Mission		Phase 1			Phase 4		
System Ops		Mode o1	Mode o2	Mode o3	Mode o4	Mode o3	Mode o2
Comms State		State 1	State 2	State 3	State 4	State 2	State 3
Subsystems	1	Mode A	Mode B	Mode C	Mode A	Mode C	Mode A
	1	State X	State Y	State Z	State X	State Y	
	2	Mode I	Mode J	Mode I	Mode J	Mode I	Mode J



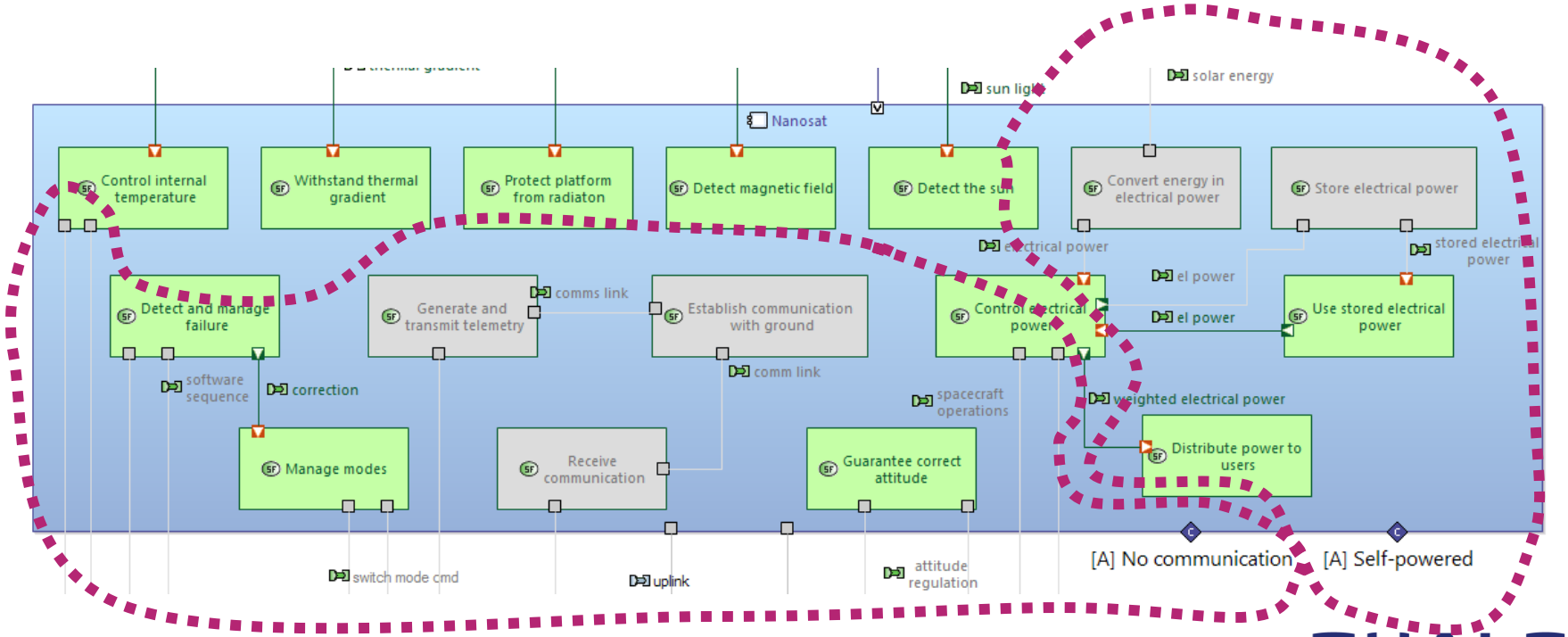
How are functional, non-functional and parametric analyses correlated with modes and states?

Modes, states, and their impacts on the system



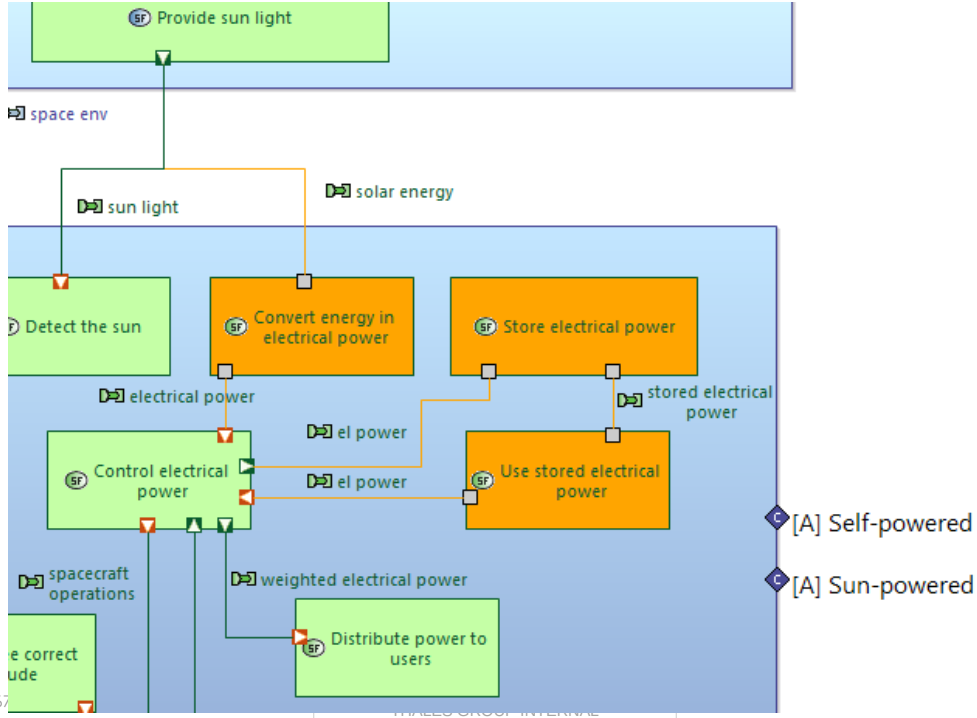
Modes, states, and their impacts on the system

[ATOMIC] No communicaton **AND** [ATOMIC] Self-Powered



Modes, states, and their impacts on the system

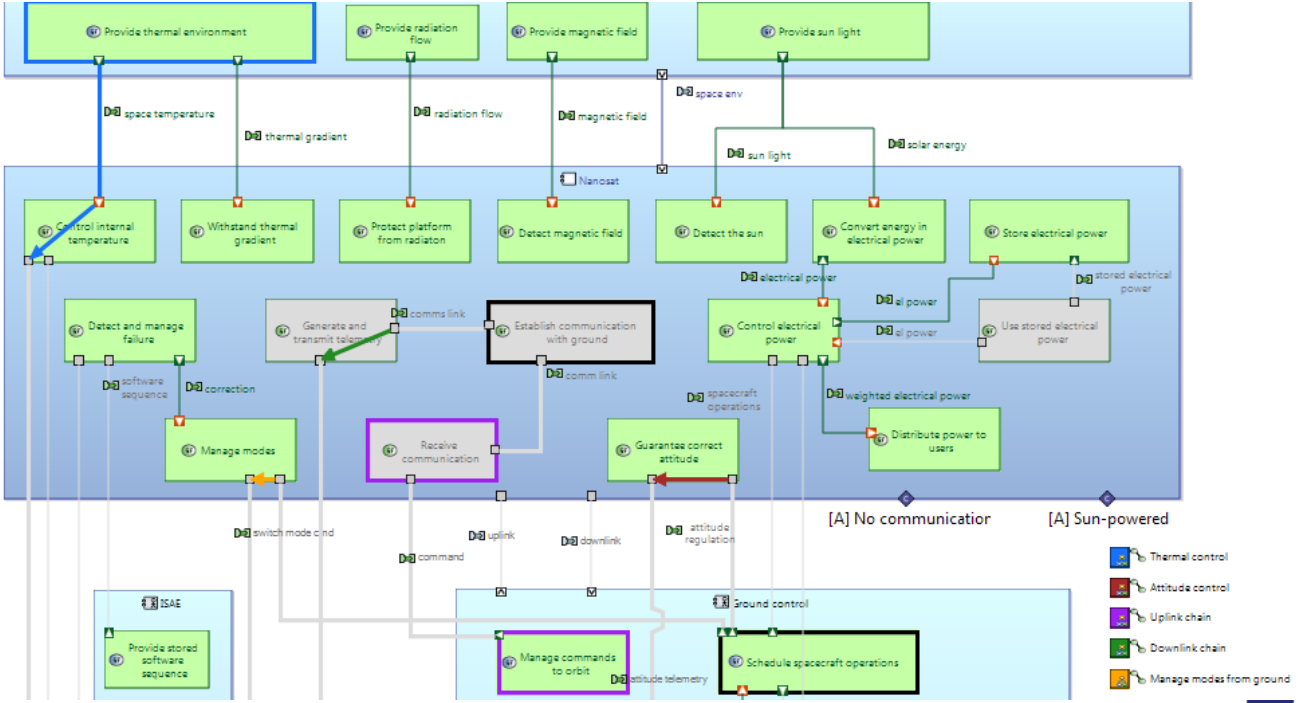
[ATOMIC] Sun-Powered **AND** [ATOMIC] Self-Powered



THALES

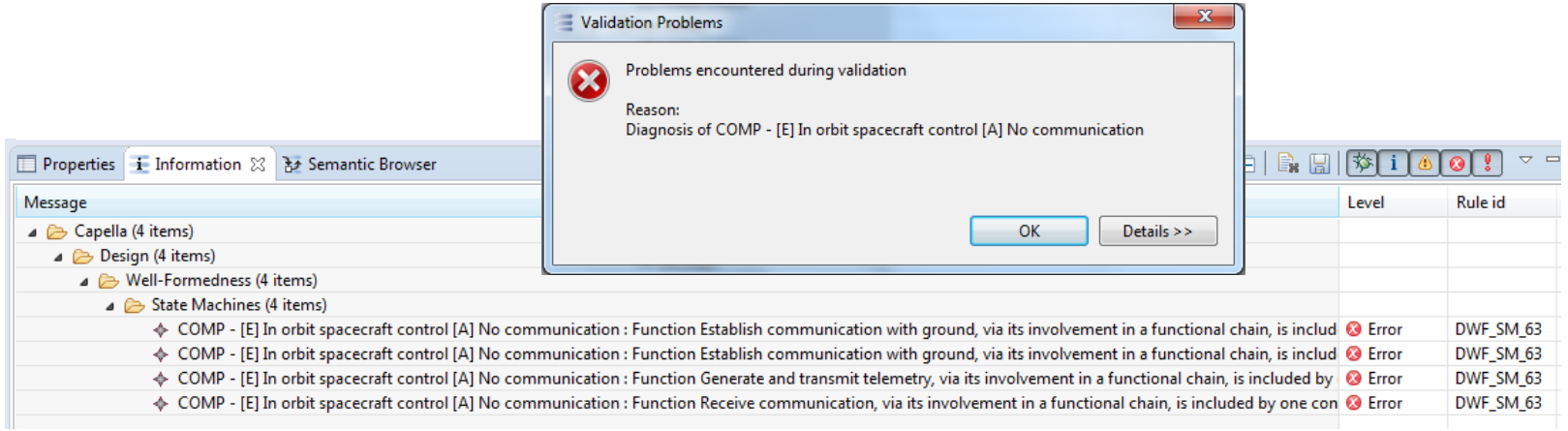
Modes, states, and their impacts on the system

[EXPECTED] In orbit spacecraft control **VS** [ATOMIC] No communication



Modes, states, and their impacts on the system

[EXPECTED] In orbit spacecraft control **VS** [ATOMIC] No communication



Current topics

Capella / Detailed design / Simulation

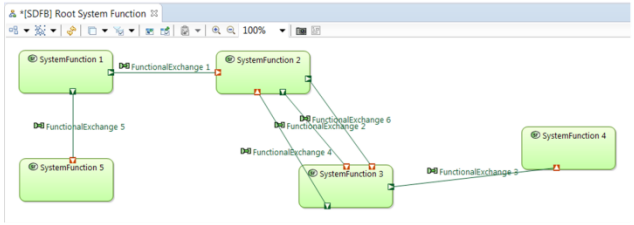
Coupling Capella with Simulink for detailed design

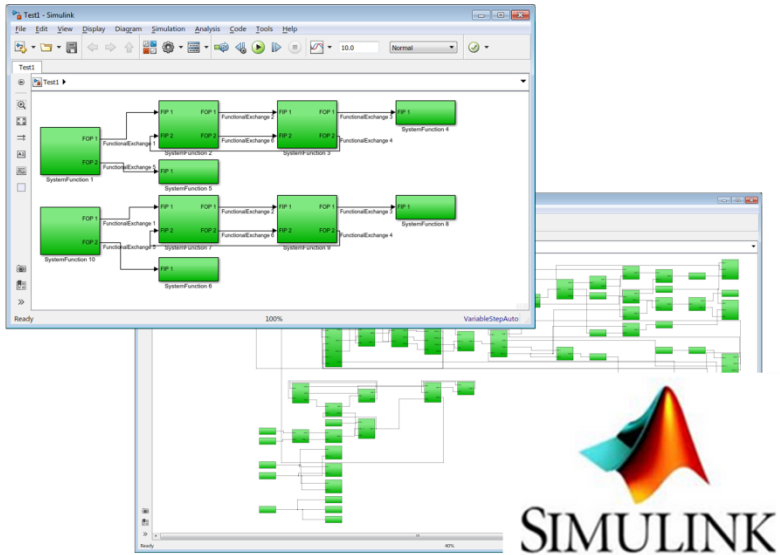
Support architecture evaluation

Validate consistency of system model

Ensure data continuity with detailed design activities

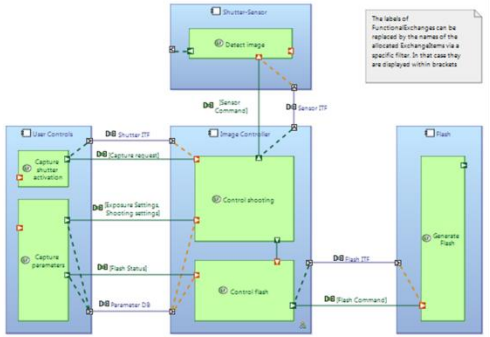
Coupling Capella with Simulink for detailed design

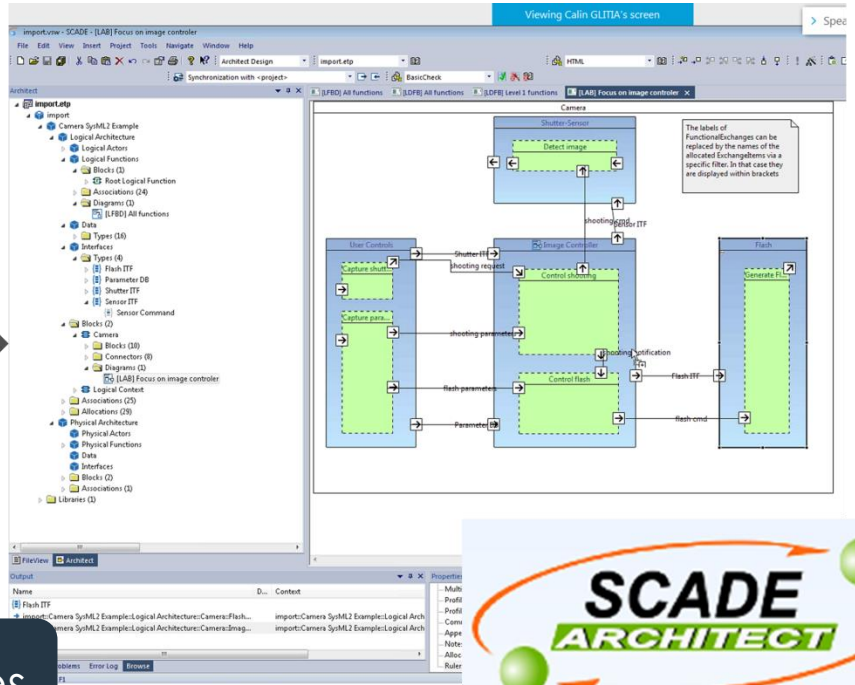




Prototyping effort in Thales

Coupling Capella with Scade for detailed design





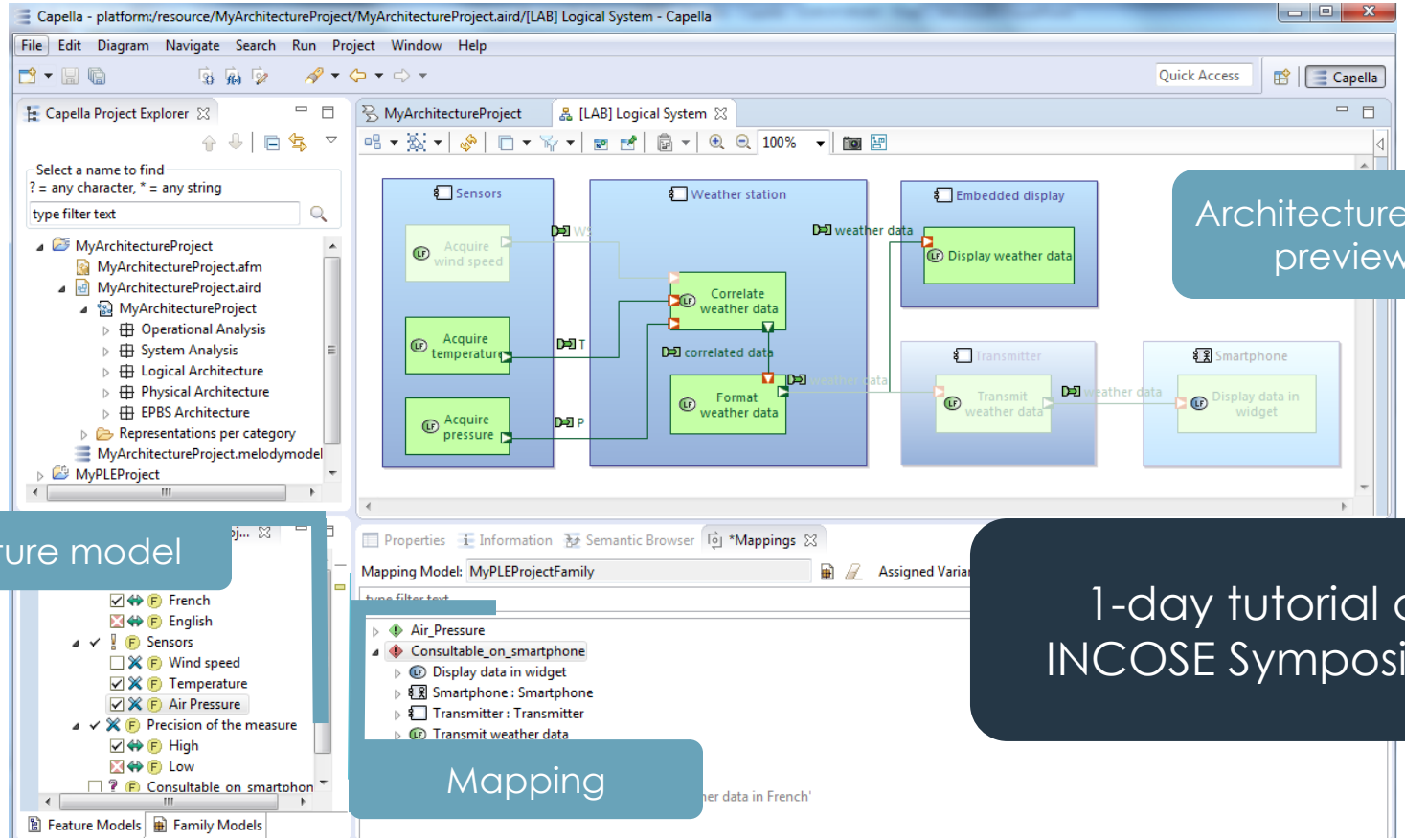
Developed by Esterel Technologies

SCADE ARCHITECT

Current topics

Articulation with Value Pulled Engineering and Product Line Engineering

[pure-systems] Pure::variants Enterprise in Capella



Architecture (with preview)

Feature model

Mapping

1-day tutorial at INCOSE Symposium

THALES

Thank You!

Capella website:
http://www.polarsys.org/capella/
LinkedIn
https://www.linkedin.com/groups/8605600
Twitter
https://twitter.com/capella_arcadia
Arcadia forum:
https://polarsys.org/forums/index.php/f/12/
Capella forum:
https://polarsys.org/forums/index.php/f/13/
IFE model & doc.:
http://www.polarsys.org/capella/start.html