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Arcadia and Capella on the Field: Real-World MBSE Examples

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OPEN

THALES

Current Systems Engineering Practices

ENGINEERING KEY QUESTIONS

- How is the customer need received? How are its **consistence and feasibility checked**?
- Which are the **engineering phases in the solution elaboration**, how are they related?
- **How is complexity managed?**
- How are different alternatives evaluated, **how do the specialists collaborate**?
- **How is the solution justified** w.r.t. the need and the different constraints?

FACTS

- Needs and solutions are more complex, more stakeholders, more constraints, less time
- **The approach Doors / Word / Visio / Excel reaches limits**
- Manual processes are not compatible with agility and short loops

The Thales MBSE Approach

ARCADIA

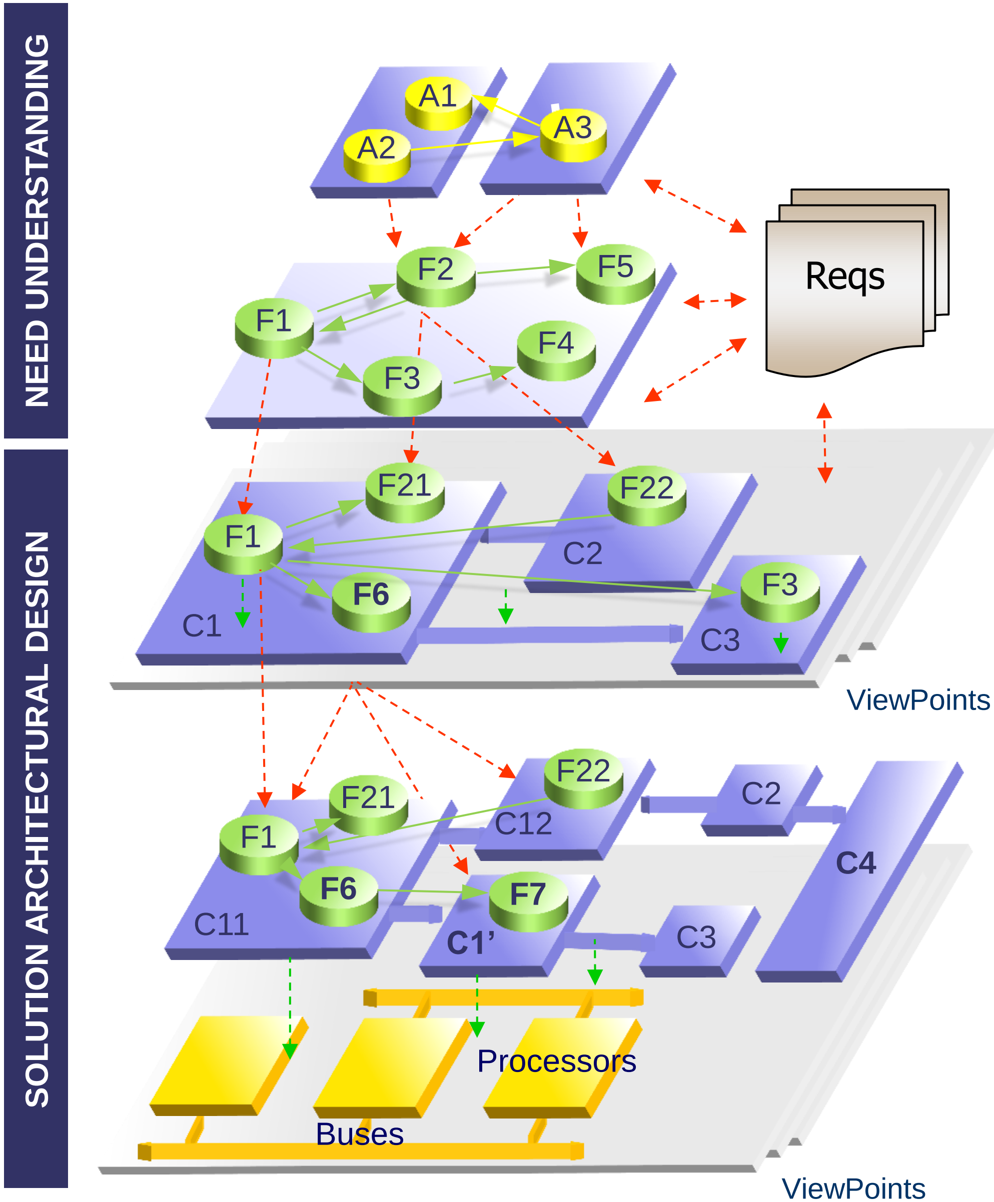
Model-Based Engineering Method for Architectural Design

Capella

Graphical Modelling Workbench supporting Arcadia

Arcadia: Model-Based Method for Architectural Design

ARCADIA



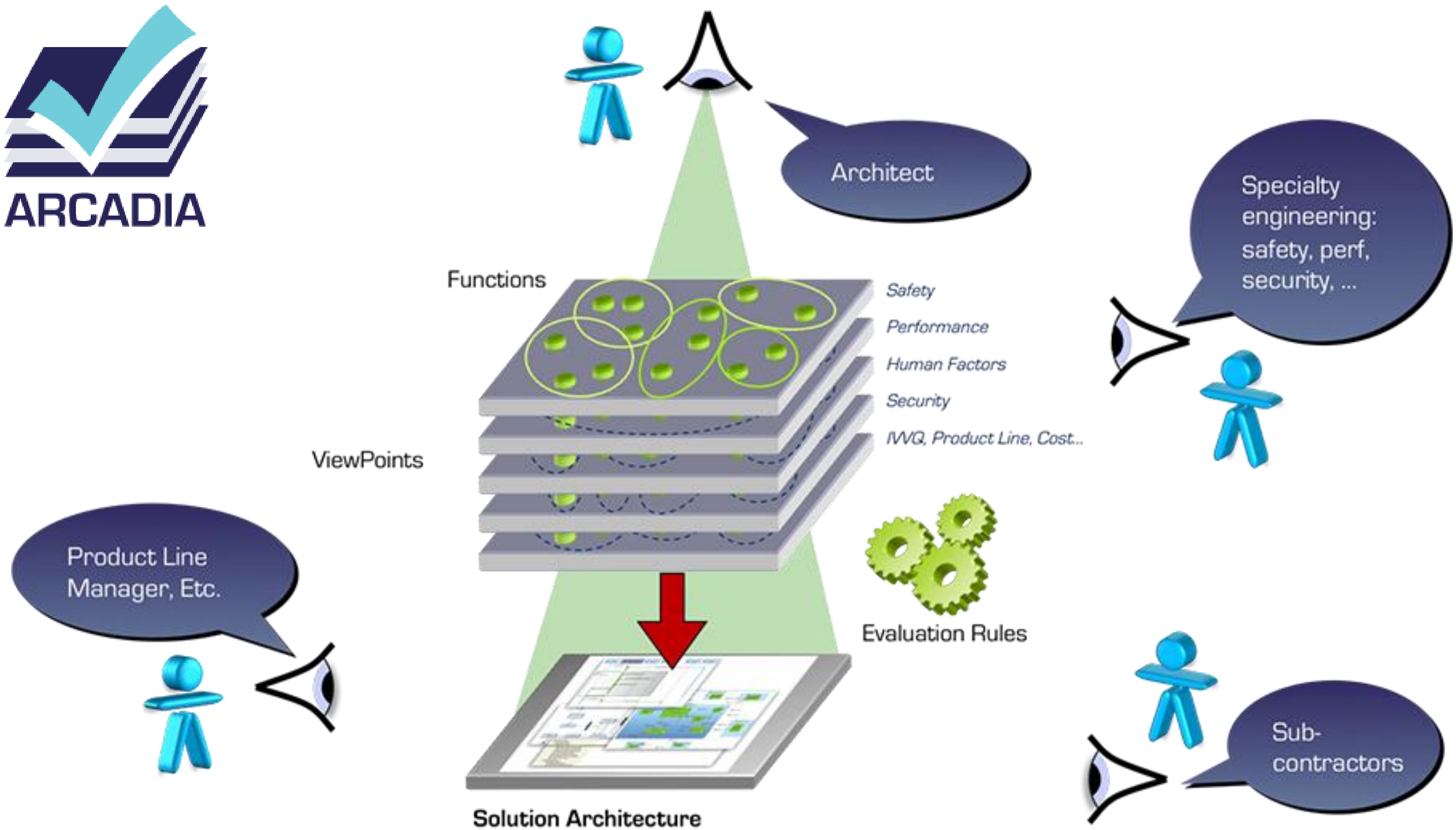
What the users of the system need to accomplish

What the system has to accomplish for the users

How the system will work to fulfill expectations

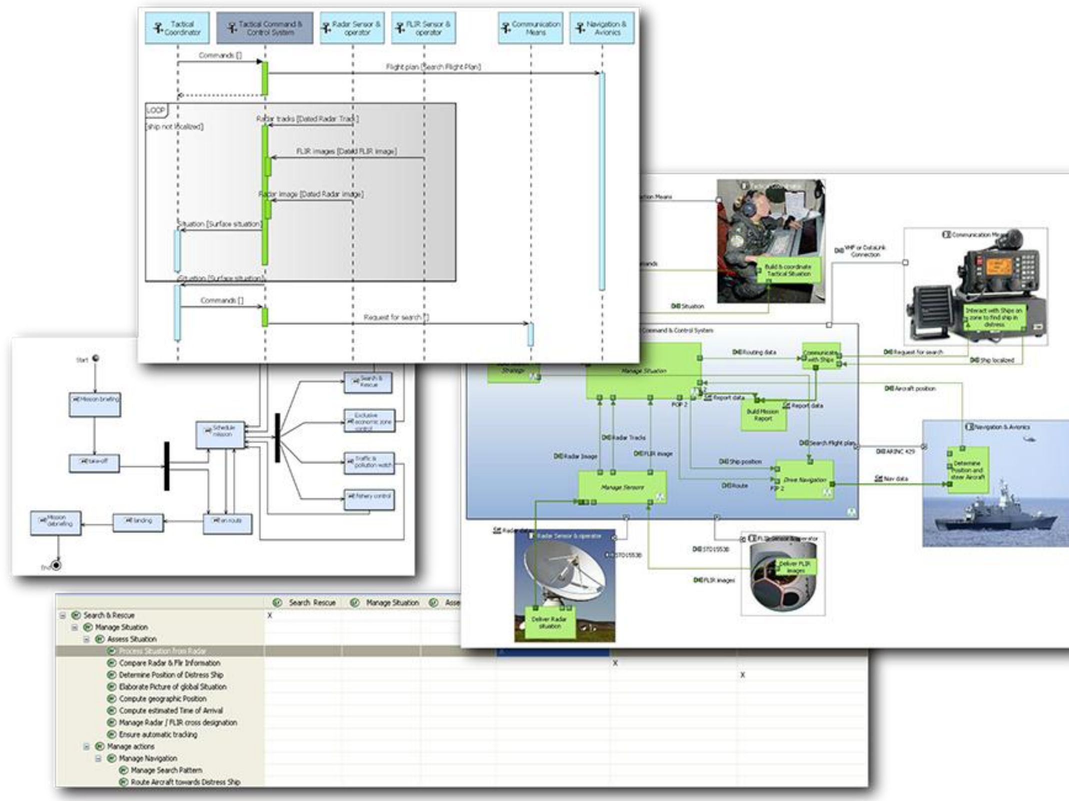
How the system will be developed and built

Arcadia: Multi-Viewpoint Trade-Off Analysis



Capella: Arcadia Graphical Modelling Workbench

- Guidance
  [Embedded methodological browser]
- Complexity management
  [Abstraction via computed information]
- Productivity tools
  [Automated transitions and diagram creation accelerators]
- Model Analysis & Navigation
  [Model validation, semantic browser]
- Multi-criteria analysis
  [Viewpoints and management framework]

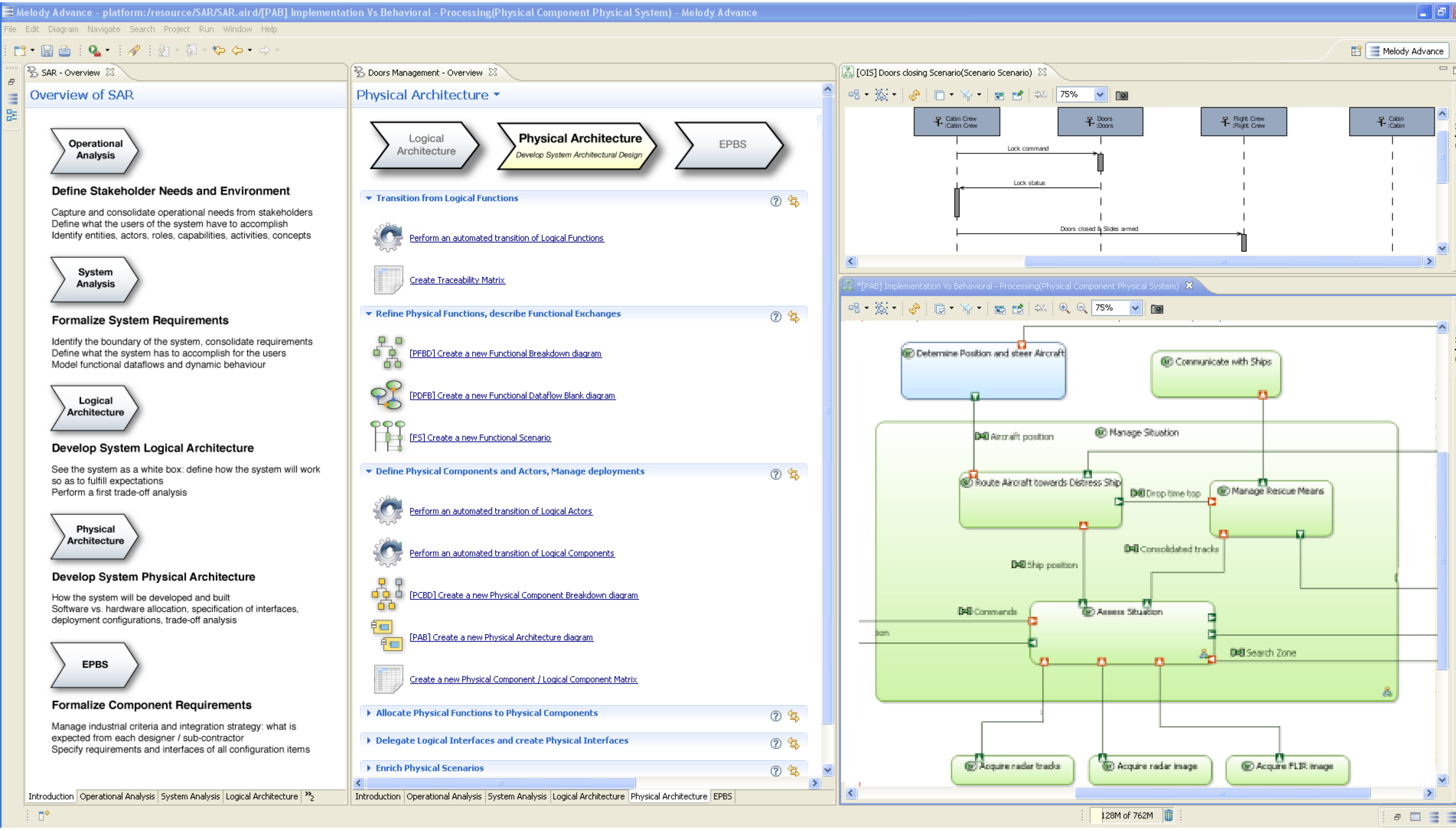


First operational deployments in 2009

Used on most major engineering projects

Open sourced in 2014

Capella: Embedded Methodological Guidance



Use Case 1:

Managing System Design Complexity

Managing System Design Complexity

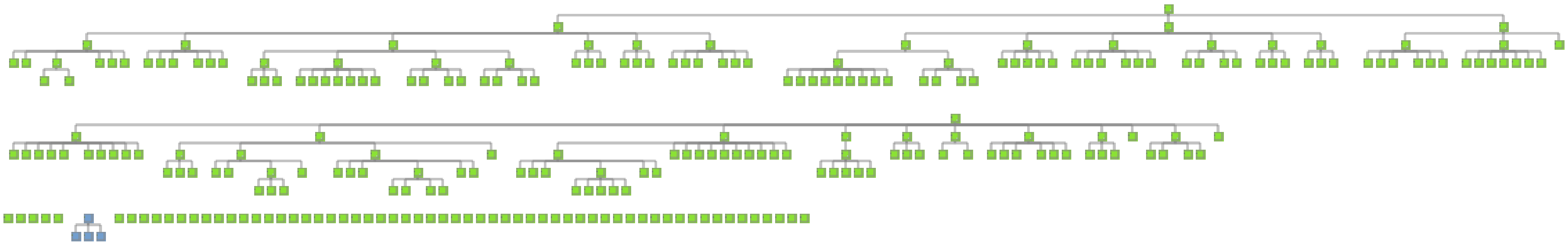
Context

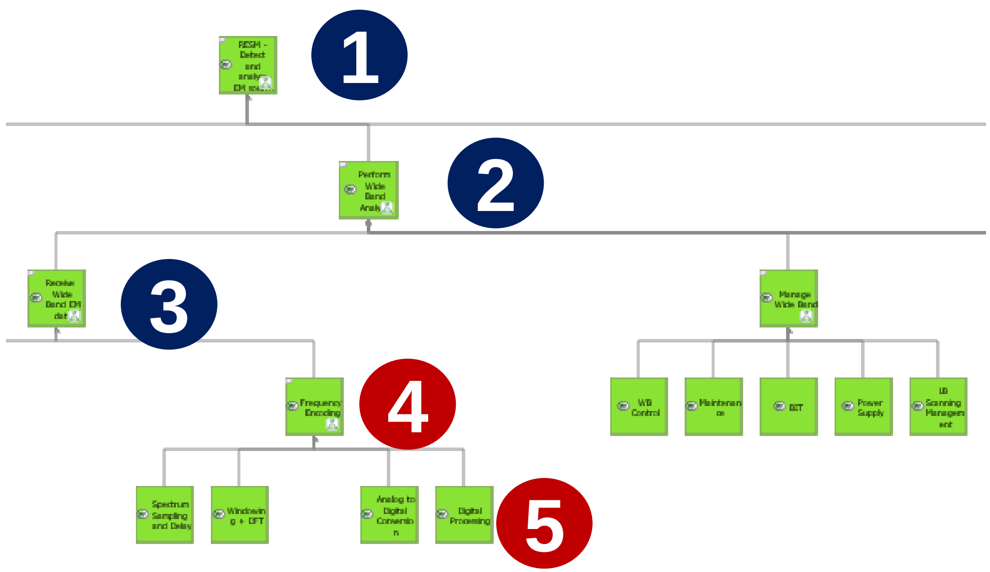
- Issues in the latest phases of operational validation
- Very good design documents, but in silos

MBSE usage

- 1 man month to **reverse a first level of detail** in a model, based on existing documents
- **First time overall views have been available**
  - Good support for discussion
  - Visualization of transverse functional chains

Managing System Design Complexity





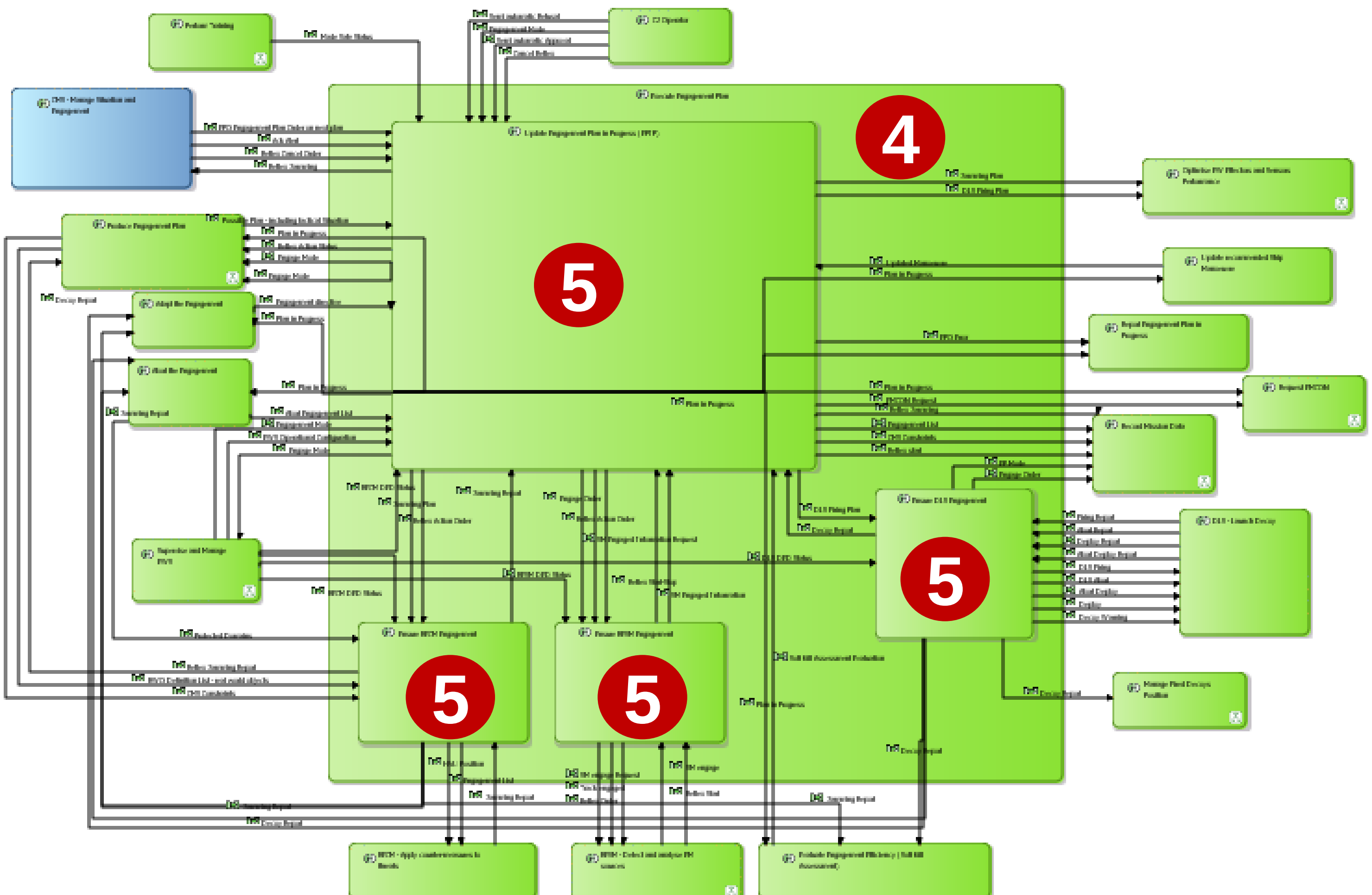
275 Functions
(230 Leaves)

578 Functional Exchanges between leaf functions

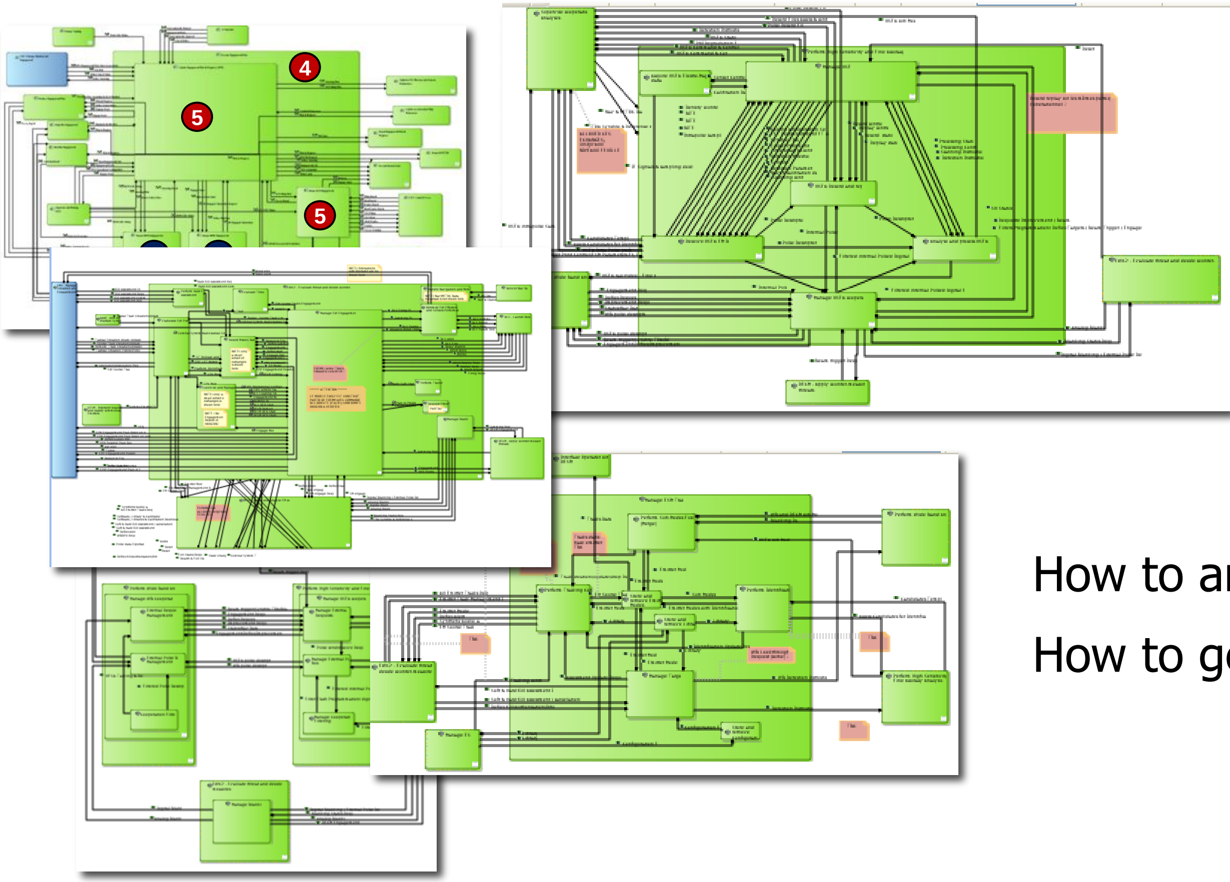
5 levels of decomposition

Managing System Design Complexity

Contextual Diagrams: Low-level internals, high-level neighboorhood



Managing System Design Complexity



X 40

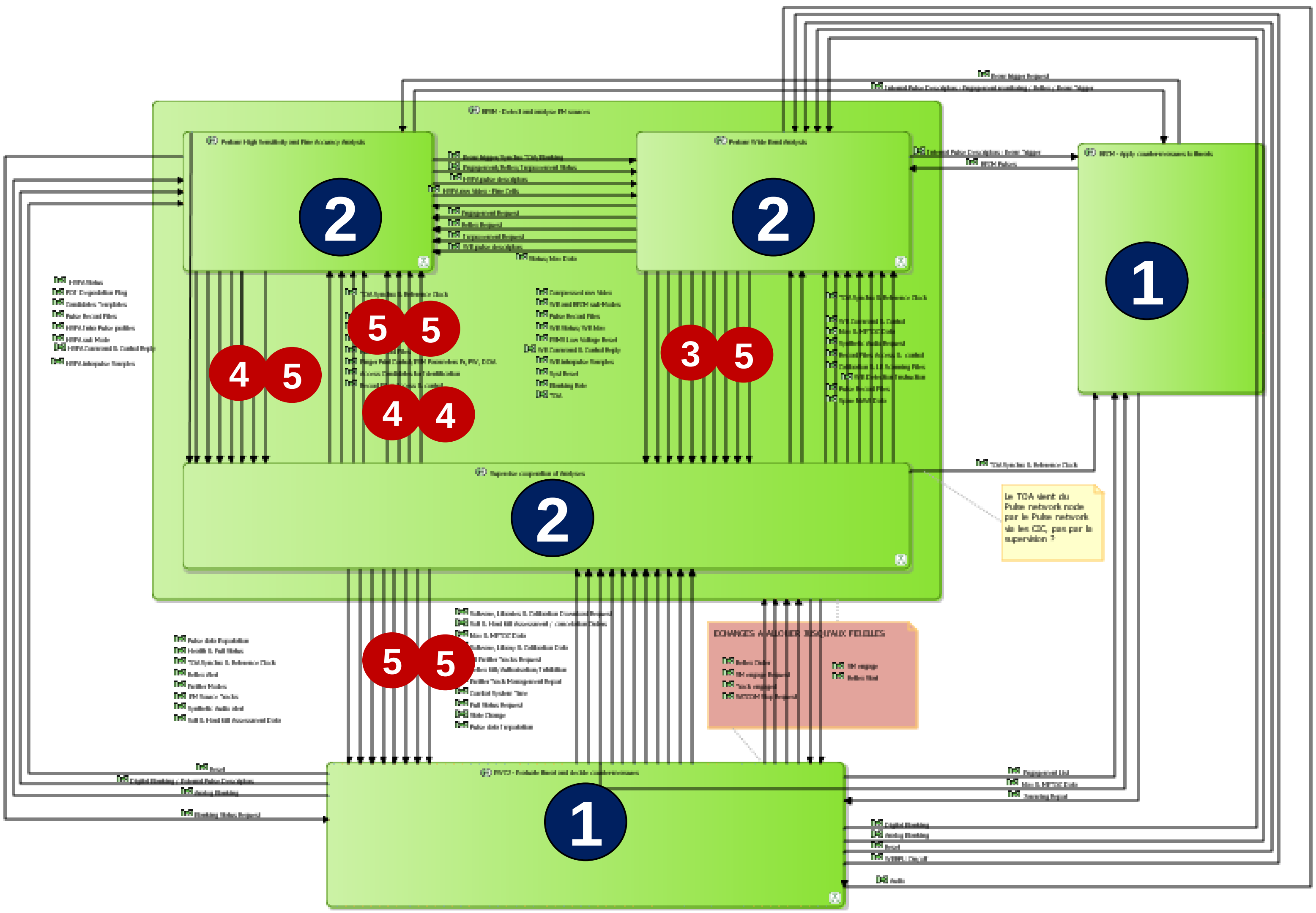
How to analyze transverse topics?

How to get transverse overviews?

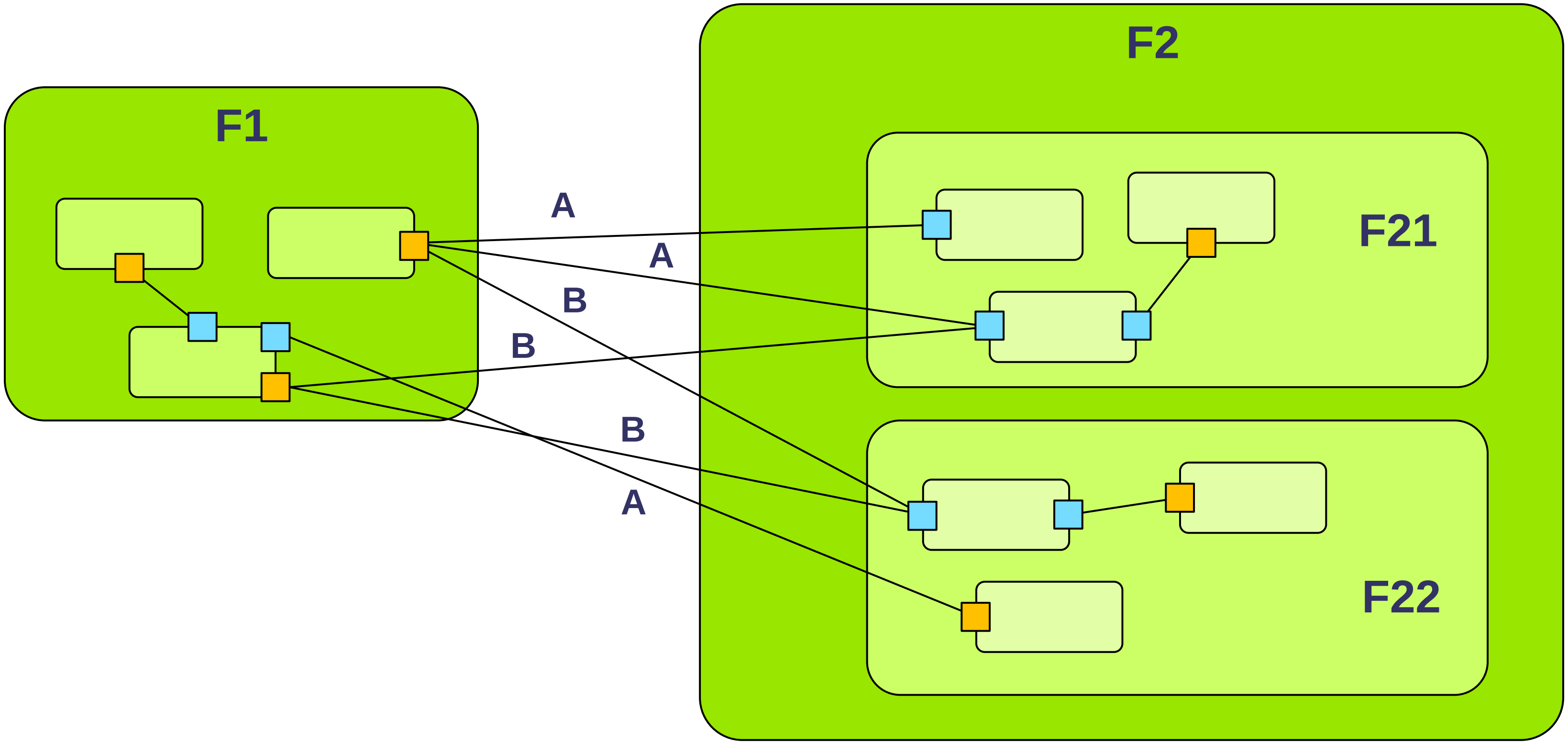
Challenge: Build and maintain simplified views

Managing System Design Complexity

Computed Diagrams: High-level Functions, Low-level Exchanges

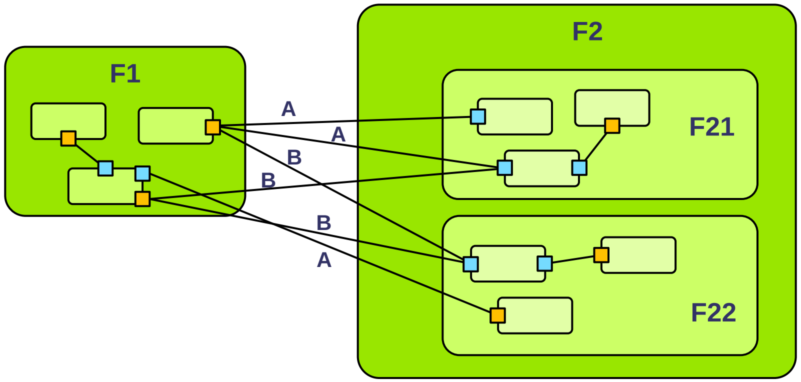


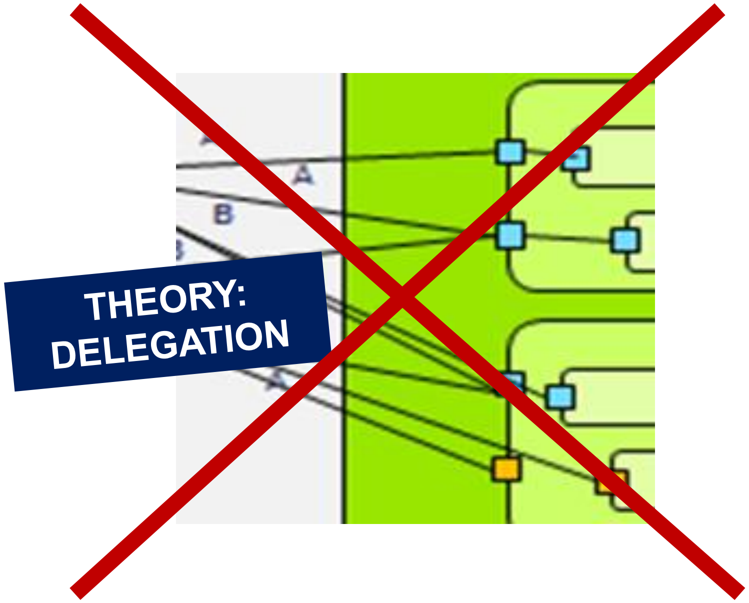
MODEL



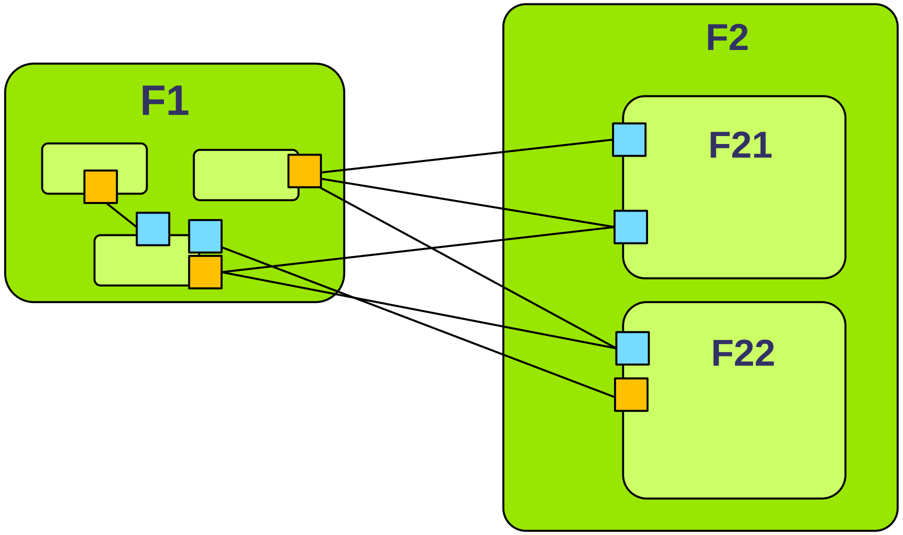
Managing System Design Complexity

MODEL





VIEW

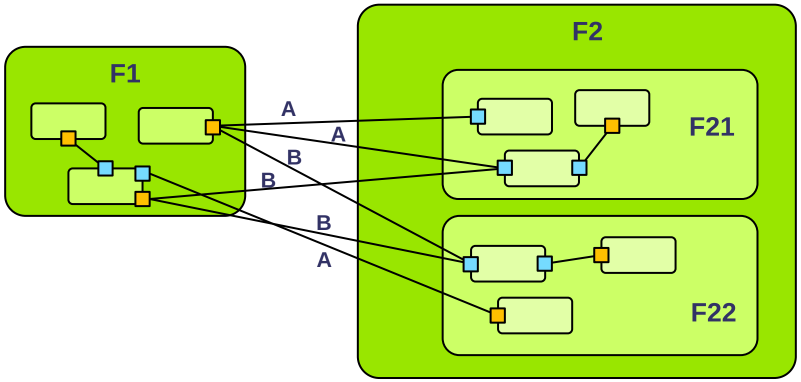


Children of F21 and F22 not displayed

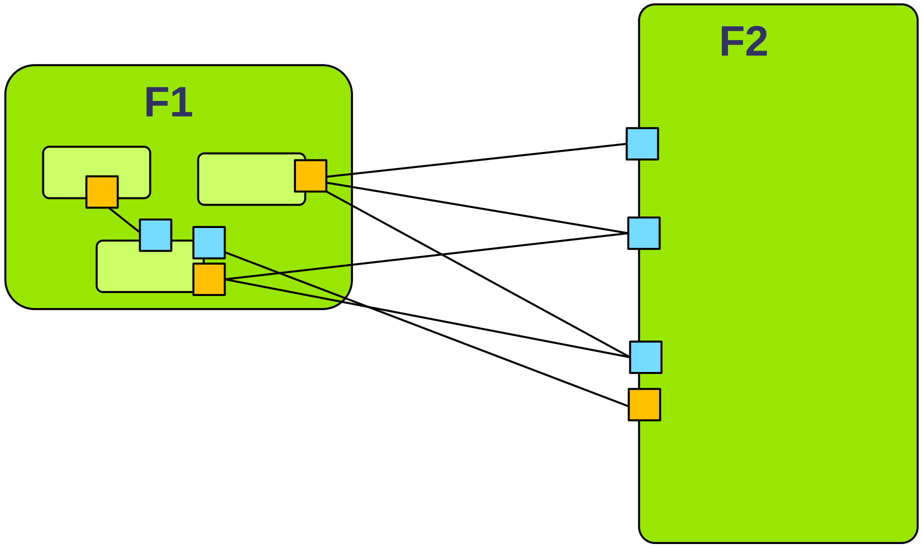
Ports on F21 and F22 are graphically computed (they actually belong to the children of F21 and F22)

Managing System Design Complexity

MODEL



VIEW

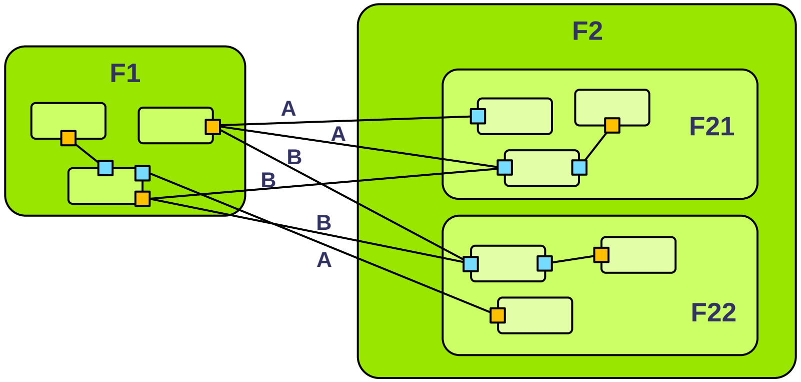


Children of F2 not displayed

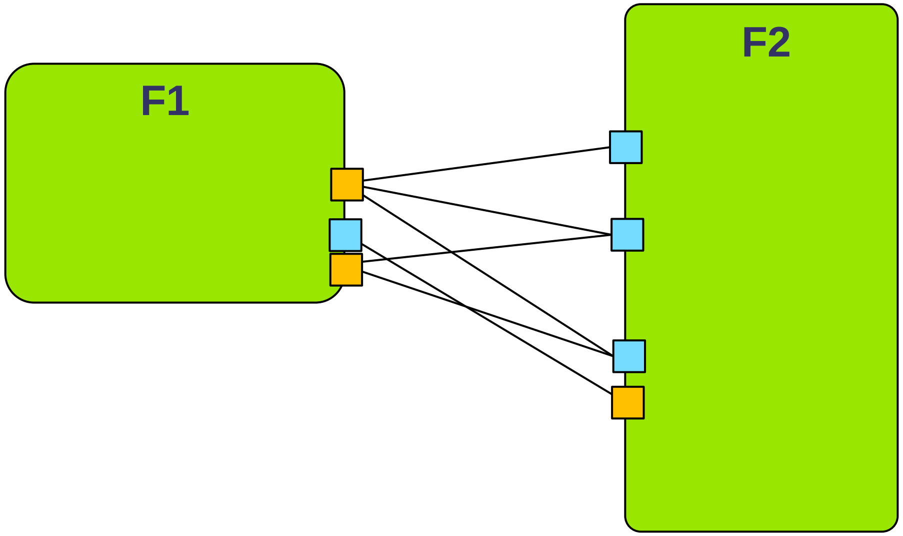
Ports on F2 are graphically computed (they actually belong to the children of F21 and F22)

Managing System Design Complexity

MODEL



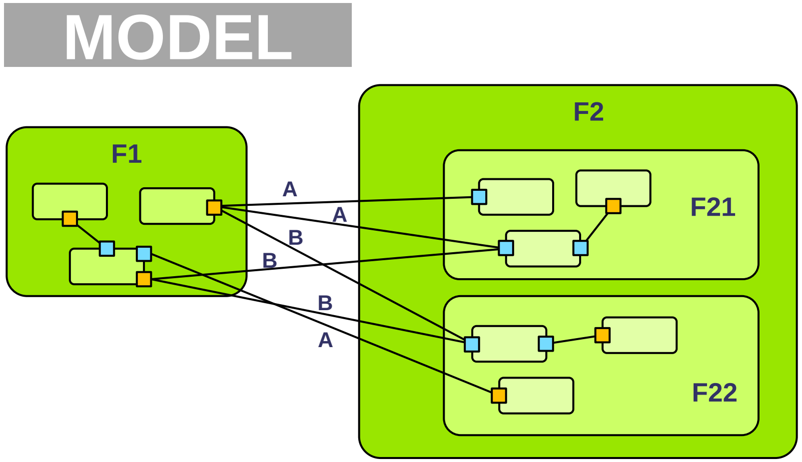
VIEW

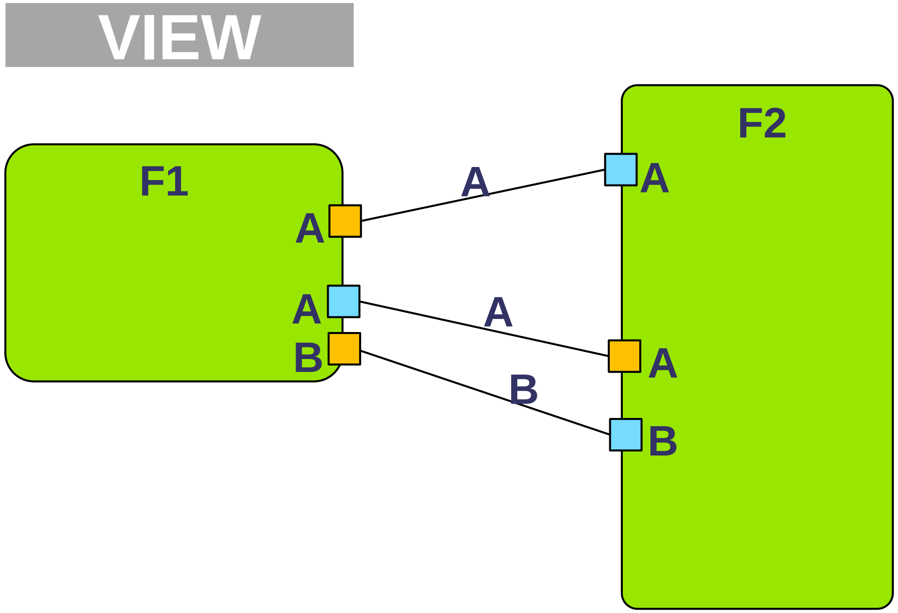


Children of F1 and F2 not displayed

Ports on F1 and F2 are graphically computed (they actually belong to the children of F21 and F22)

Managing System Design Complexity

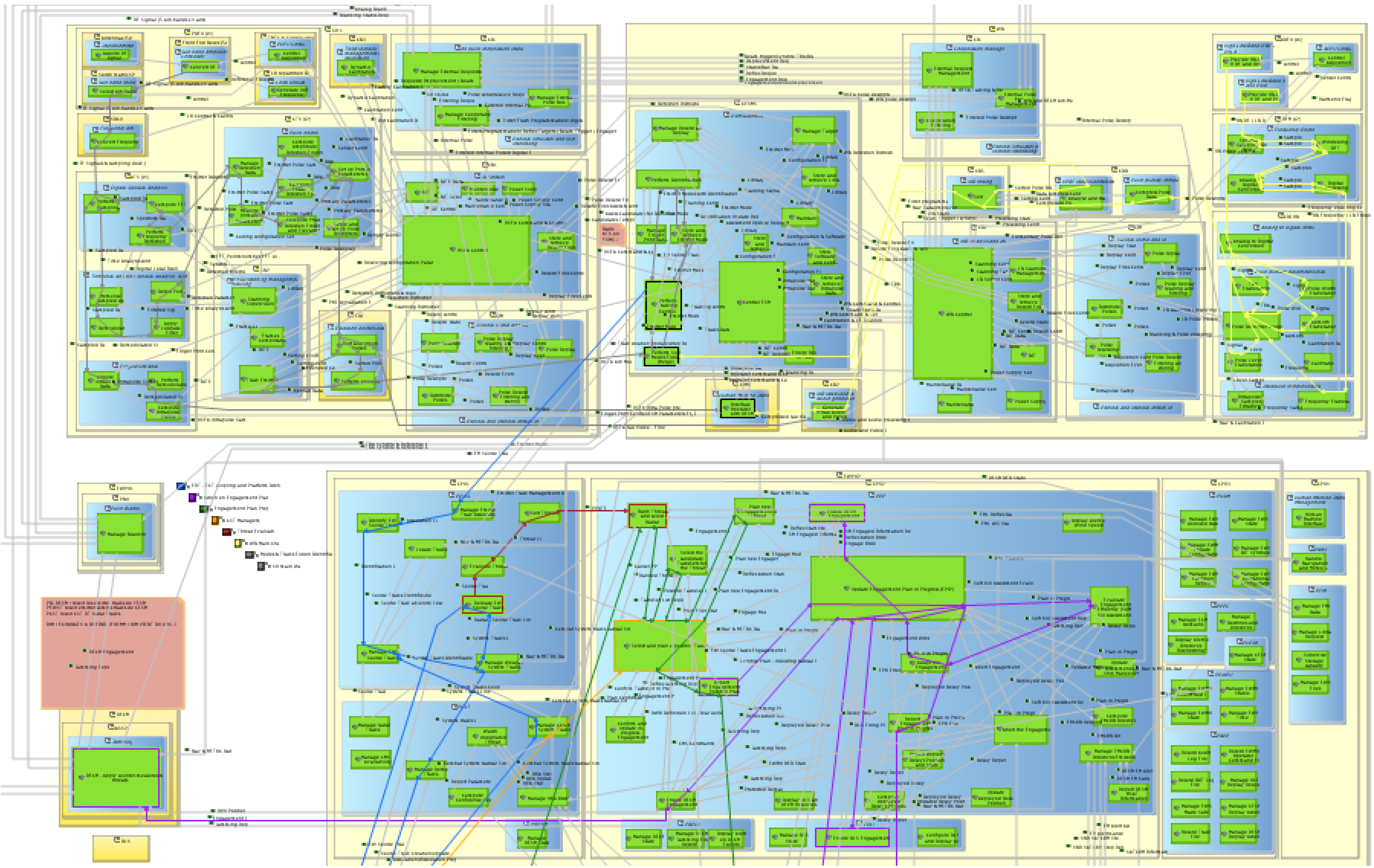




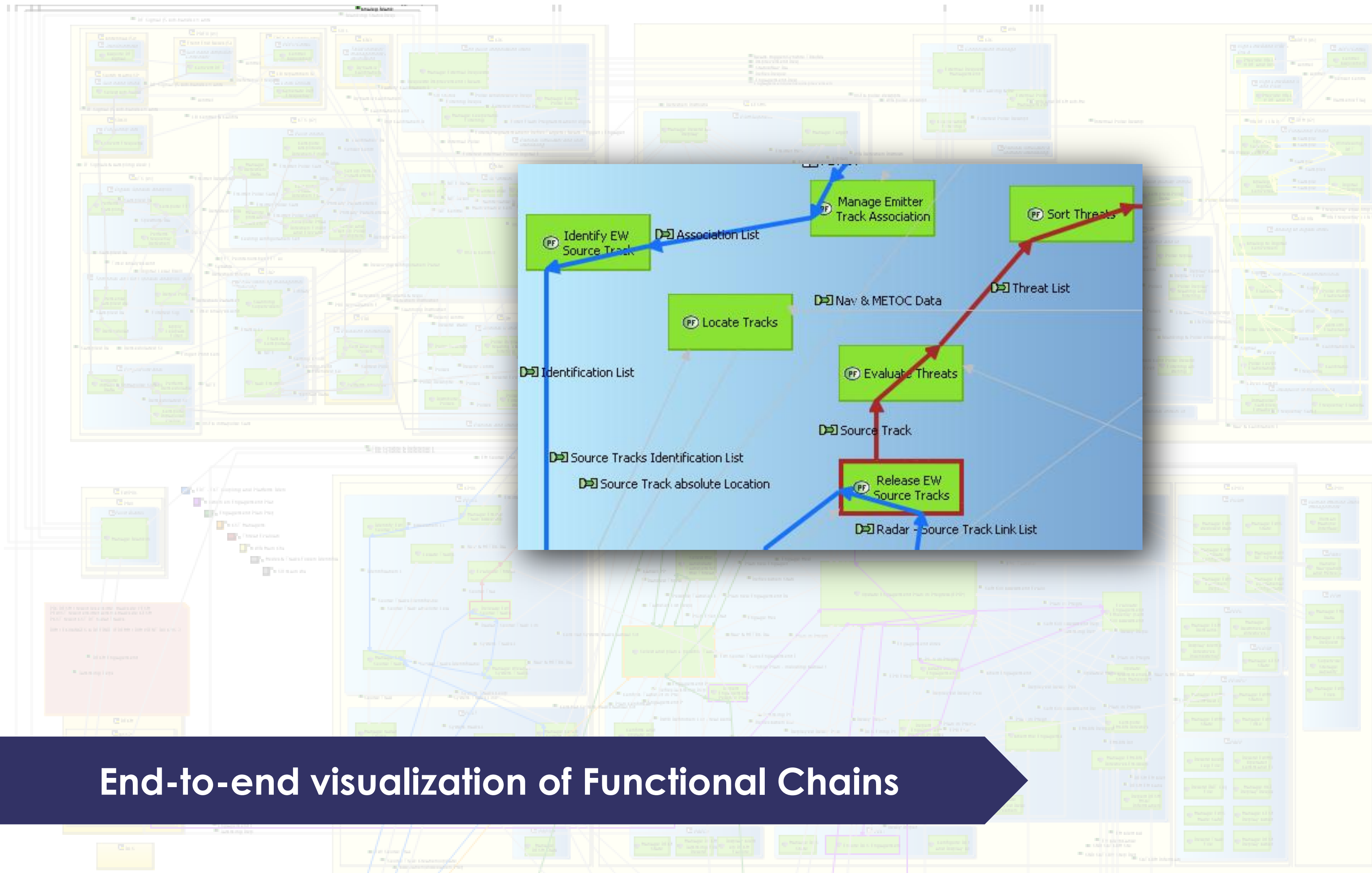
Tag-based simplification mechanism: each exchange can be marked with several « grouping » tags

Computed graphical simplifications free engineers from tedious and error-prone maintenance of abstraction levels

Managing System Design Complexity: Global Overview



Managing System Design Complexity: Global Overview



End-to-end visualization of Functional Chains

Use Case 2:

MBSE-based Change Management

Use Case 2: Change Management

Context

- Maritime Patrol Program delivered to the Customer
- New functionalities asked by the Customer

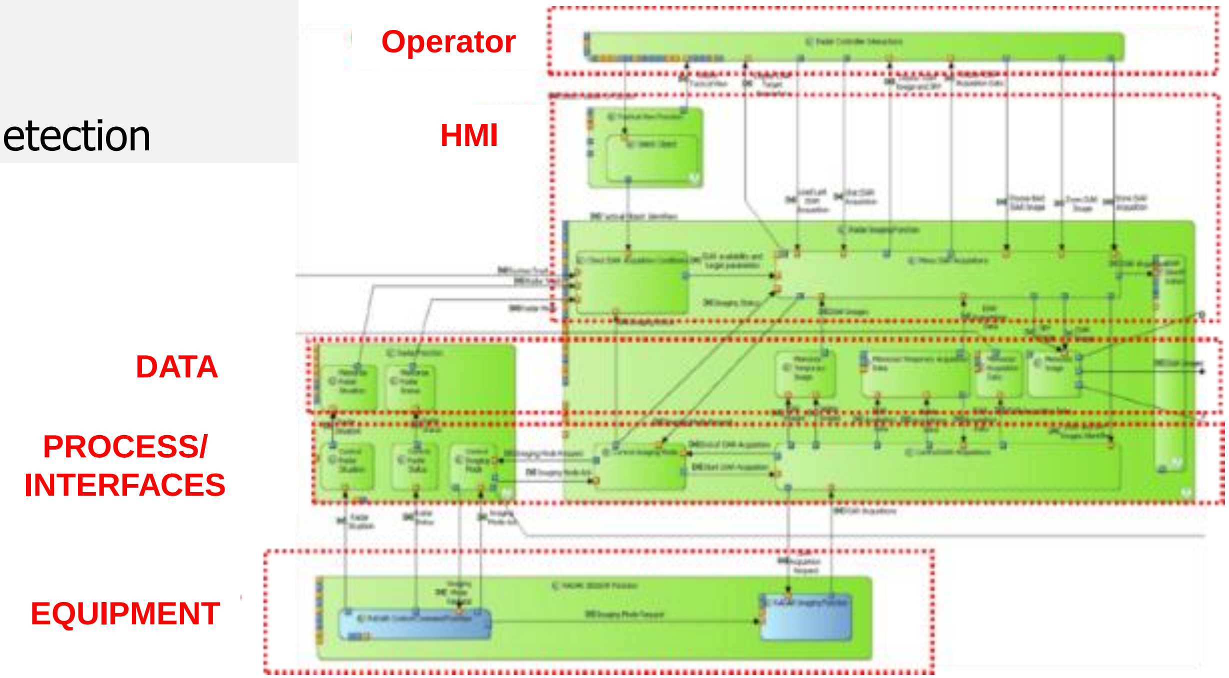
MBSE usage

- Up-to-date model of the delivered System available
- Modification of the model in order to:
  - **Estimate feasibility, cost and risks**
  - Drive developments and IVVQ
- **Product line** management

« HDPI » Model Representation

A regular layout / reading pattern across all diagrams

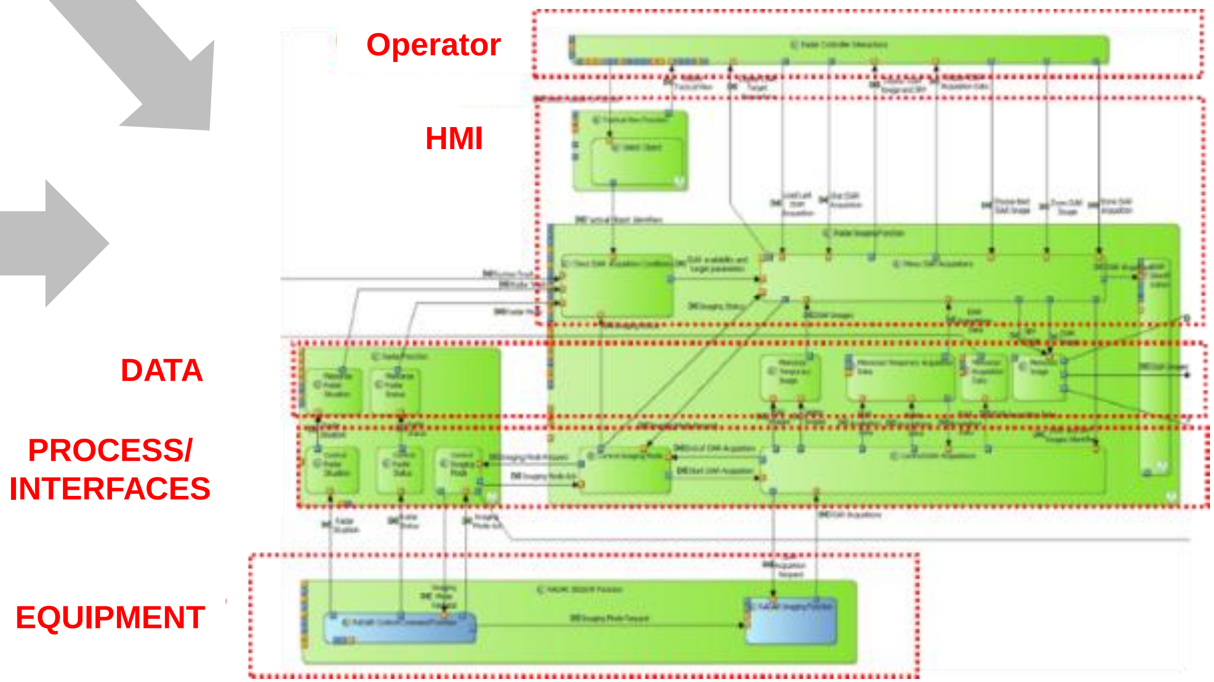
- Multiple contributors modelling the same way
- Facilitates first access to diagrams
- Eases diagram review
- Allows quick inconsistency detection



Need Representation based on Delivered Solution

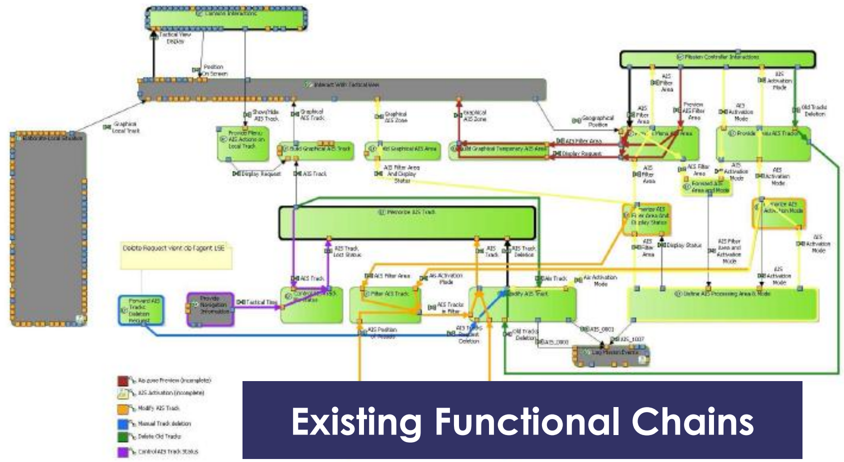
SSS: Need

PIDS: Reverse Engineering from Software Specification

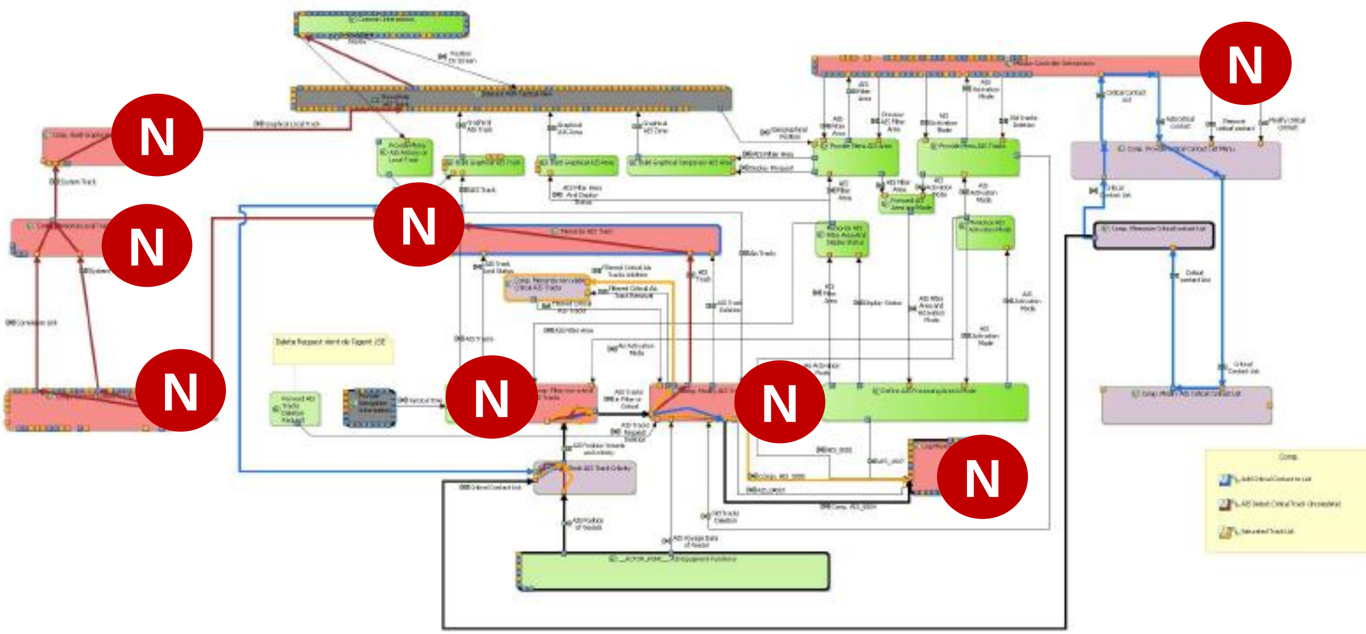


Managing Change: Feasibility and Risks

New Customer needs



Existing Functional Chains



N Impacted Functions

New Functional Chains

Change Management: Automated Cost Estimation

COST Analysis Viewpoint

Elementary work decomposition, and estimation of an average development cost for each category of function

- Panels
- External / Internal Interfaces
- Data Memorisation
- Processing Complexity

Computed Data: Estimated Cost

Capella Outputs (model export)

K	N	O	P	Q	R	AI	AJ	AK	AL	AM	AP	AQ	AR
Fct 9	Panneaux OMI ou	Interfaces internes	Interfaces externes	Memorisation: 1 si	Algo: Niveau 1=	ire	Fonctions chiffrées		Complexité Calculée	Implem TU retenue sans		à développer (Exemple 40% signifi	Implem et TU avec Reuse et
	528	1485	82	45	697		238		13650			100%	
	800	1300	70	50	400		239		14843		New	77%	
Complexité	7	2	5	2	10	1	####				Reuse	15%	0
Totaux	528	1485	82	45	697	234	238		16009	13912	COTS	8,4%	9419
	1	3	0	0	5	1	1		69	69	New	100%	69
	0	3	0	0	1	1	1		20	20	New	100%	20
	0	4	0	1	0	1	1		18	18	New	100%	18
				0		0							
				0		0							
	3	15	0	0	2	2	1		101	101	New	100%	101
	0	11	0	1	0	1	1		32	32	New	100%	32
	2	8	0	0	4	2	1		96	96	New	100%	96
	2	8	0	0	2	2	1		70	70	New	100%	70
	0	2	0	0	2	1	1		30	30	New	100%	30
				0		0							
	4	9	0	0	0	1	1		57	57	New	100%	57
	0	5	0	0	0	0	1		10	10	New	100%	10
				0		0							
	0	4	0	0	0	0	1		14	14	New	100%	14
	0	9	0	1	0	1	1		31	31	New	100%	31
	2	3	0	0	0	0	1		20	20	New	100%	20
				0		0							
	0	6	0	1	0	1	1		17	17	New	100%	17
	0	6	0	1	0	1	1		17	17	New	100%	17
	0	8	0	1	0	1	1		23	23	Reuse	75%	17
	4	8	0	0	5	1	1		103	103	COTS	50%	52
											New	100%	10

Use Case 3:

Multi-Level Engineering

Use Case 3: Multi-Level Engineering and Automated Transitions

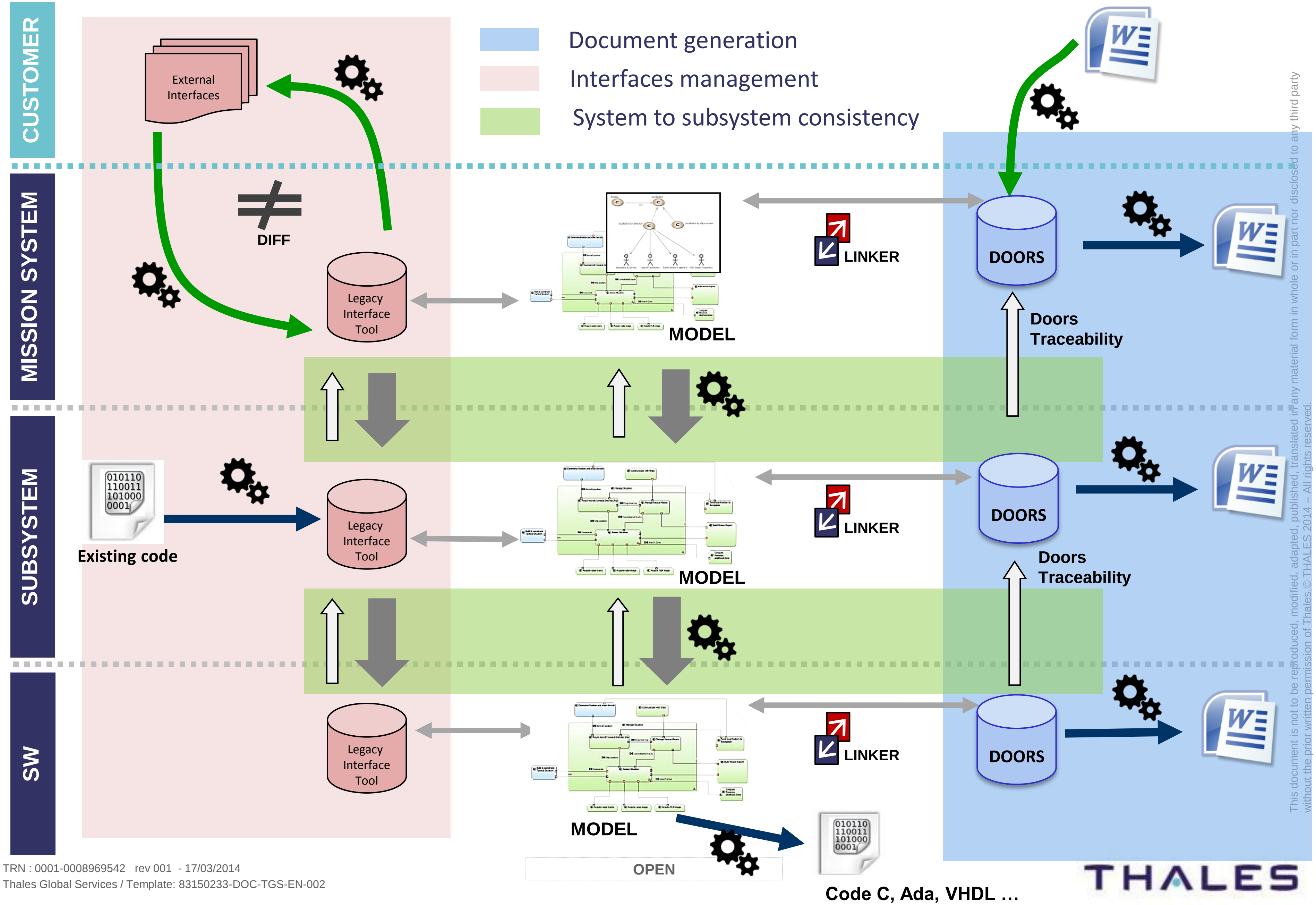
Context

- Complex systems with full Thales responsibility (from Mission System to SW Component)

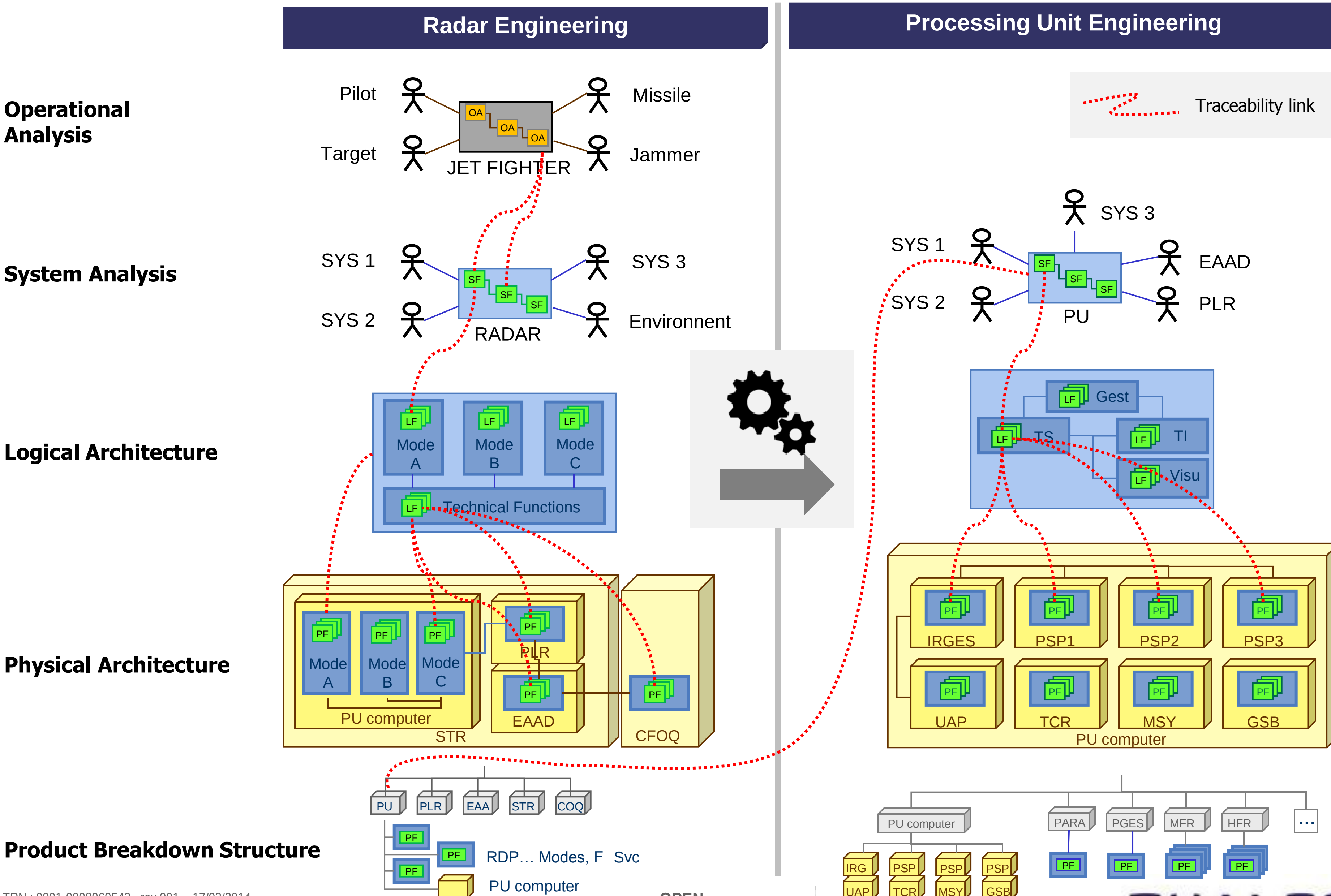
MBSE usage

- Setup a global, **multi-level engineering approach**
- Joint effort with Thales Airborne Systems / Thales Corporate to **specify and develop an automated, iterative transition**
- Incubation on two projects
- Now integrated in the product and used in other contexts

Multi-Level Engineering and Automated Transitions

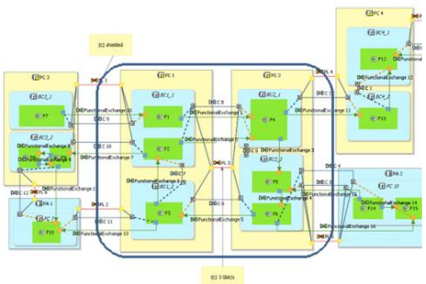


Multi-Level Engineering and Automated Transitions

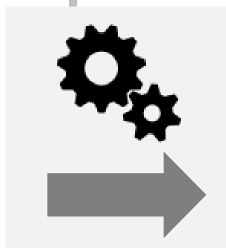


Multi-Level Engineering and Automated Transitions

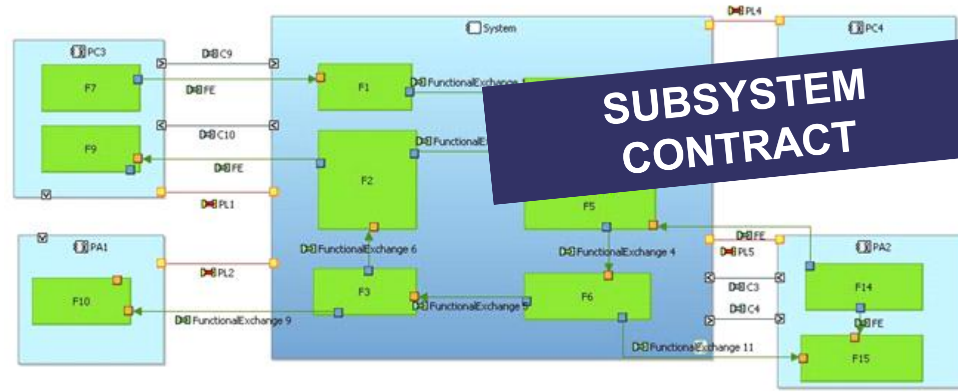
System Physical Architecture



CO-ENGINEERING

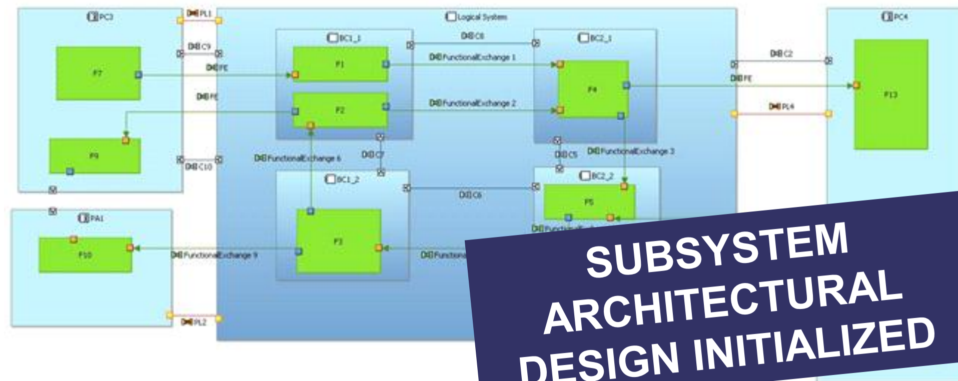


Subsystem Need Analysis



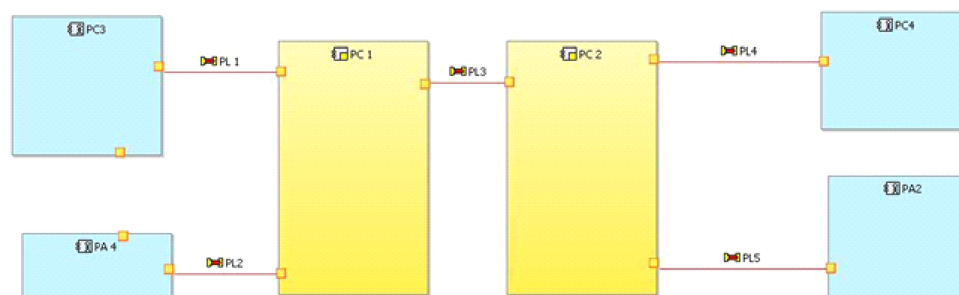
SUBSYSTEM CONTRACT

Subsystem Logical Architecture



SUBSYSTEM ARCHITECTURAL DESIGN INITIALIZED

Subsystem Physical Architecture



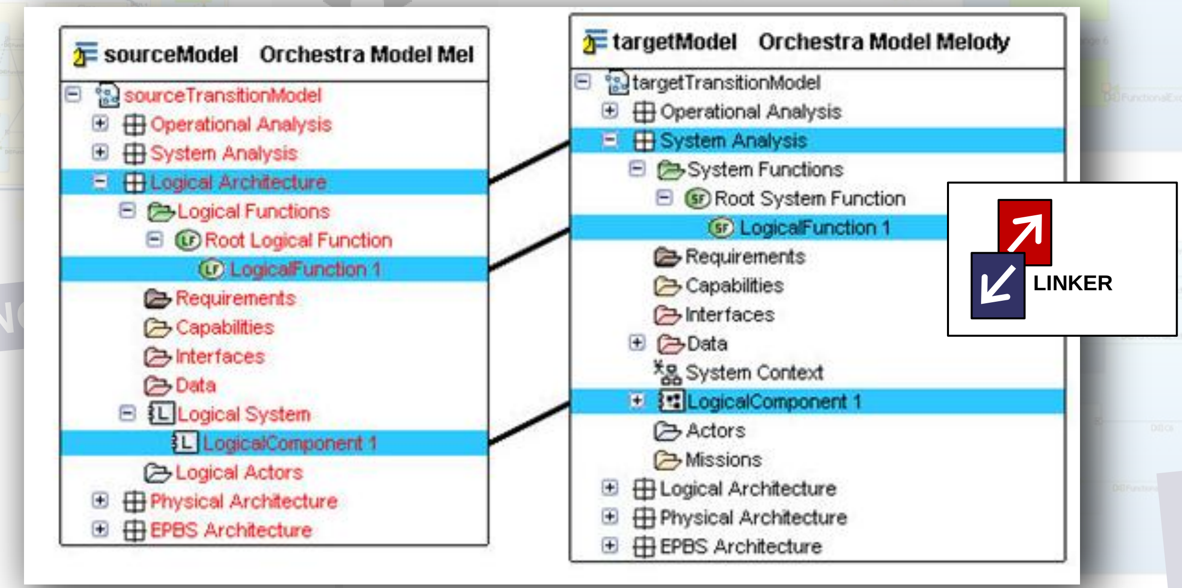
Multi-Level Engineering and Automated Transitions

System Physical Architecture

Subsystem Need Analysis

SUBSYSTEM CONTRACT

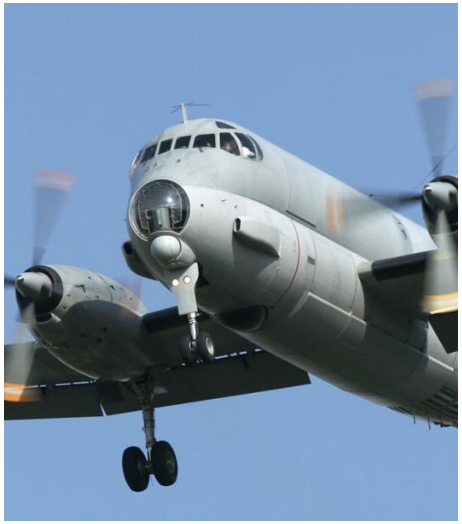
CO-EN



SUBSYSTEM ARCHITECTURAL DESIGN INITIALIZED

Subsystem Physical Architecture

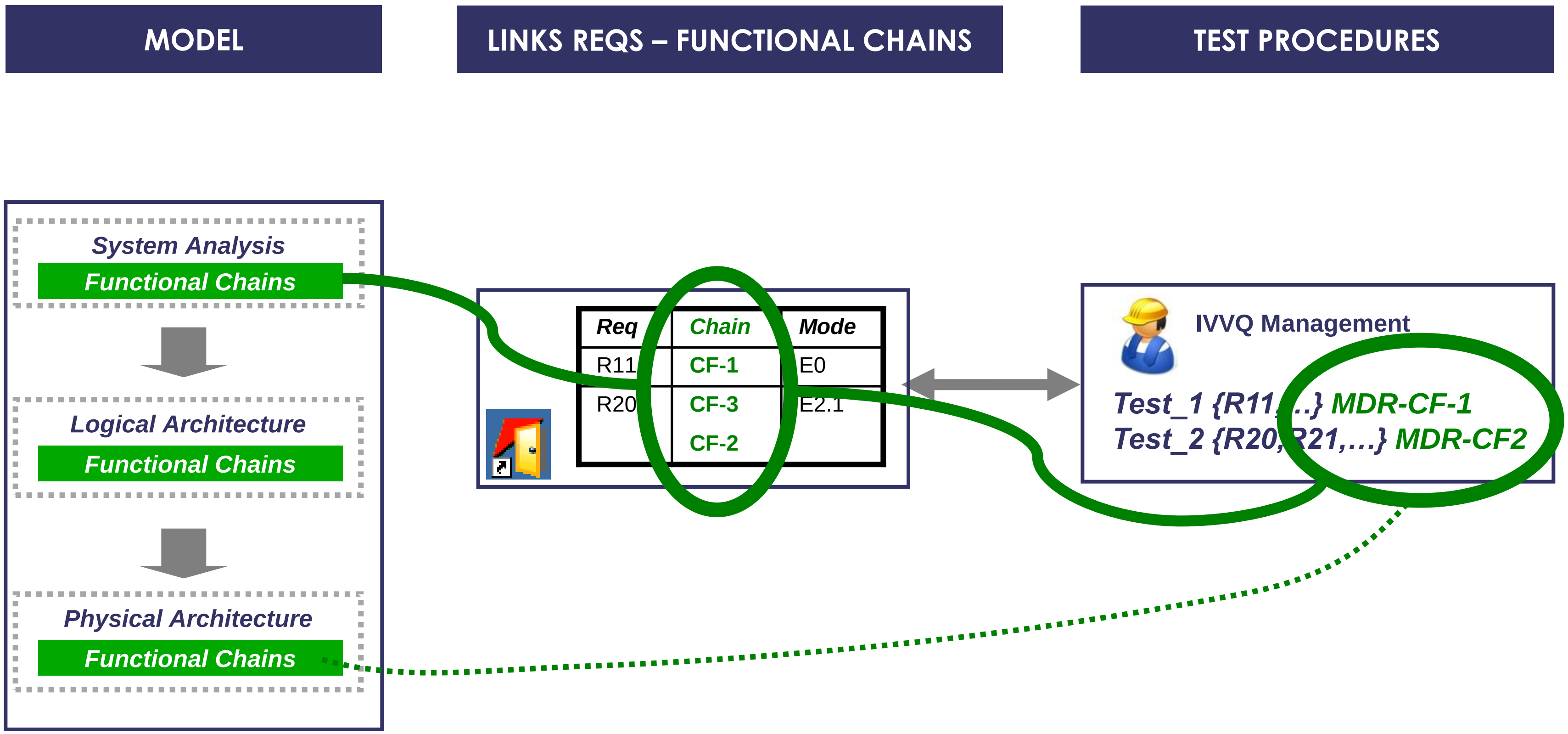
Computed system - subsystem traceability



Use Case 4:

Model-driven IVV

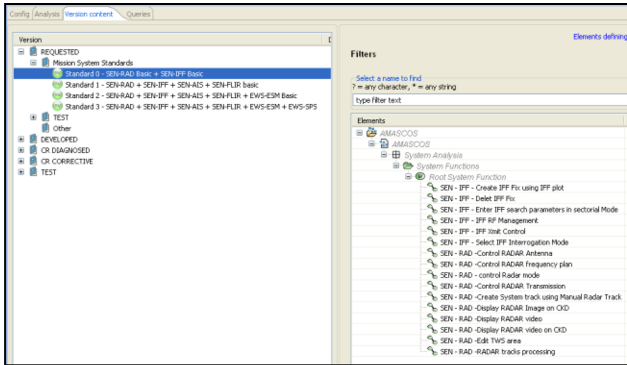
Functional Chains Driving Engineering Activities



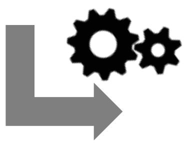
Requirements are clarified with Functional Chains

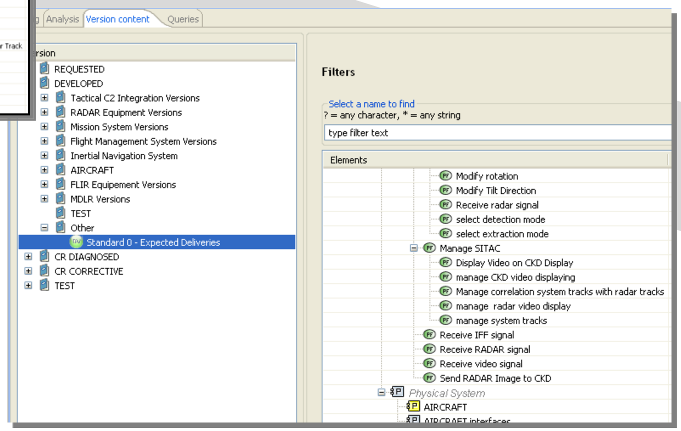
Test Procedures are linked to Functional Chains

IVV Strategy: Requested Versions / Developed Versions

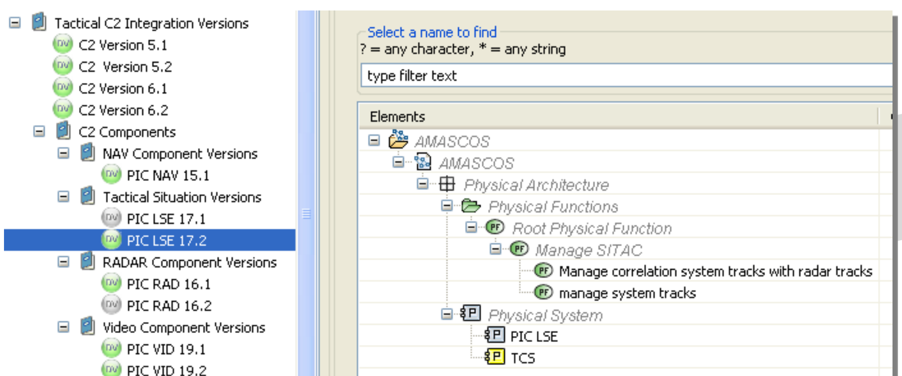


Define operational content expected for each project milestone





Deduce functional content and components to be delivered

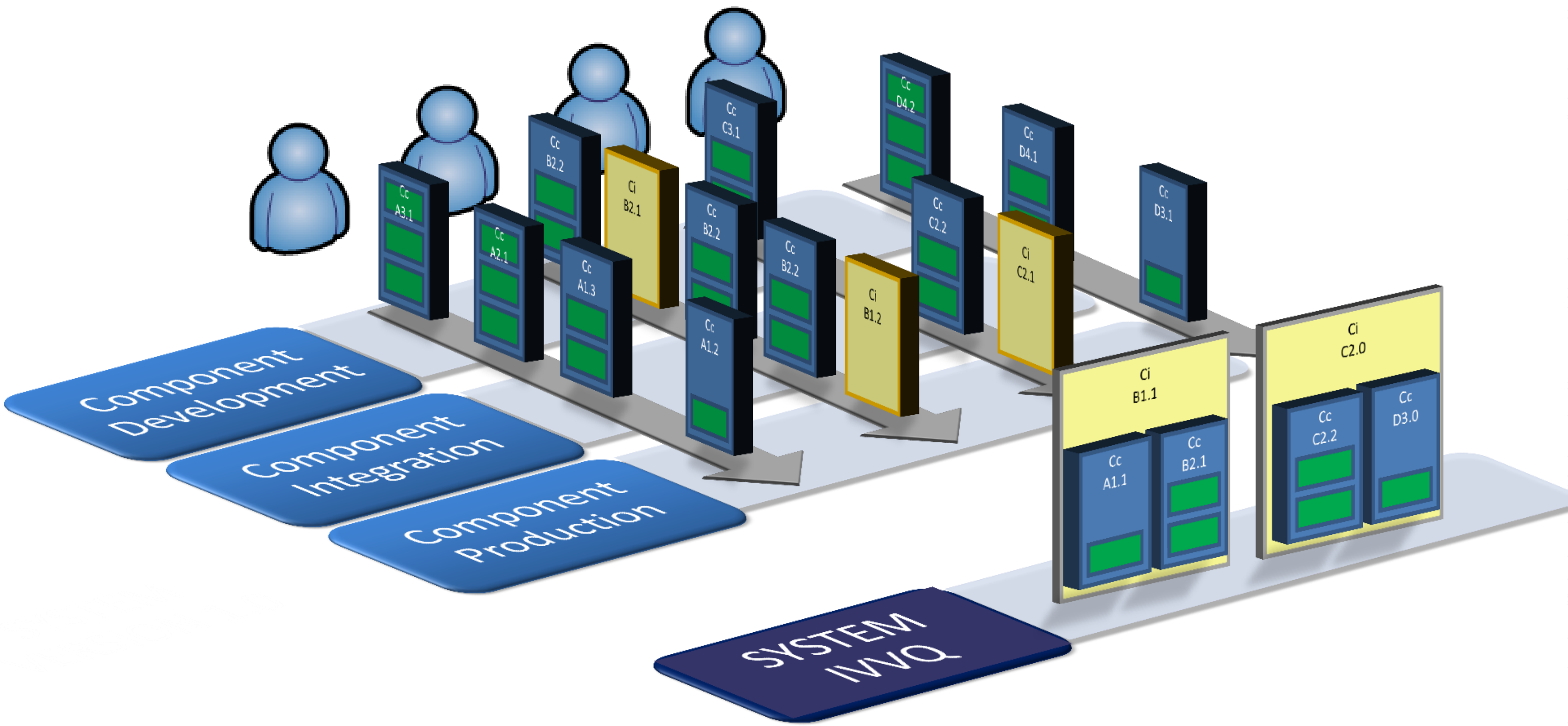


Define components versions and content

Based on an (non open source) IV&V viewpoint on top of Capella

Mastering System & Components Configurations

Blue: Software
Yellow: hardware

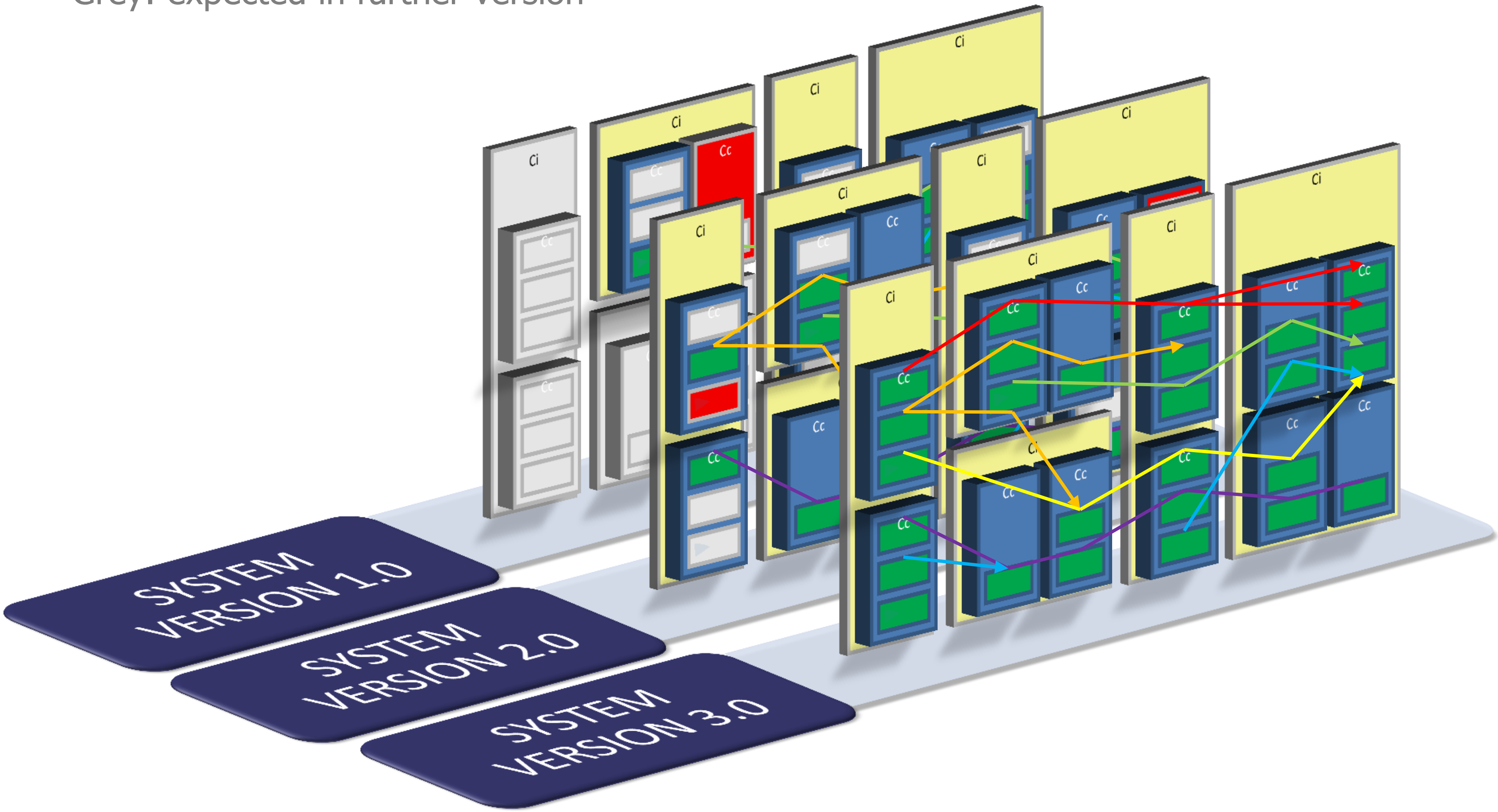


Based on an (non open source) IV&V viewpoint on top of Capella

IVV in Progress : Mastering Iterations

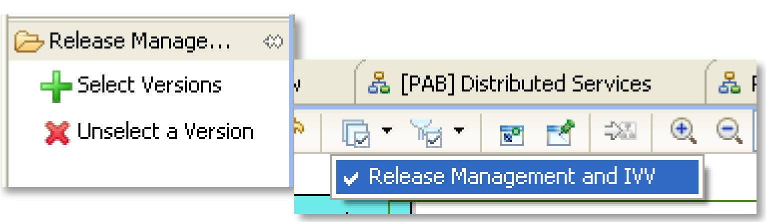
Red: Delayed, missing

Grey: expected in further version



Based on an (non open source) IV&V viewpoint on top of Capella

IVV in Progress: Comparing Versions



Based on an (non open source) IV&V viewpoint on top of Capella

Release management viewpoint:

Automated visualization of versions based on activation of diagram layers

IVV in Progress: Comparing Versions

Developed Version 1
Available elements in BLUE

Based on an (non open source) IV&V viewpoint on top of Capella

IVV in Progress: Comparing Versions

Developed Version 2
Available elements in CYAN

Based on an (non open source) IV&V viewpoint on top of Capella

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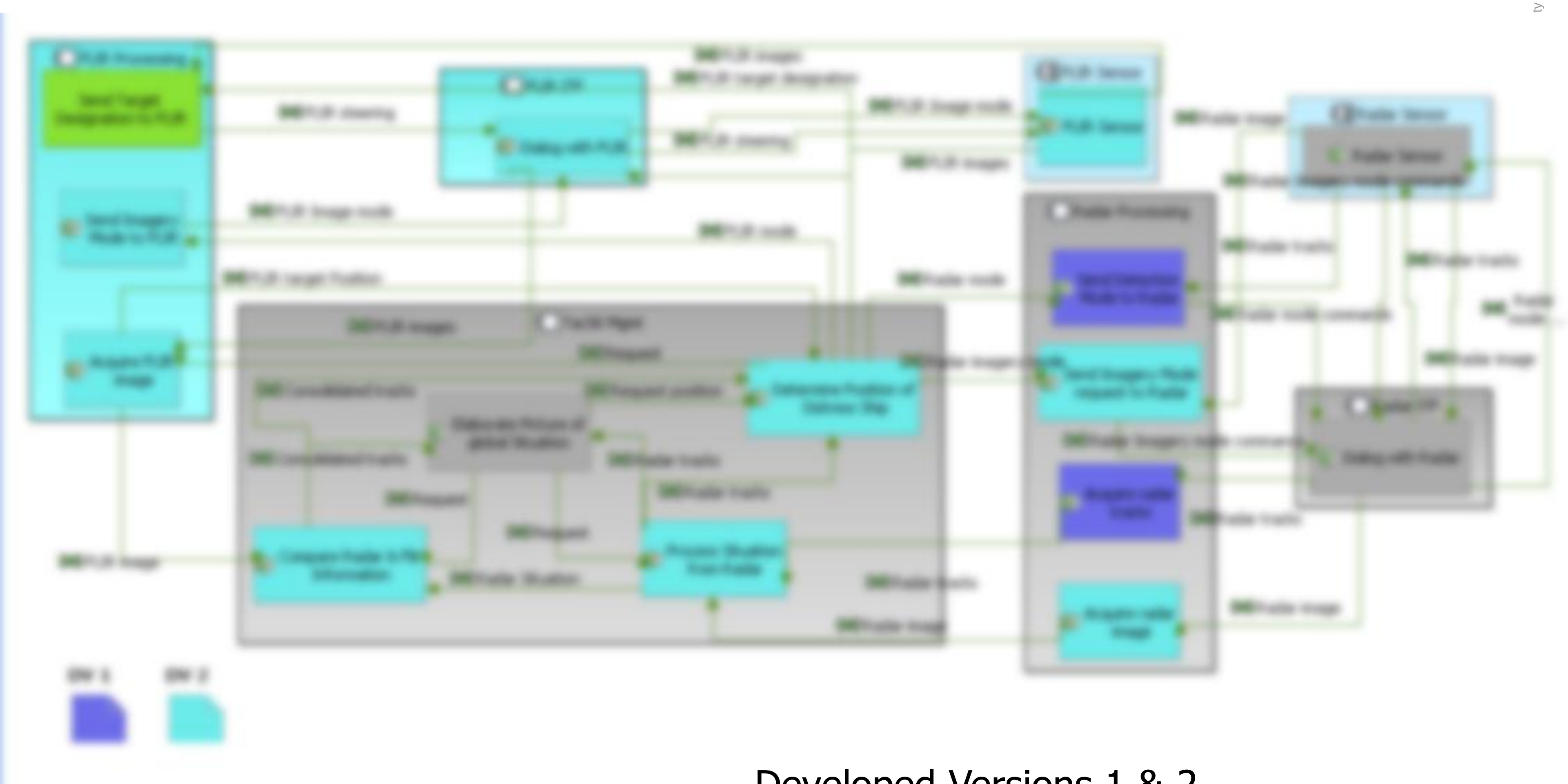
IVV in Progress: Comparing Versions

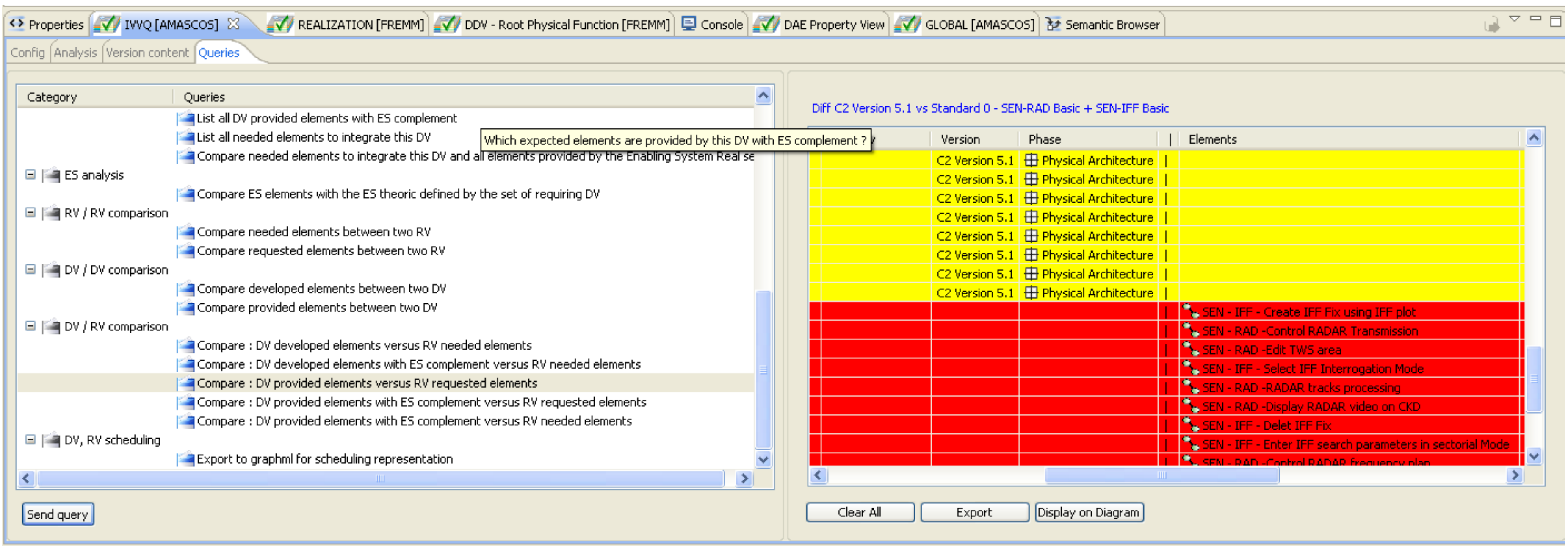


Developed Versions 1 & 2
Common available elements in GREY

Based on an (non open source)
IV&V viewpoint on top of Capella

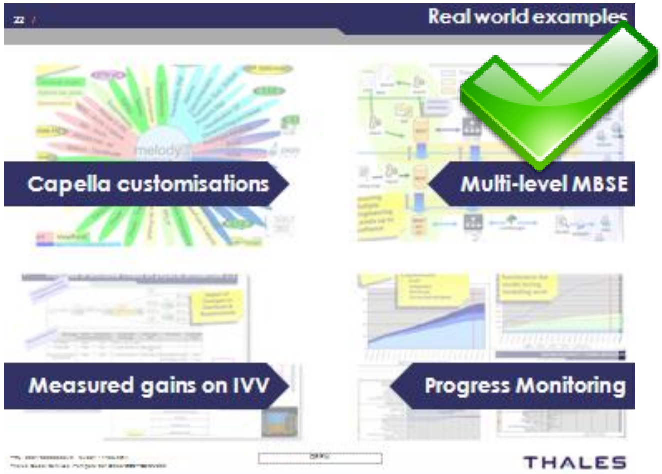
IVV in Progress: Ups and Downs

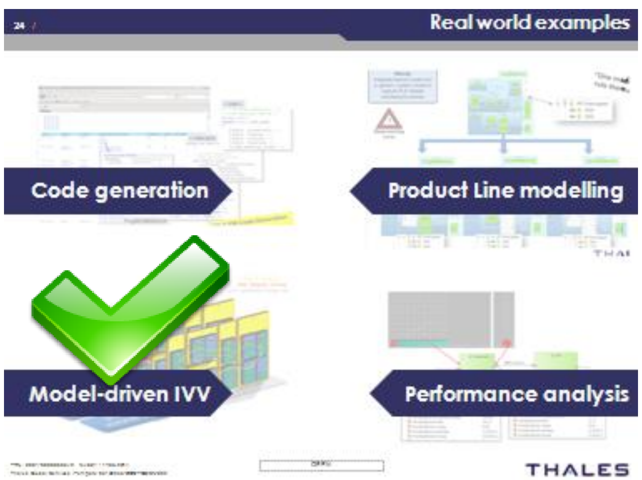
Compare Planned vs Developed versions



Based on an (non open source)
IV&V viewpoint on top of Capella

Lots of Other Different Use Cases





And more to come!

Thank you!

Thank you for your attention!

Any Questions?

Capella Open Source Project
https://www.polarsys.org/projects/capella

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