

Arcadia and Capella: Augmenting requirements with models to improve the articulation between systems engineering levels and optimize V&V practices

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THALES



1. Preamble: Arcadia method and Capella workbench

2. Model elements ARE requirements

3. Contracts between engineering levels: workflow

4. (Happy) consequences on V&V and incremental development strategy

5. Instantiated workflow



1. Arcadia and Capella

Methodology and
high level concepts
and viewpoints



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

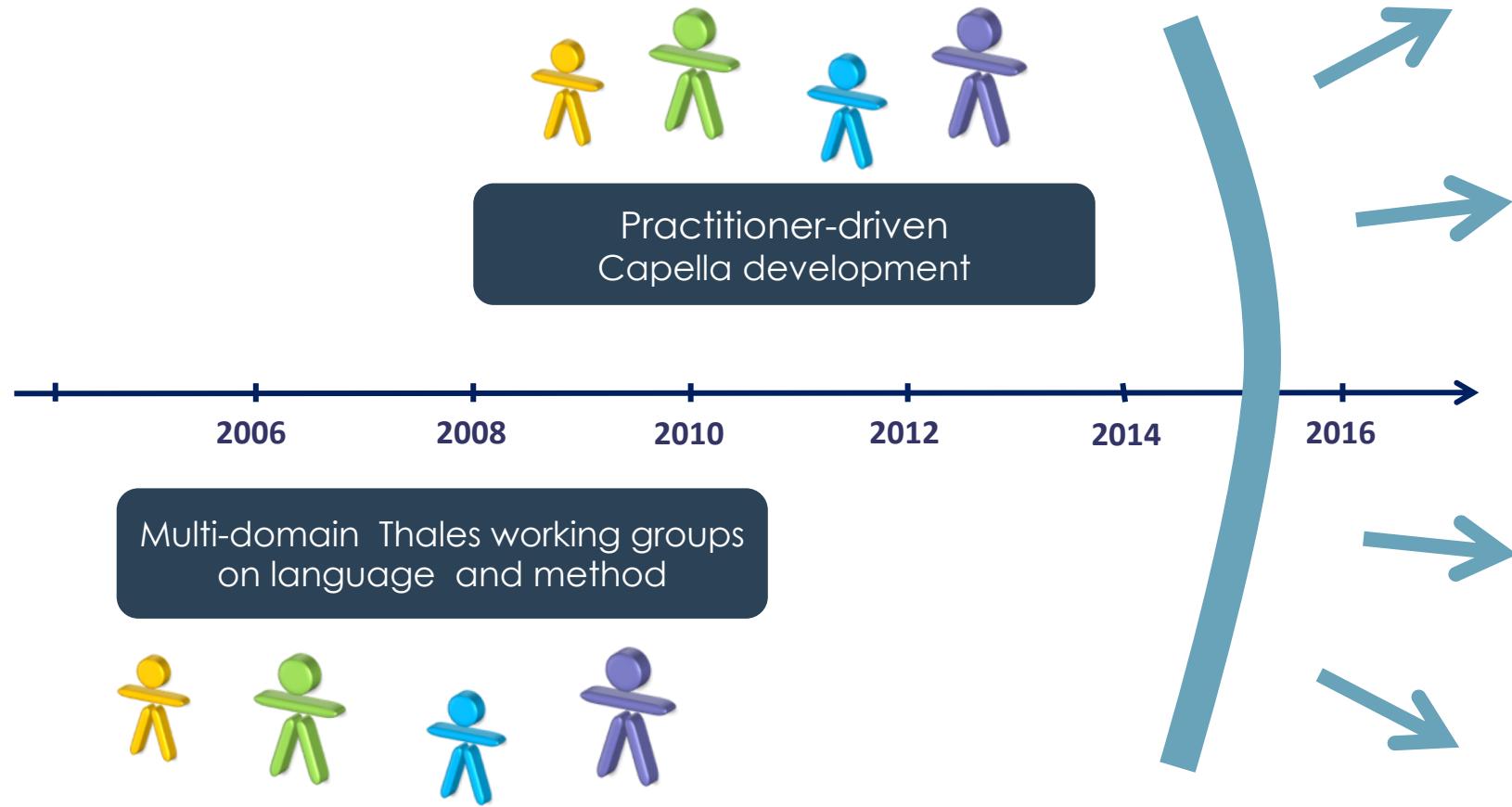


METHOD STEPS	TASKS	SAMPLE MODEL	CONCEPTS	DESCRIPTION MEANS
Customer Operational Need Analysis <small>What the users of the system need to accomplish</small>	<ul style="list-style-type: none"> ✓ Define operational capabilities ✓ Perform an operational need analysis 		<ul style="list-style-type: none"> - Operational capabilities - Actors, operational entities - Actor activities - Interactions between activities & actors - Information used in activities & interactions - Operational processes chaining activities - Scenarios for dynamic behaviour 	
System/ SW/HW Need Analysis <small>What the system has to accomplish for the Users</small>	<ul style="list-style-type: none"> ✓ Perform a capability trade-off analysis ✓ Perform a functional and non-functional analysis ✓ Formalise and consolidate requirements 		<ul style="list-style-type: none"> - 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 	
Logical Architecture Design <small>How the system will work so as to fulfill expectations</small>	<ul style="list-style-type: none"> ✓ Define architecture drivers and viewpoints ✓ Build candidate architectural breakdowns in components ✓ Select best compromise architecture 		<p>SAME CONCEPTS, PLUS :</p> <ul style="list-style-type: none"> - Components - Component ports and interfaces - Exchanges between components - Function allocation to components - Component Interface Justification by functional exchanges allocation 	
Physical Architecture Design <small>How the system will be developed & built</small>	<ul style="list-style-type: none"> ✓ Define architectural patterns ✓ Consider reuse of existing assets design a physical ✓ Design a physical reference architecture ✓ Validate and check it 		<p>SAME CONCEPTS, PLUS :</p> <ul style="list-style-type: none"> - Behavioural components refining logical ones, and implementing functional behaviour - Implementation components supplying resources for behavioural components - Physical links between implementation components 	
Development Contracts <small>What is expected from each designer/ sub-contractor</small>	<ul style="list-style-type: none"> ✓ Define a components IVVQ strategy ✓ Define & enforce a PBS and component integration contract 		<ul style="list-style-type: none"> - Configuration items tree - Parts numbers, quantities - Development contract (expected behaviour, interfaces, scenarios, resource consumption, non-functional properties...) 	

METHOD STEPS	TASKS	SAMPLE MODEL	CONCEPTS	DESCRIPTION MEANS
Customer Operational Need Analysis What the users of the system need to accomplish	<ul style="list-style-type: none"> ✓ Define operational capabilities ✓ Perform an operational need analysis 		<ul style="list-style-type: none"> - Operational capabilities - Actors, operational entities - Actor activities - Interactions between activities & actors - Information used in activities & exchanged between them - Operational processes - Functionalities & dynamic behaviour 	 Dataflow; functions, op. activities interactions & exchanges
System/ SW/HW Need Analysis What the system has to accomplish for the Users	<ul style="list-style-type: none"> ✓ Perform a capability trade-off analysis ✓ Perform a functional and non-functional analysis ✓ Formalise and consolidate requirements 		<ul style="list-style-type: none"> - Functions or system & actors - Dataflow exchanges between functions - Functional chains traversing dataflow - Information used in functions & exchanges, data model - Scenarios for dynamic behaviour - Modes & states 	 Scenarios: actors, system, components interactions & exchanges
Logical Architecture Design How the system will work so as to fulfill expectations	<ul style="list-style-type: none"> ✓ Define architecture drivers and viewpoints ✓ Build candidate architectural breakdowns in components ✓ Select best compromise architecture 		<p>SAME CONCEPTS, PLUS :</p> <ul style="list-style-type: none"> - Components - Component ports and interfaces - Exchanges between components - Function allocation to components - Component Interface Justification by functional exchanges allocation 	 Functional chains, operational processes through functions & op. activities
Physical Architecture Design How the system will be developed & built	<ul style="list-style-type: none"> ✓ Define architectural patterns ✓ Consider reuse of existing assets design a physical ✓ Design a physical reference architecture ✓ Validate and check it 		<p>SAME CONCEPTS, PLUS :</p> <ul style="list-style-type: none"> - Behavioural components refining logical ones and implementing functional behaviour - Implementation components supplying resources for behavioural components - Physical links between implementation components 	 Modes & states of actors, system, components
Development Contracts What is expected from each designer/ sub-contractor	<ul style="list-style-type: none"> ✓ Define a components IVVQ strategy ✓ Define & enforce a PBS and component integration contract 		<ul style="list-style-type: none"> - Configuration items tree - Parts numbers, quantities - Development contract (expected behaviour, interfaces, scenarios, resource consumption, non-functional properties...) 	 Component wiring: all kinds of components

NEED SOLUTION

A practitioner-driven journey started in Thales...



... and now continuing beyond

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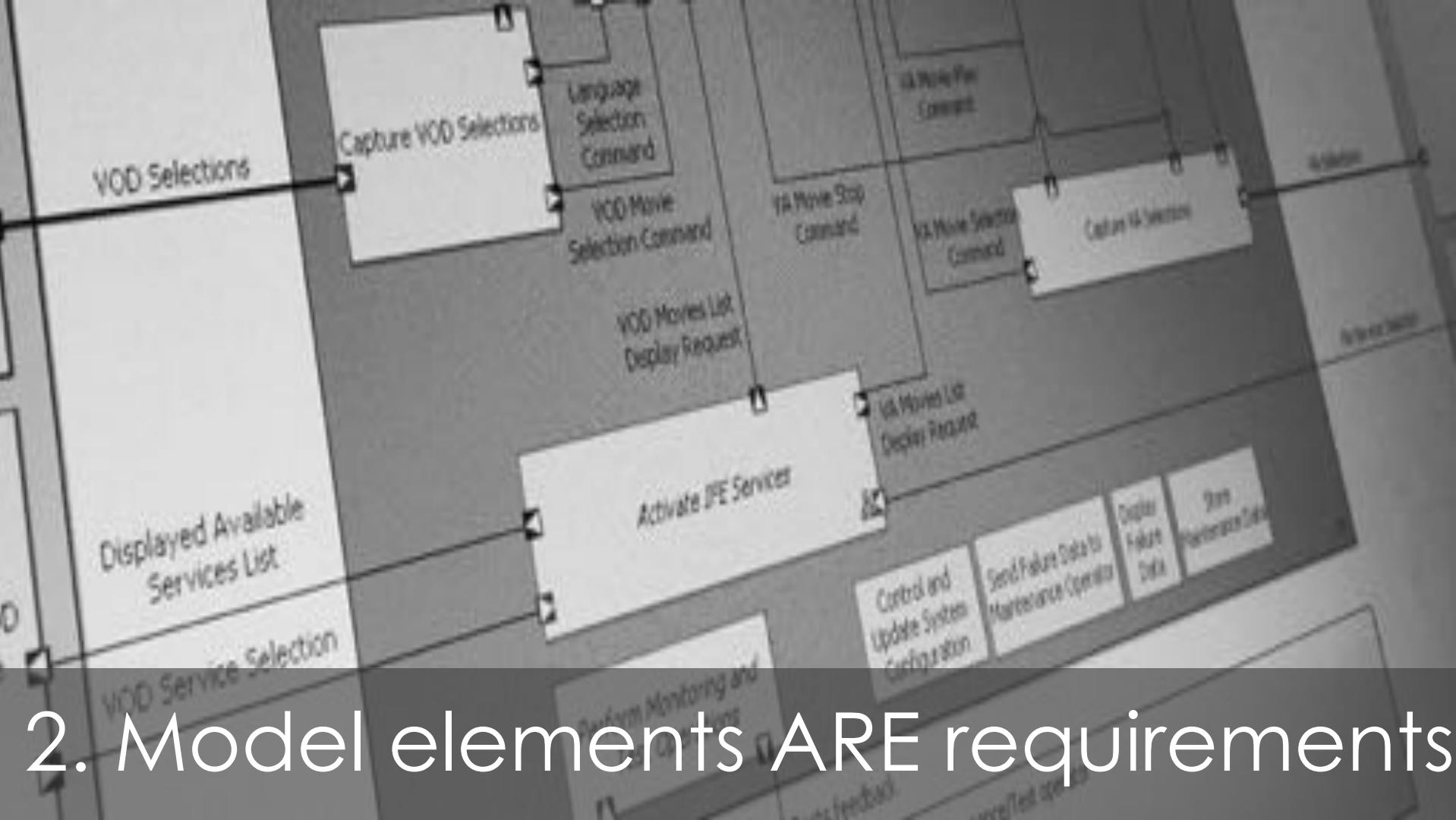
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2. Model elements ARE requirements

Need model

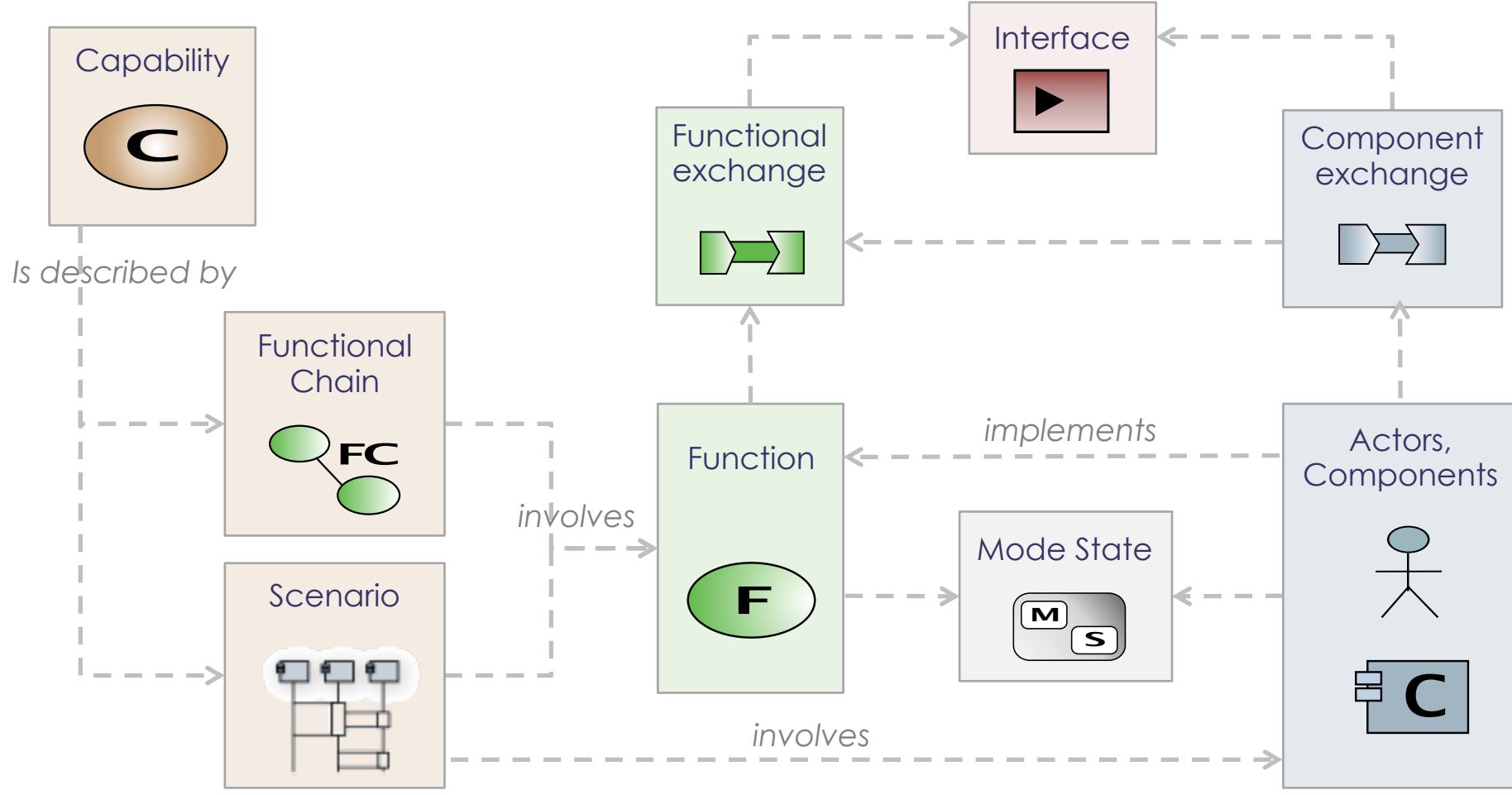
helps formalize and
consolidate
customer and
system requirements

Textual requirements

are at the heart of
the current
engineering
practices

Solution model

helps validate
feasibility,
elicit/justify new
requirements for the
system/subsystems

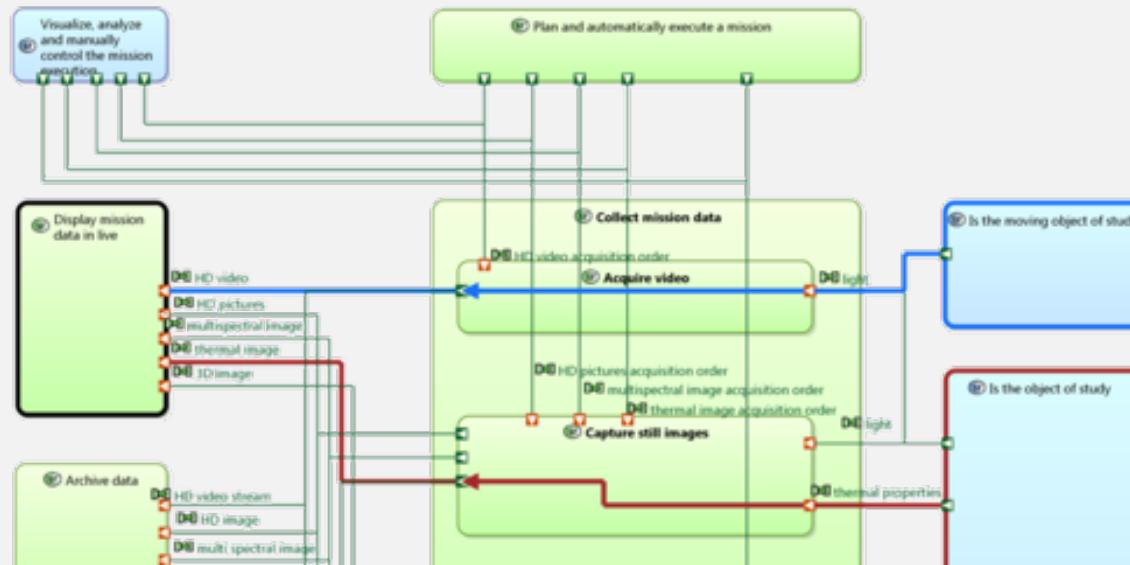


C

Visualize data in live during flight



- Display acquired HD video in live ■
- Display multi-spectral image in live
- Display thermal image in live ■
- Visualize all collected mission data
- Visualize substance level in live

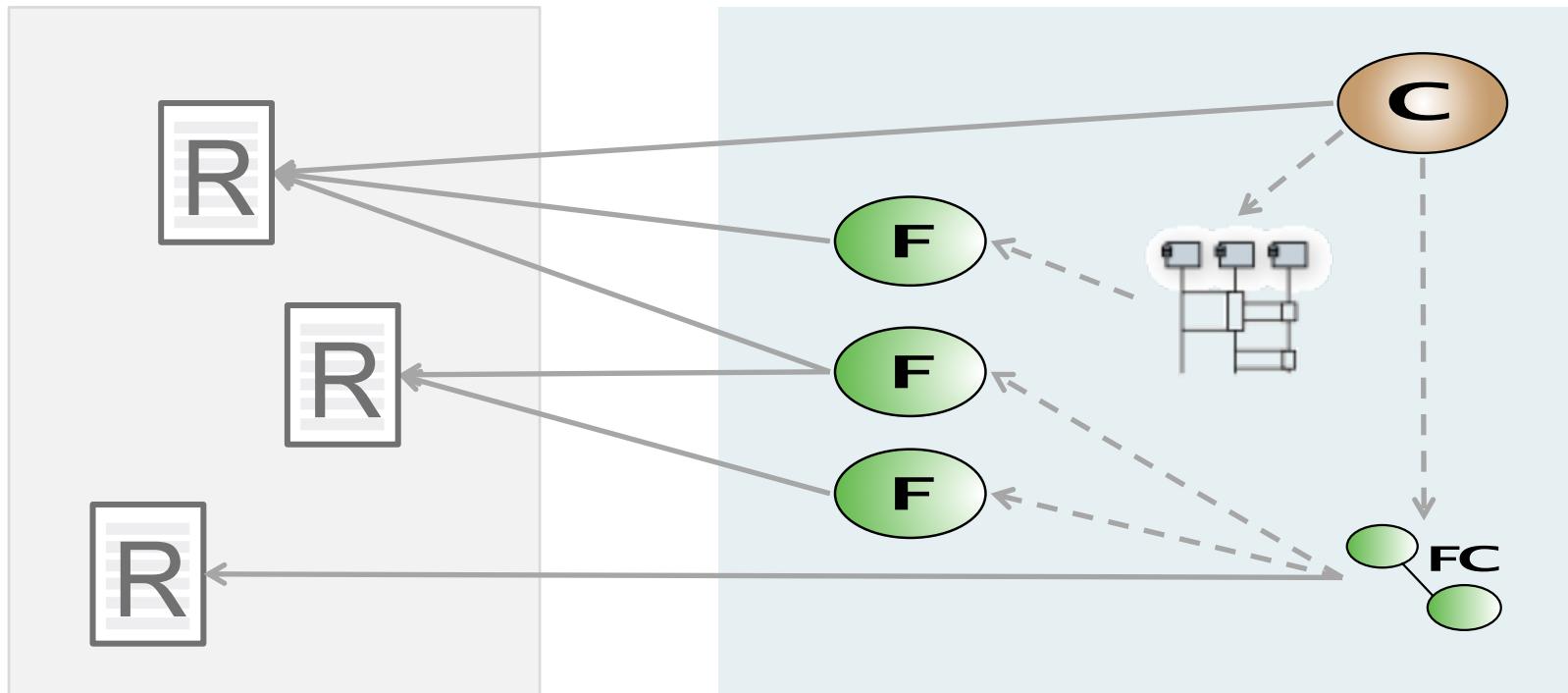


Models add rigor to need expression / solution description

Models enable automated processing

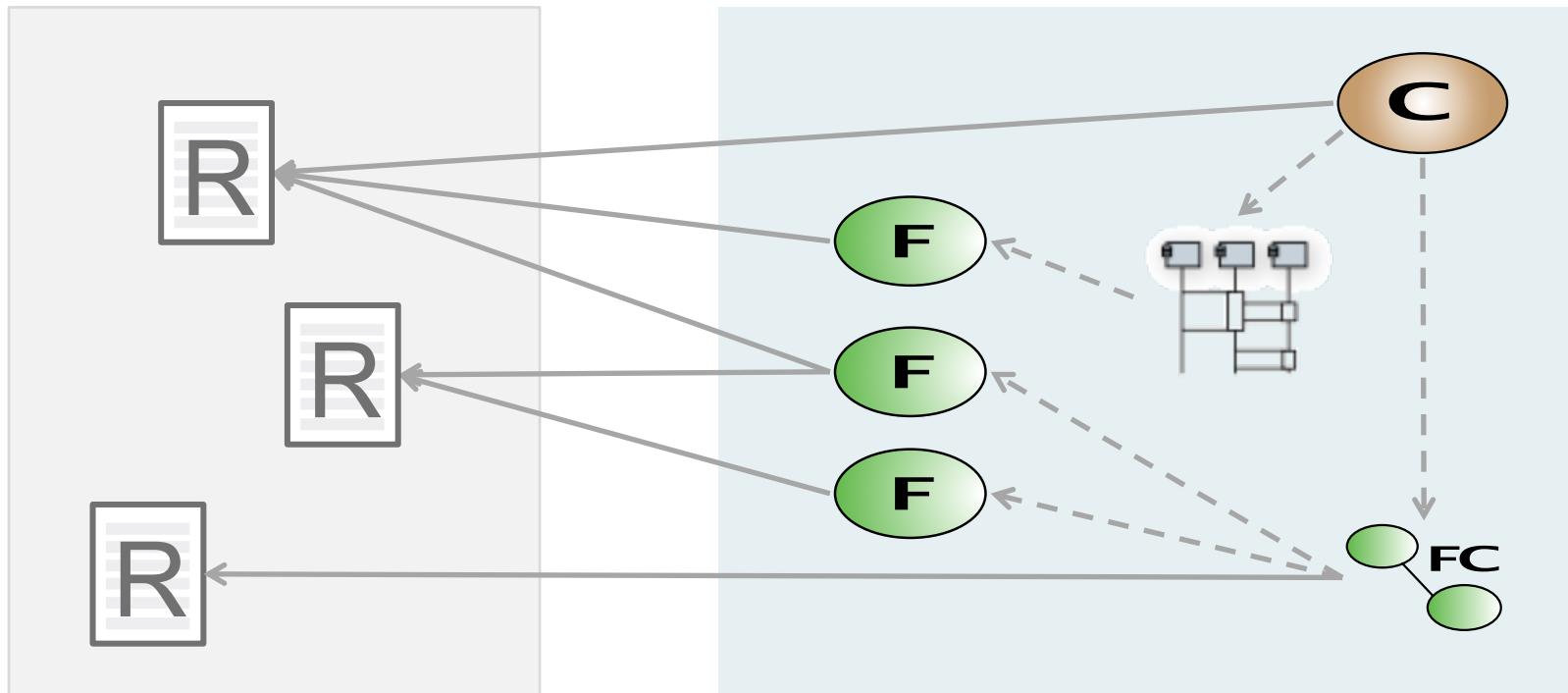
Requirements

Model elements

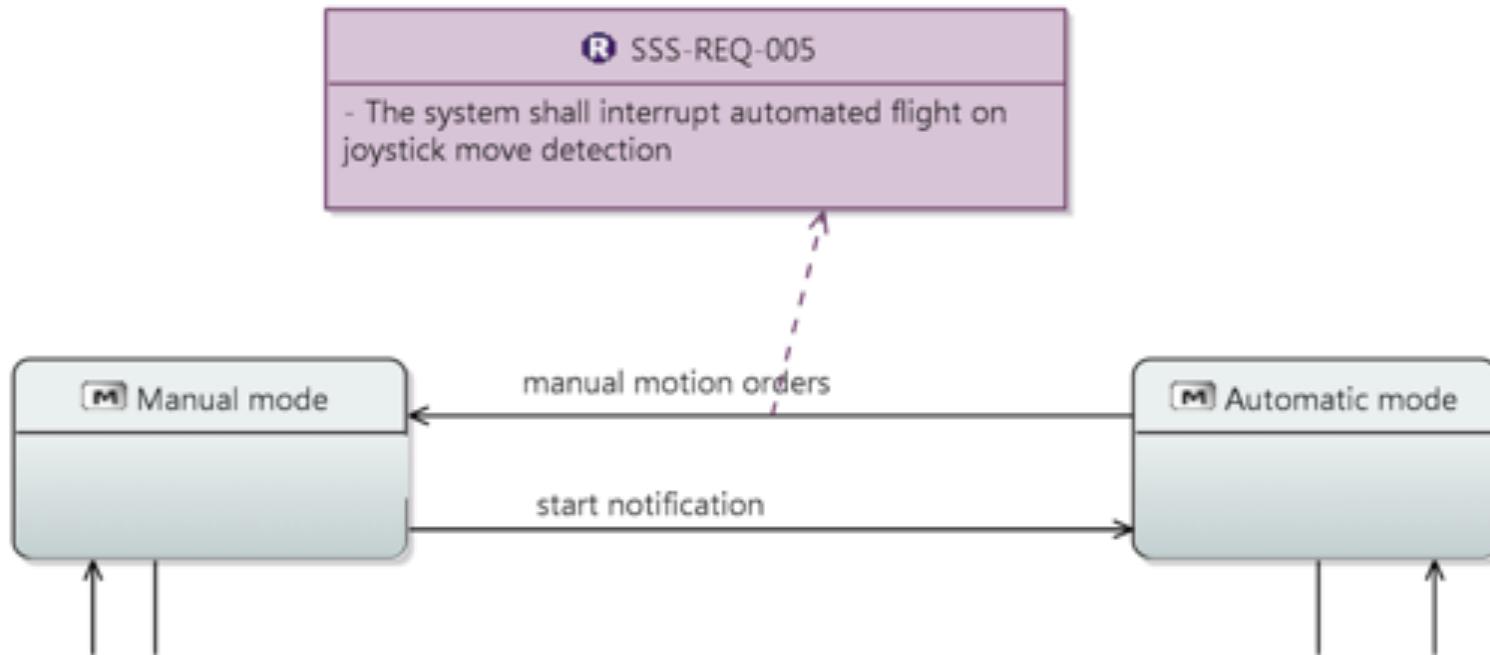


Textual Requirements

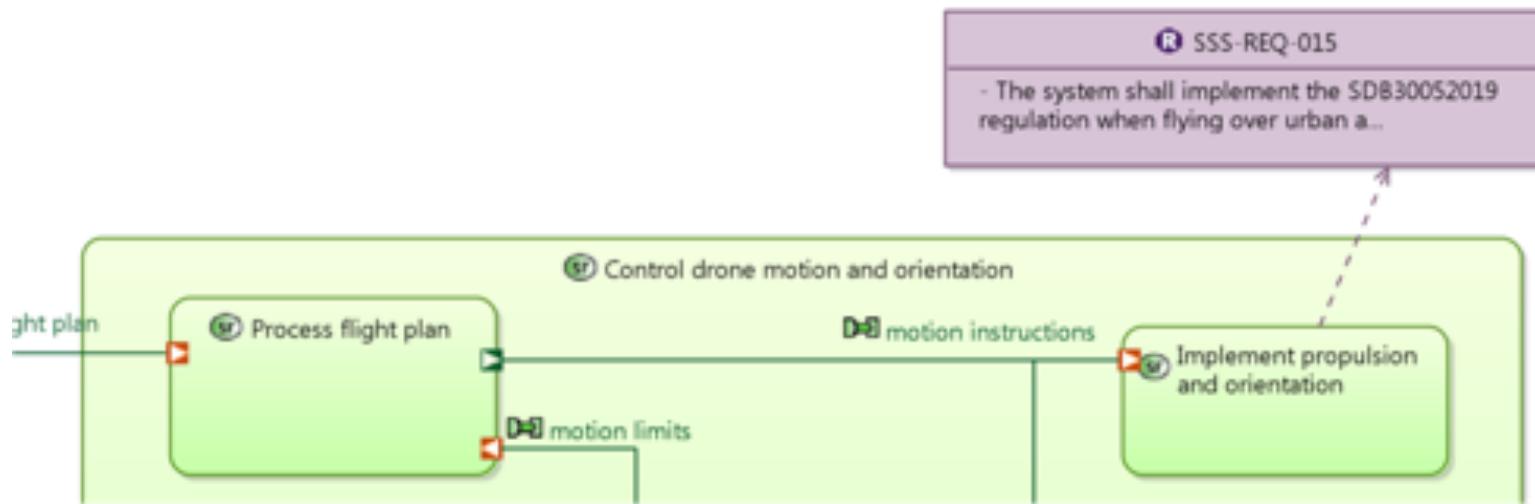
Model elements Requirements



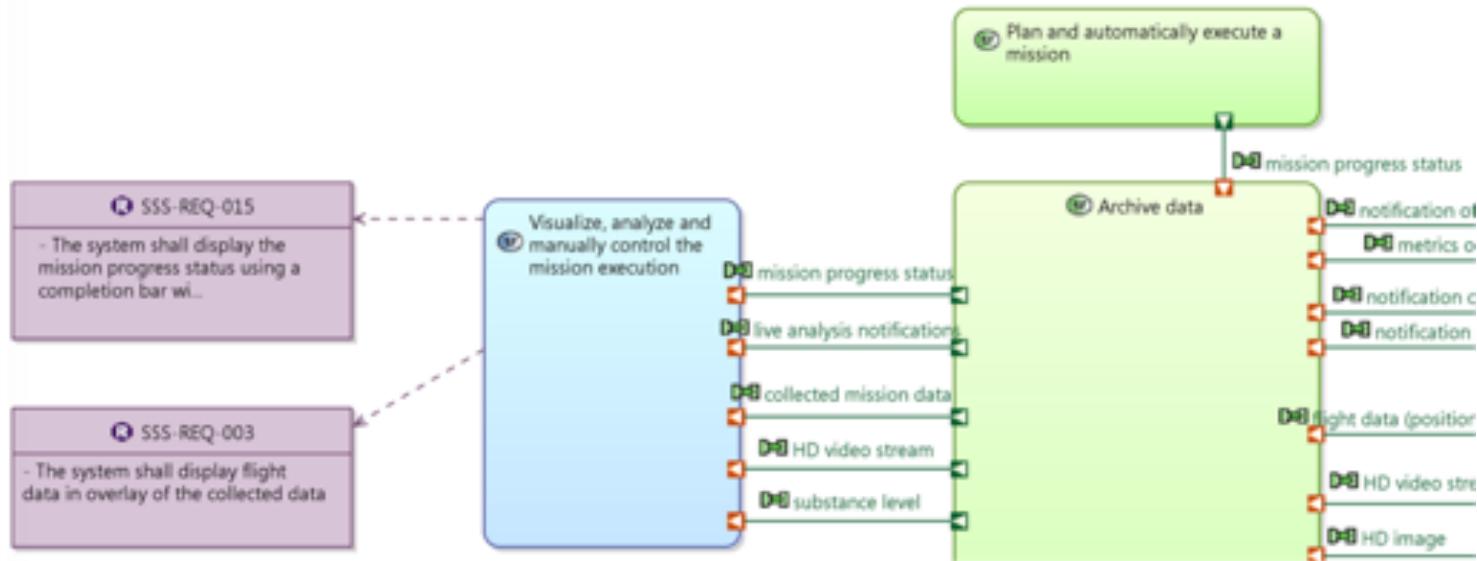
A model requirement can formalize a textual requirement
and explicit its effects and ramifications



Some expectations (environmental, regulations, etc.)
are easier to express with textual descriptions.



Some expectations on a model element at a given engineering level do not require a formal modeling (which is left to subsystem design)





Tooling support

Coupling models and textual requirements

RAT (The Reuse Company) authoring in Capella

The screenshot shows the Capella tool interface with the following details:

- Title Bar:** RAT (The Reuse Company) authoring in Capella
- Menu Bar:** File, Edit, Design, Navigate, Dash, Project, Run, Help, Window, Help
- Project Explorer:** Shows the "Capella Project Explorer" with nodes like "In-Flight Entertainment System", "System Requirements", and "System Functions".
- Central View:** Displays a UML-like diagram titled "TMC01 Capabilities Center". It includes actors "User" and "User Crew", a central node "Provide Video Streaming Services", and a boundary object "Provide Audio and Video Intercommunication Needs". A requirement "The Aircraft shall provide video streaming services" is associated with the central node.
- Toolbars:** Standard Capella toolbars for selection, creation, and modification.
- Right Panel:** Shows a tree view of "Elements" including "Actor", "Boundary", "Capability", "Requirement", "Interface", "Data", "System Context", "System", "Actor", and "Message".
- Bottom Panel:** A floating window titled "RAT Plugin for Capella" with tabs "New - Requirements Authoring Tool", "Edit - Suggestion", "View - Log", and "Help". It displays the message "Authoring with pattern 'StarNode/Functional Requirement'".
- Bottom Left Panel:** "Requirements SP" view showing a list of requirements.
- Bottom Right Panel:** "Connectness metric summary" table with a green checkmark icon.

Capella in Siemens TeamCenter via Obeo SMW

The screenshot displays two windows from the Siemens TeamCenter interface.

Left Window: A Capella model diagram titled "PML/Passenger Video Playing". The diagram shows a system architecture with components: PML Server, PML Provider, PML PRO Decoule, and PML PRO Decoule. The PML Server component contains a state "Display video in flight". The PML Provider component contains states "Display interrupted VOD Movie" and "Display and Buffer Video Packets". The PML PRO Decoule component contains a state "Display video Movie". Interactions include "Request" from PML Server to PML Provider, "Display video in flight" from PML Server to PML PRO Decoule, "Display interrupted VOD Movie" from PML Provider to PML PRO Decoule, and "Display and Buffer Video Packets" from PML Provider to PML PRO Decoule.

Right Window: An "Active Workpage" titled "Passenger can watch movies during the flight". The workpage includes tabs for Architecture, Documentation, Overview (selected), Parameters, and Diagrams. The Overview tab displays the requirement ID RQ00004, Revision A, and Revision Name "After an interruption, movie resumes". The Description section provides the following details:

- Element Name: RQ00004
- Description: In the case of an interruption (paused movie, movie interruption, ...), the movie will resume where it was interrupted.
- Details:
 - Passenger can watch movies during the flight
 - After an interruption, movie resumes
 - Movie resumes



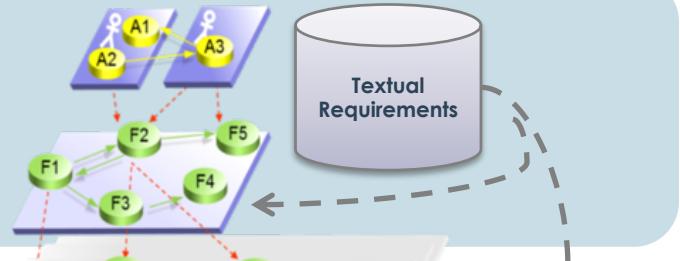
Certain model elements can
be considered as requirements



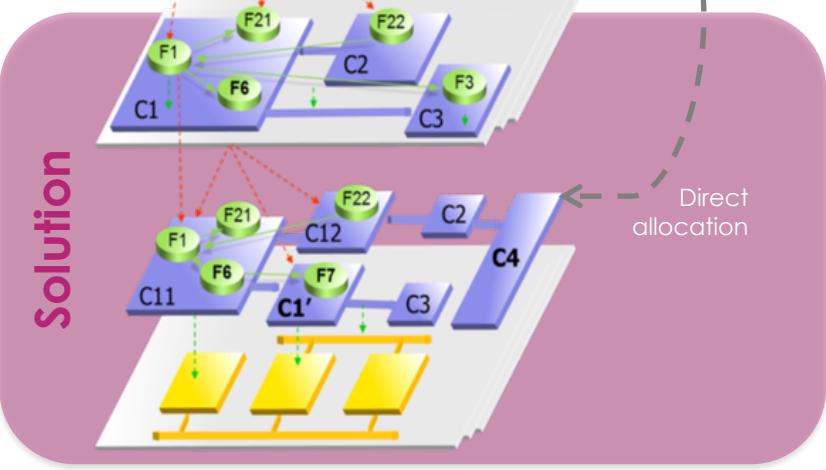
3. Contracts between
engineering levels: workflow

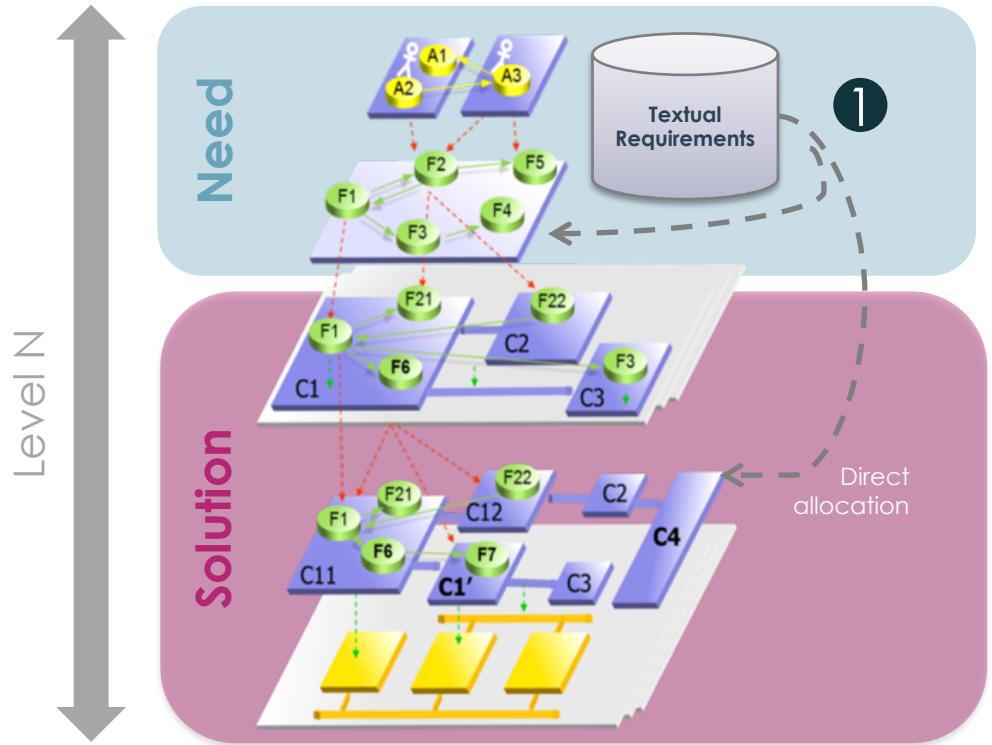
Level N

Need

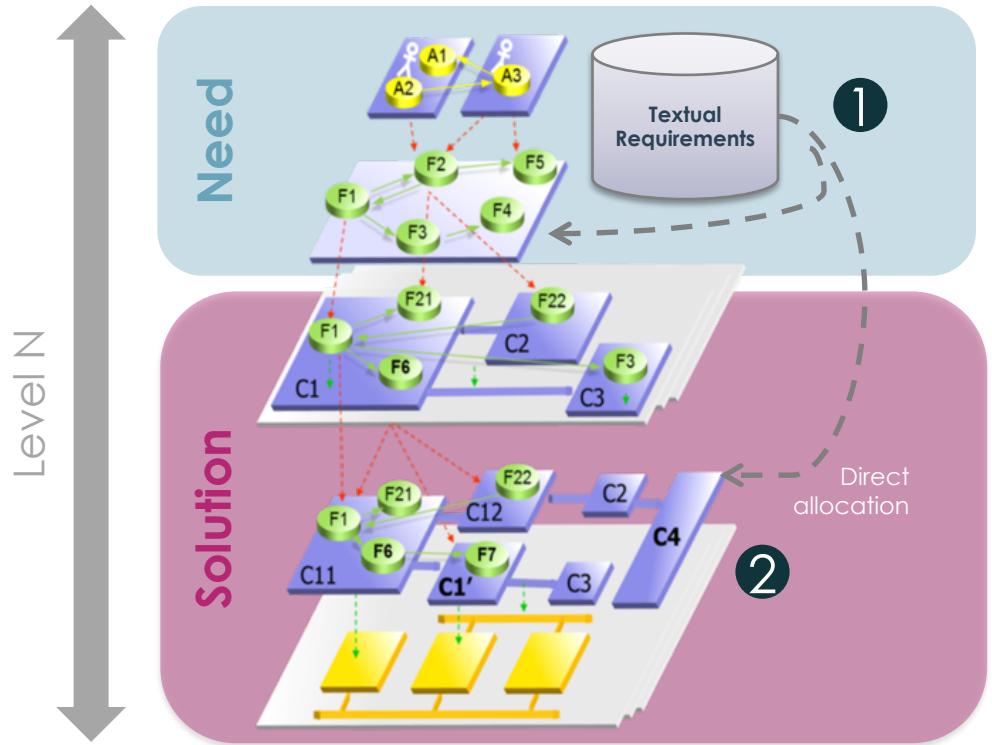


Solution





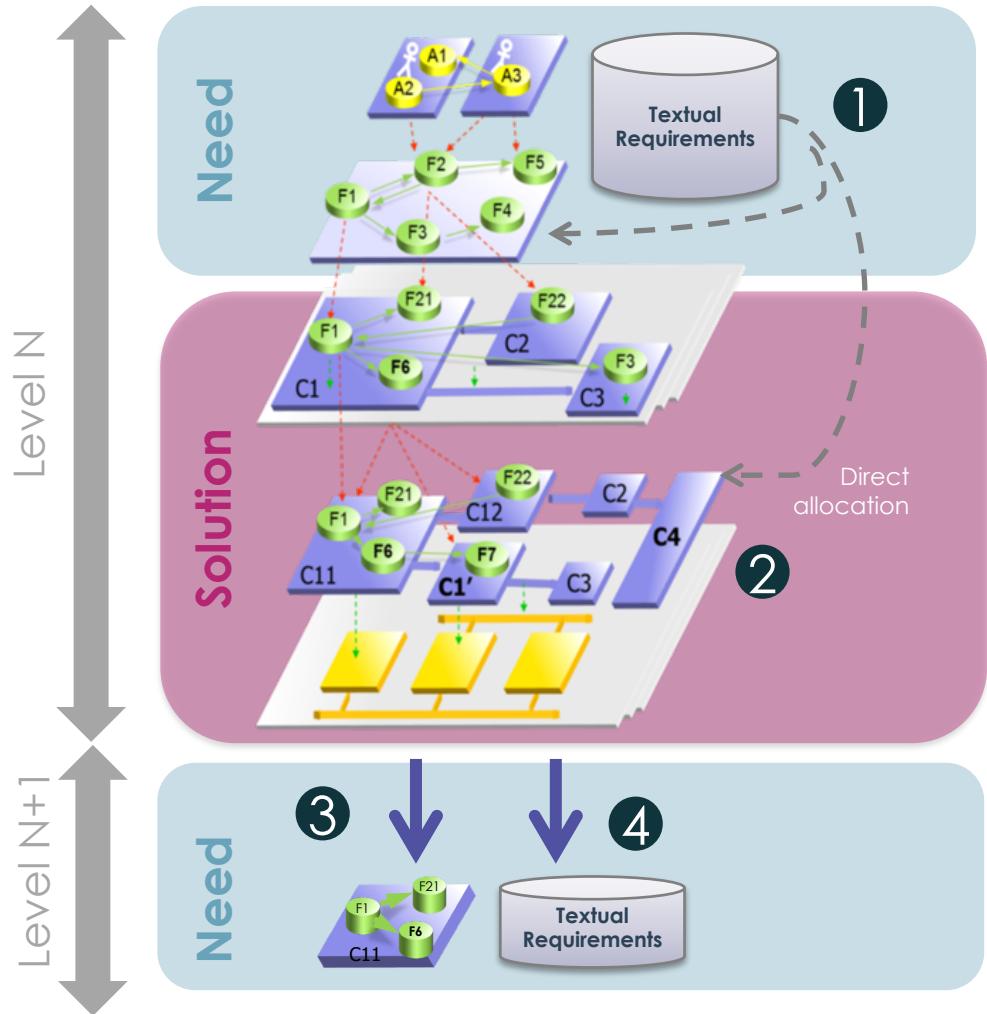
1. Elicitation of model and textual requirements on the system



2.

Architecture description specifies with the adequate level of detail how the system works and what is expected from each constituent

The goal here is to prepare the contracts for all subsystems and guarantee their proper integration.



3.

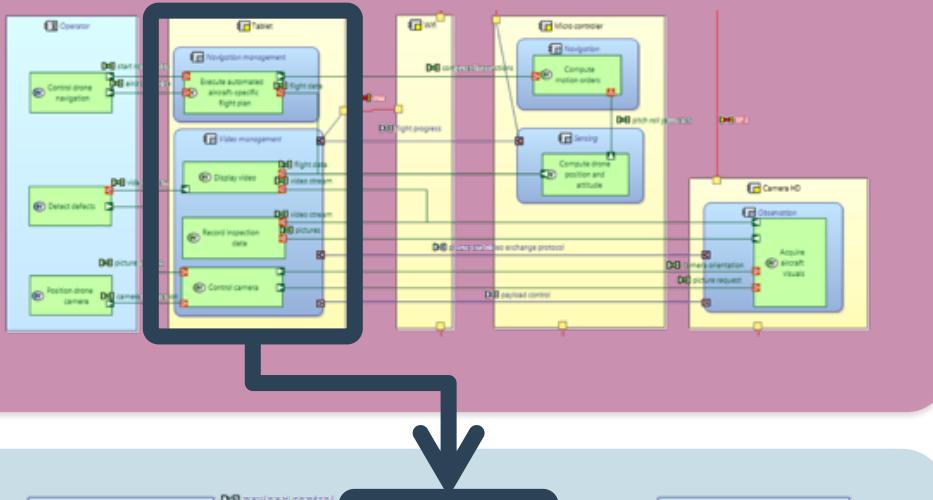
The context of a given system constituent is entirely computed (anything contributing to the definition of this constituent including allocated Functions, interfacing Components, etc.)

4.

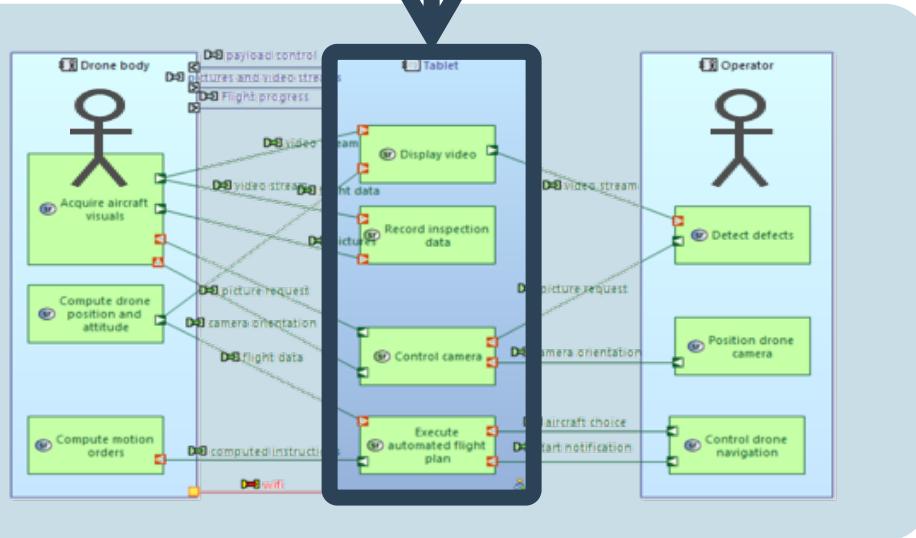
Textual requirements are created when needed, in addition to the model requirements: legal, non-functional, additional specification of internal expected behaviour

3

Tablet is a constituent of a drone-based system



Tablet is the (sub)system of interest





Model-based workflow favors co-engineering over the traditional differentiation between “customer” requirements and “system” requirements

4. (Happy) consequences on V&V and incremental development strategy



ATR 42/72 aircraft.
part technology in Integrated Modular Avionics (IMA)
aircraft mission.

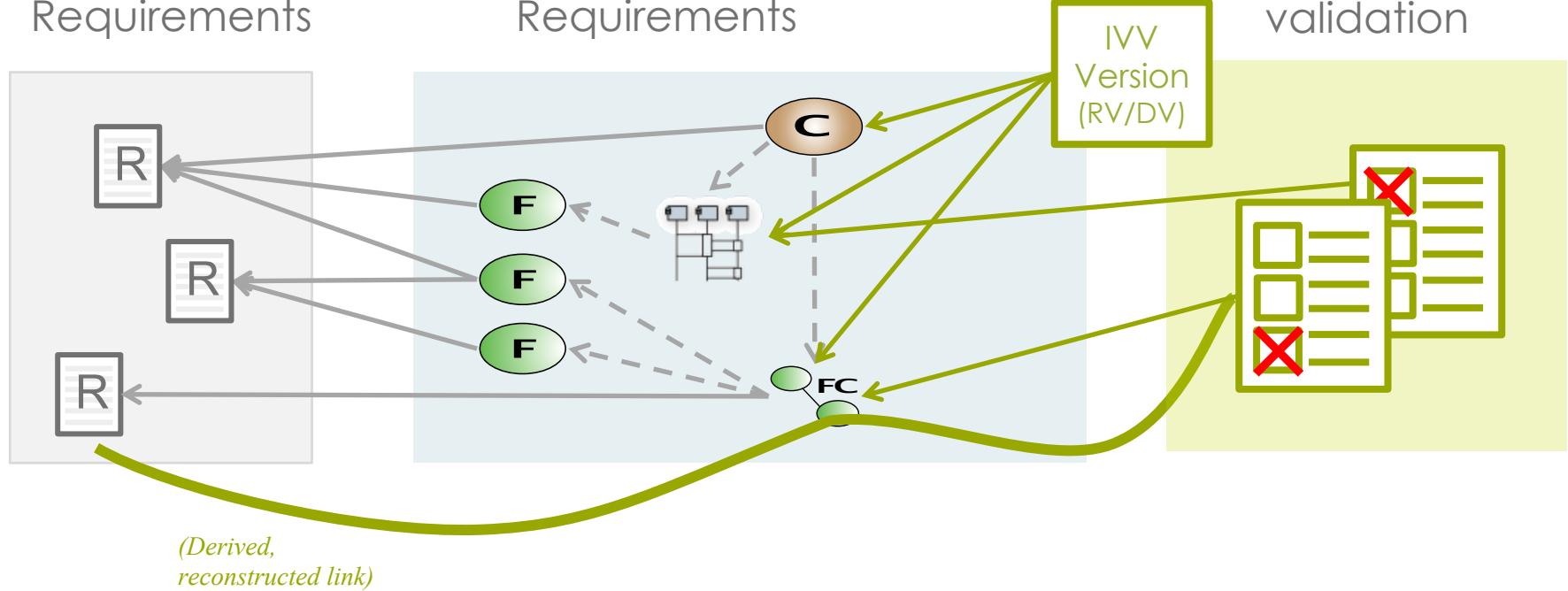
About ATR:

- The Turboprop with the latest technological advancements
- An up-to-date regional aircraft offering the same performance as a larger aircraft with reduced fuel consumption, reduced noise and reduced maintenance costs.

Textual Requirements

Model Requirements

Verification and validation



C

Visualize data in live during flight



Display acquired HD video in live



Display multi-spectral image in live



Display thermal image in live



Visualize all collected mission data

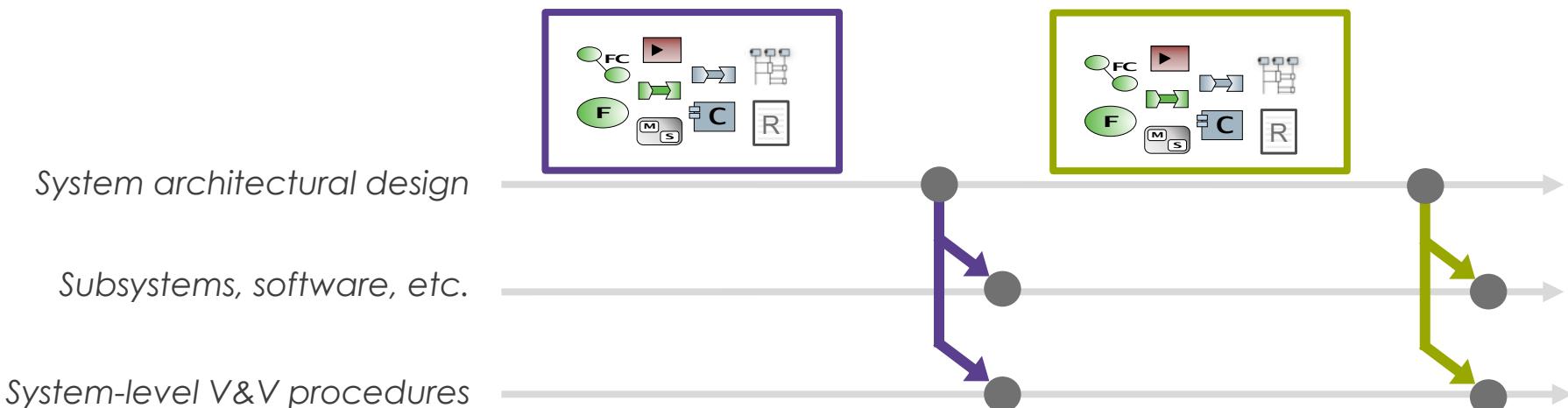


Visualize substance level in live



Definition of increments with expected functional chains (user stories)

Vertical slices of architectural design across need and solution models

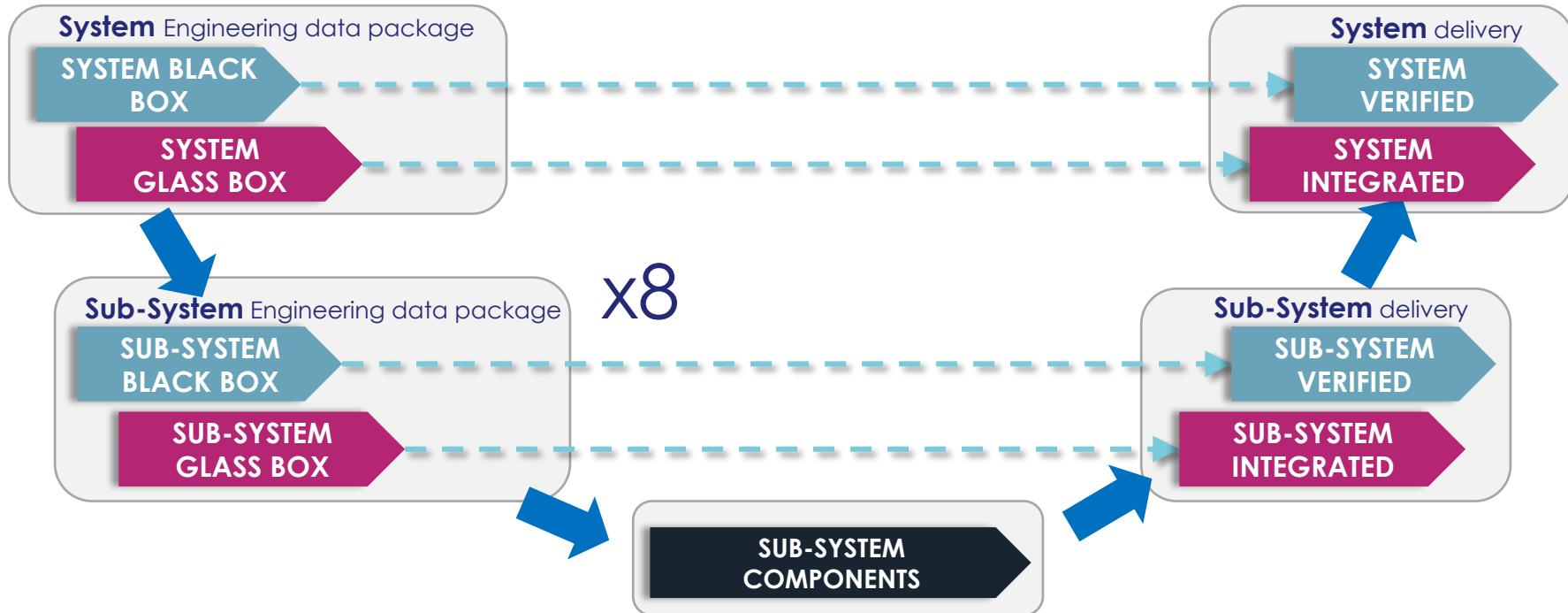




5. Instanciated workflow

Two years, 30 persons

Classic scheme, rolled out by increments



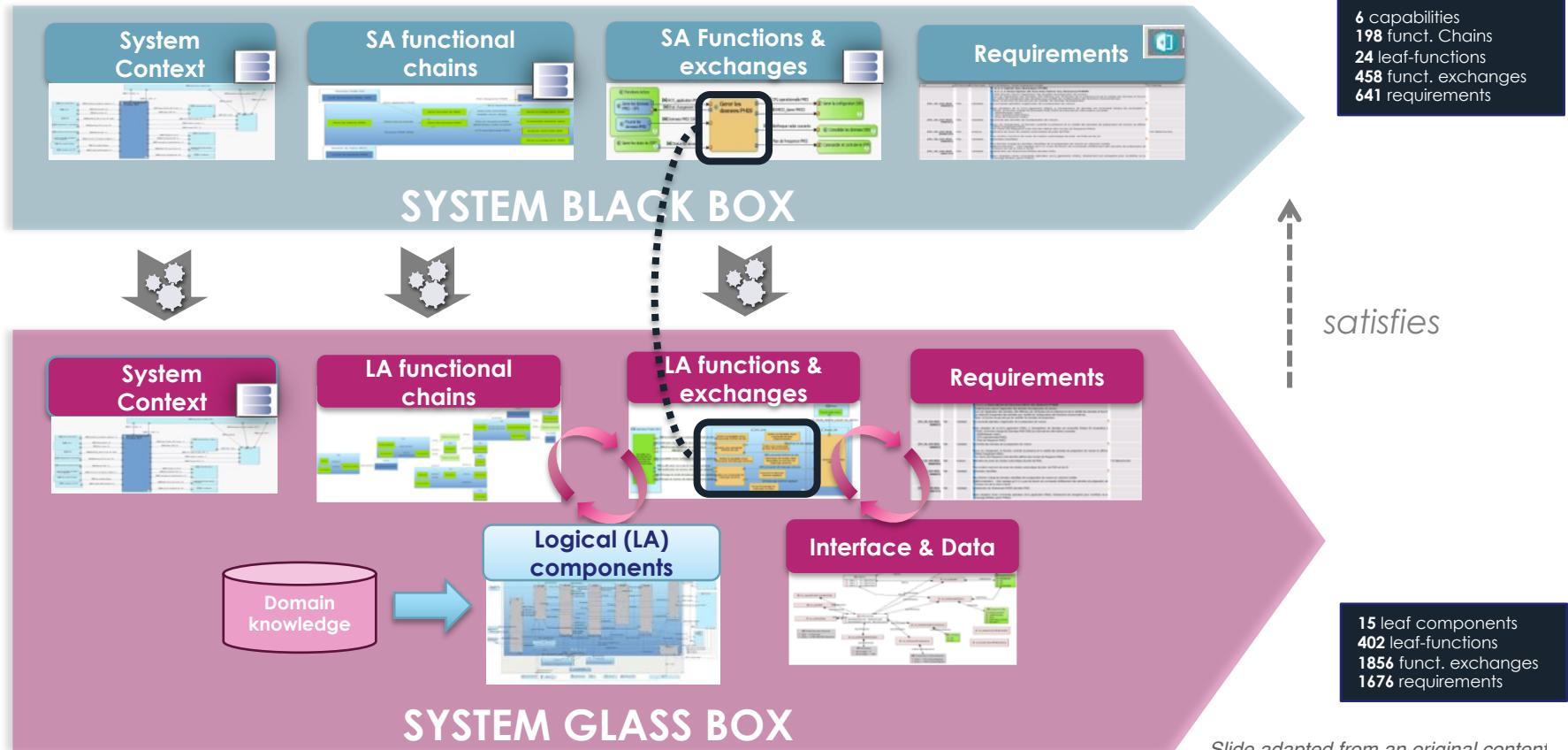
Slide adapted from an original content
created by the project team

Identical pattern at all levels

The diagram illustrates a top-down flow of requirements management:

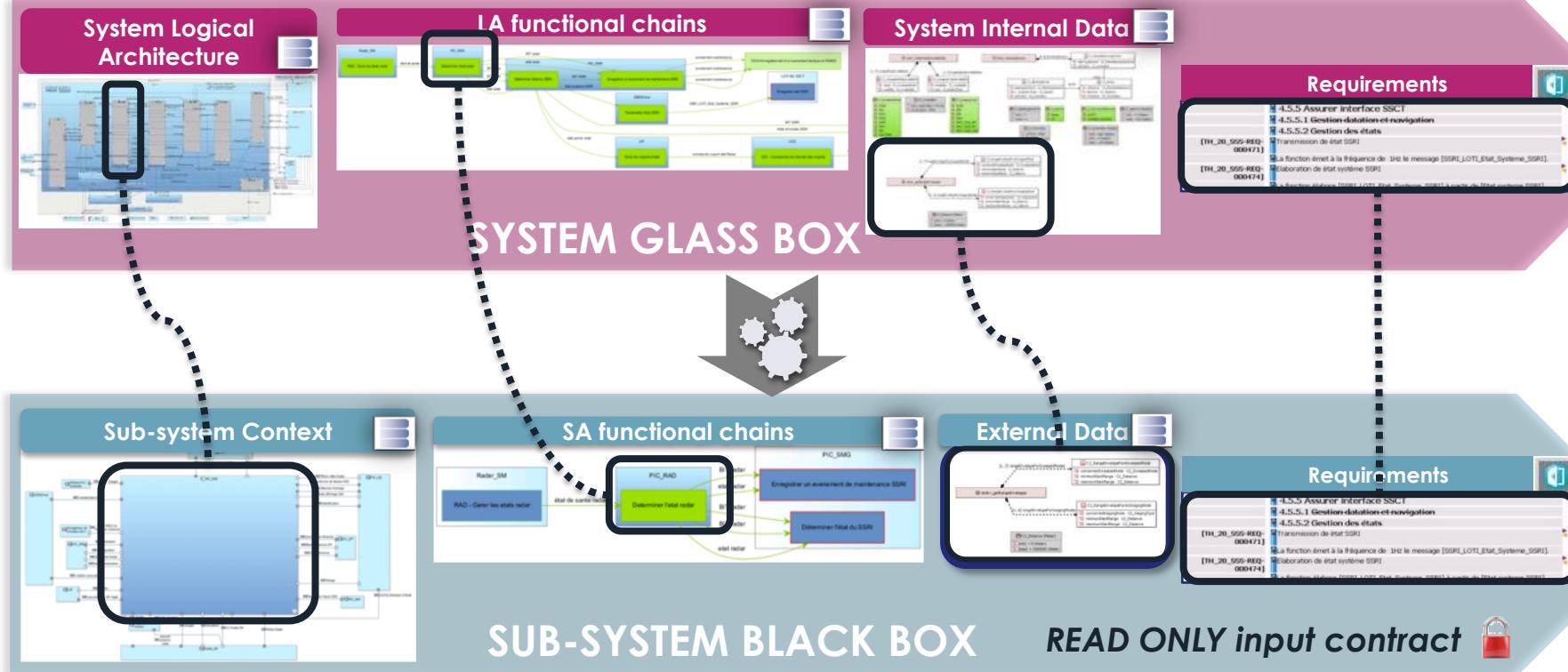
- Functional Chains list**: Shows a list of functional chains, such as "CF-SMG-020 - Déterminer et lancer l'état du système" and "CF-SMG-0201 - Alerter l'opérateur d'une panne de liaison SSR1-SSCT".
- Functional Chains release definition**: Shows the release definition for ATLL2 - SSR1, detailing components like SSR1_V1, SSR1_V2, SSR1_V3, and SSR1_V4, and their dependencies.
- Functional chain**: A detailed view of a functional chain, showing its internal logic and interactions with other components.
- Requirements**: A list of requirements, such as "4.5.1 Gestion datation et navigation" and "4.5.2 Gestion des états", each associated with specific tasks and messages.
- IVV Test Suite Repository**: A repository interface for managing test cases, showing campaigns like "JHS_JCC_ARO_200" and "JHS_JCC_ARO_200" across various phases.

Slide adapted from an original content created by the project team



Slide adapted from an original content
created by the project team

Automated transitions



System verification: enhanced progress monitoring

Content removed

Test results: models facilitate analyses

Content removed



Tooling support

Managing increments with Capella

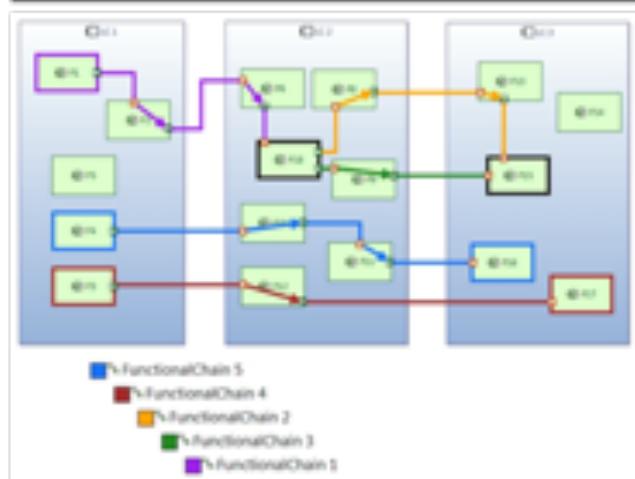


Associate functional chains to increments

Compute, visualize and compare the footprints
in terms of expected components and functions

Focus on the dedicated tooling

Global architecture



RV 1 expected content

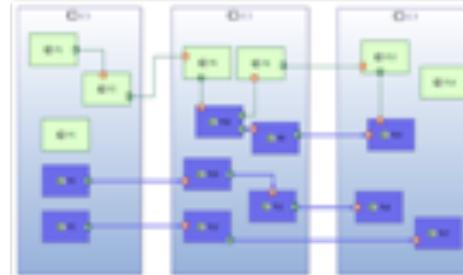
[[Requested Version] RV 1

Elements

To add an element to this version, drag it from the palette on the right.

Element	Correction
FunctionalChain 3	
FunctionalChain 4	
FunctionalChain 5	

REV 1 footprint



RV 2 expected content

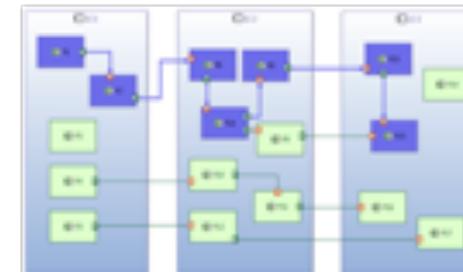
[[Requested Version] RV 2

Elements

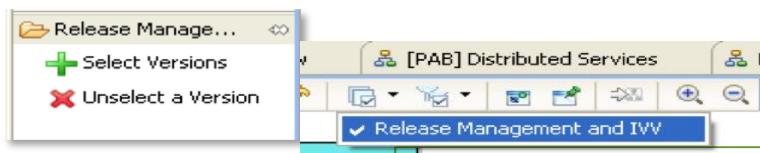
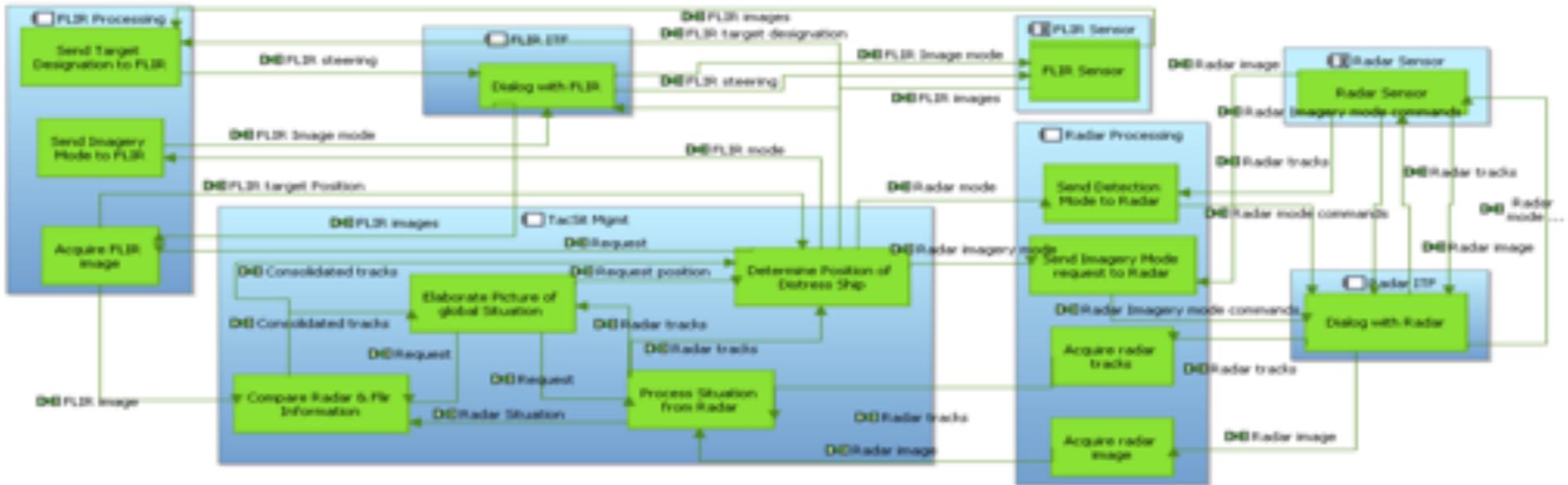
To add an element to this version, drag it from the palette on the right.

Element	Correction
FunctionalChain 1	
FunctionalChain 2	

REV 2 footprint



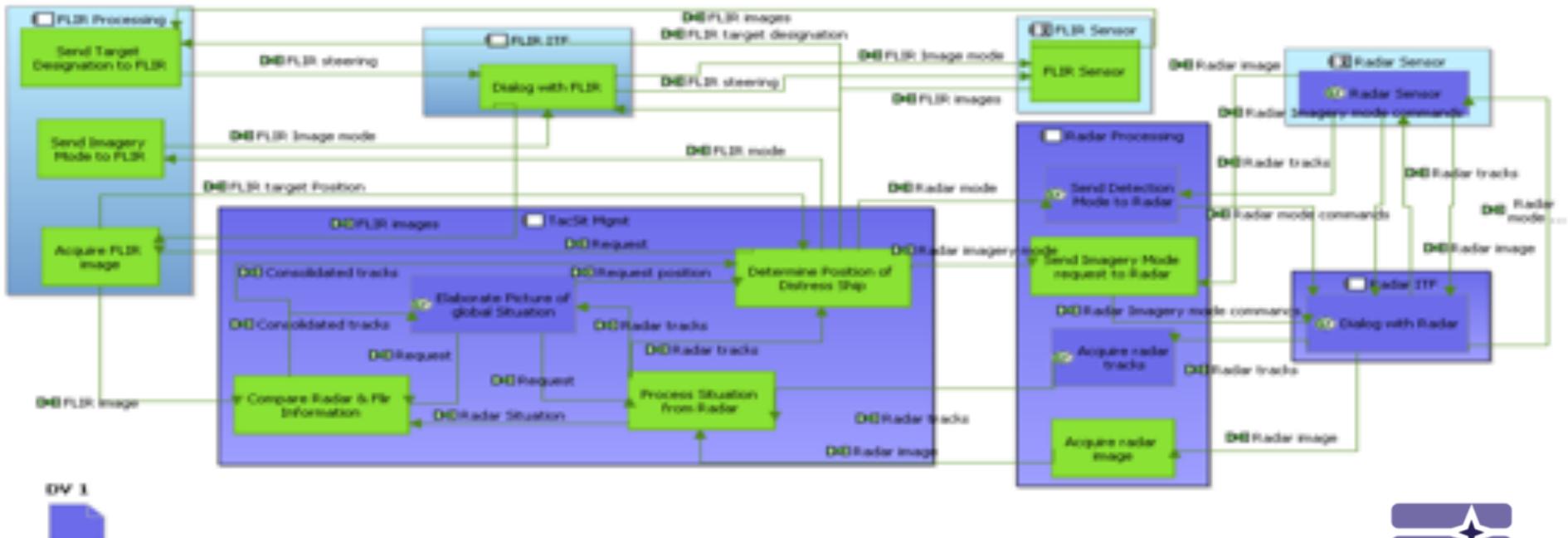
Preview of functional increments footprints



Release management viewpoint: Automated visualization of versions



Preview of functional increments footprints

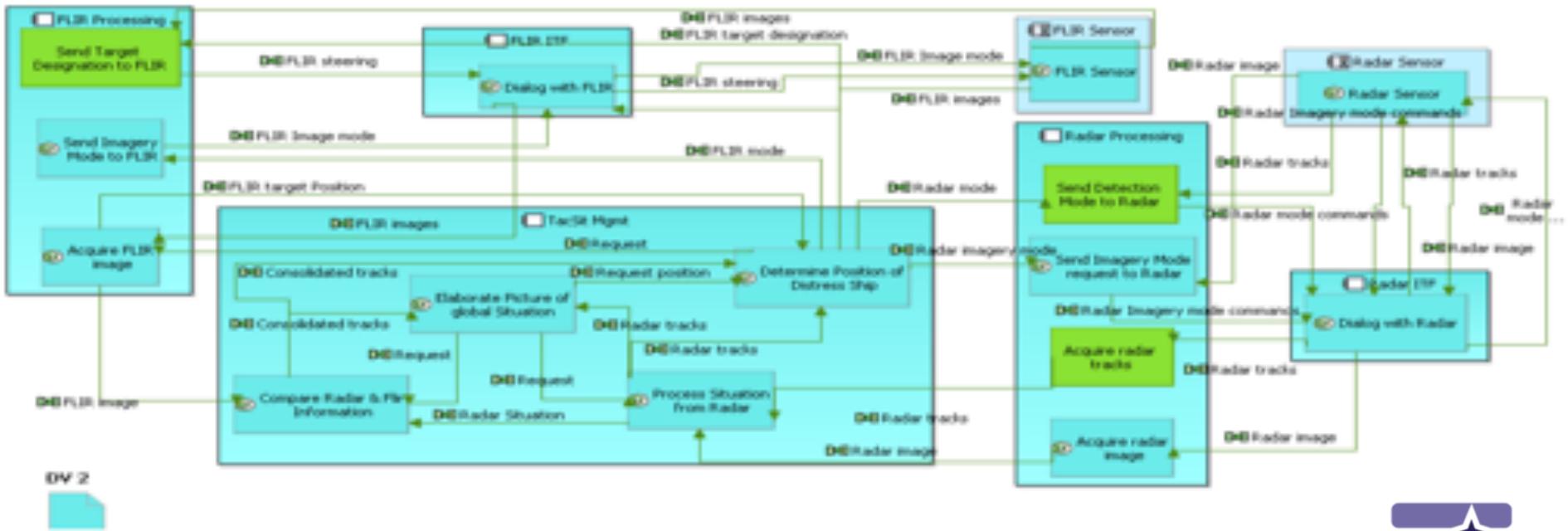


Developed Version 1

Available elements in BLUE



Preview of functional increments footprints

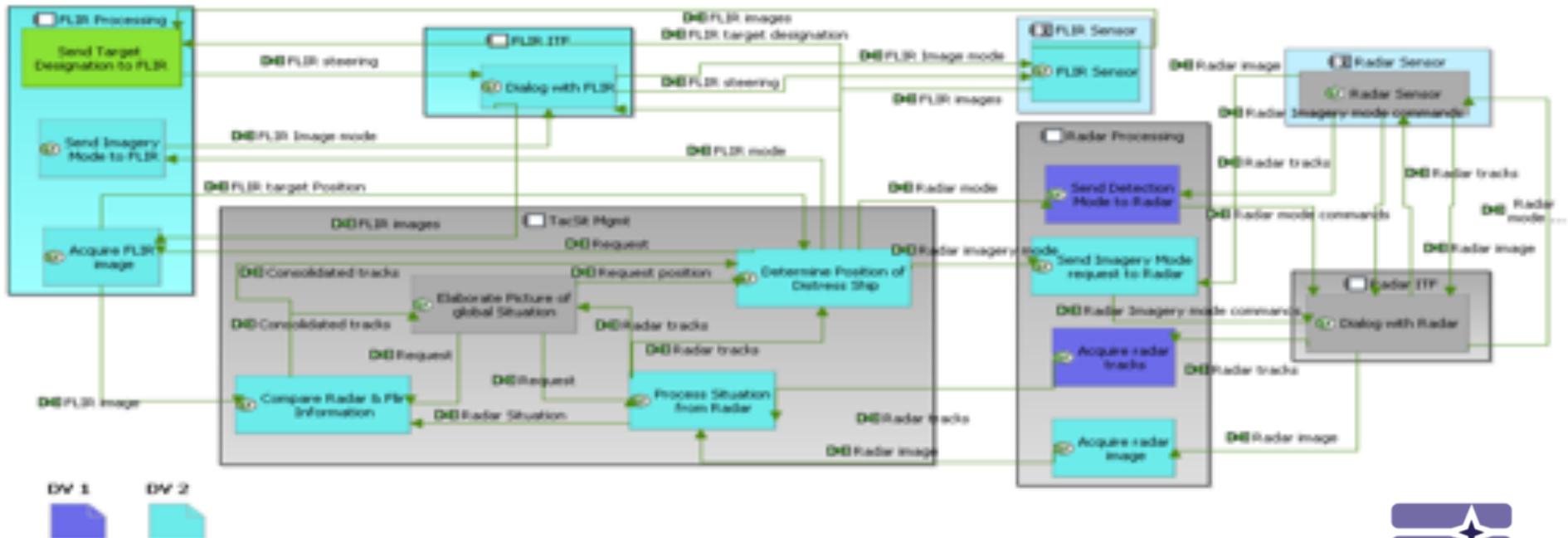


Developed Version 2

Available elements in CYAN



Preview of functional increments footprints



Developed Versions 1 & 2
Common available elements in GREY



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Capella - Capella Modeling Workbench and Arcadia MBSE Method - Click +/- to expand/collapse			
General Information Latest news about Capella	171	65	Mon, 29 October 2018 By: stephanie.lacrampe.obeo.fr ⓘ
Arcadia The Arcadia model-based engineering method	214	50	Wed, 21 November 2018 By: xurenfei.glaway.com ⓘ
Capella workbench Any tool-related question, suggestions, problem, etc	1625	363	Thu, 06 December 2018 By: zhangtonghui.glaway.com ⓘ
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THALES

How is Capella different?

WEBINAR, SEPTEMBER 12th 2017

Stéphane Bonnefond
In charge of Thales Corporate MBSE Coaching & Community
Capella Design Authority

stéphane.bonnefond@thalesgroup.com

www.thalesgroup.com

Webinar - How is Capella different?

Capella Webinars

PolarSys Capella - 1/8

- 1 Capella [Webinar] How is Capella different? PolarSys Capella 51:52
- 2 Capella [Webinar] [Webinar] Thales return on experience: usage of Capella in PolarSys Capella 49:47
- 3 Capella [Webinar] Equivalences and differences between Arcadia/Capella and PolarSys Capella 44:46
- 4 Capella [Webinar] What's new in Capella 1.2? PolarSys Capella 47:24

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Capella website



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to successfully design systems architecture

<https://polarsys.org/capella/index.html>



CapellaDay

MUNICH 2019

bit.ly/CapellaDay2019
Sept. 16th 2019



Thank You! Questions?

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>

www.thalesgroup.com

