www.thalesgroup.com

Model-Based Systems Engineering Backbone of the Thales Engineering Manifesto

MBSE Symposium, Canberra – Oct. 28th, 2014

Olivier Flous, VP Engineering

THALES

Collective intelligence for a safer world

Whenever critical decisions need to be made, Thales has a role to play.
In all its markets — aerospace, space, ground transportation, defence and security — **Thales solutions help customers to make the right decisions at the right time and act accordingly**.

World-class technology, the combined expertise of **65,000 employees** and operations in **56 countries** have made **Thales a key player in keeping the public safe and secure**, guarding vital infrastructure and protecting the national security interests of countries around the globe.

Employees

65,000 (workforce under management at 31 Dec. 2012)

Global presence

56 countries

Research and development

2.5 billion euros
(approx. 20% of revenues)

A balanced revenue structure

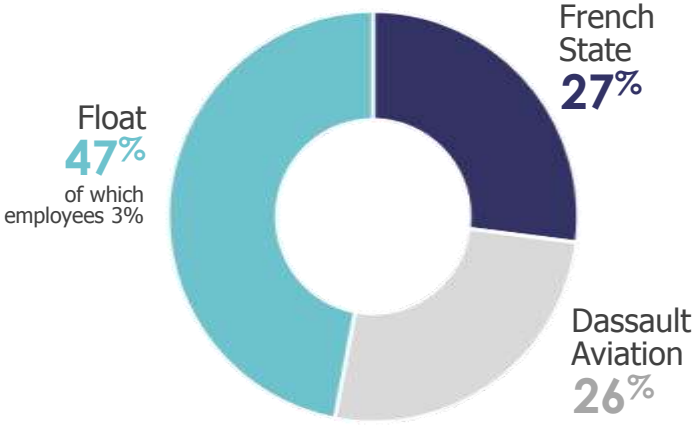
Defence	Civil
55%	45%

Revenues in 2012

€ **14.2** billion euros

Shareholders

(at 31 May 2013)



Thales: A Wide Spectrum of Complex Systems

N 1 worldwide

Payloads
for telecom satellites

Air Traffic Management

Sonars

Security for interbank transactions

N 2 worldwide

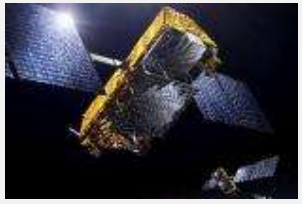
Rail signalling systems

In-flight entertainment
and connectivity

Military tactical
radiocommunications

N 3 worldwide

Avionics



Civil satellites

Surface radars

€14 billion
in revenues

MBSE in Thales: Arcadia & Capella

Current Systems Engineering Practices and Challenges

INCOSE System Engineering Vision 2025

Current Systems Engineering Practices and Challenges

Current systems engineering practice, based on well-defined processes and innovative analytic approaches, has demonstrated significant value to stakeholders, but in the future, the systems community must tackle many new fundamental interdisciplinary and integration-related challenges.

FIVE SYSTEMS ENGINEERING CHALLENGES

Adapted from Todd Bayer, Jet Propulsion Laboratory

1. Mission complexity is growing faster than our ability to manage it . . . increasing mission risk from inadequate specifications and incomplete verification.
2. System design emerges from pieces, rather than from architecture . . . resulting in systems that are brittle, difficult to test, and complex and expensive to operate.
3. Knowledge and investment are lost at project life cycle phase boundaries . . . increasing development cost and risk of late discovery of design problems
4. Knowledge and investment are lost between projects . . . increasing cost and risk: dampening the potential for true product lines.
5. Technical and programmatic sides of projects are poorly coupled . . . hampering effective project risk-based decision making.
6. Most major disasters such as Challenger and Columbia have resulted from failure to recognize and deal with risks. The Columbia Accident Investigation Board determined that the preferred approach is an "independent technical authority".

20 • The Current State

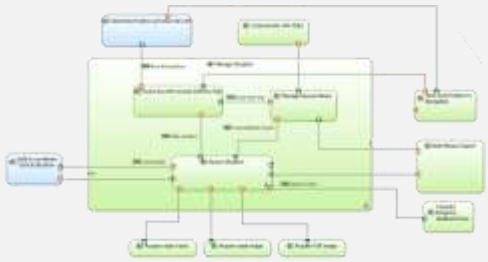
Need for an Engineering Transformation

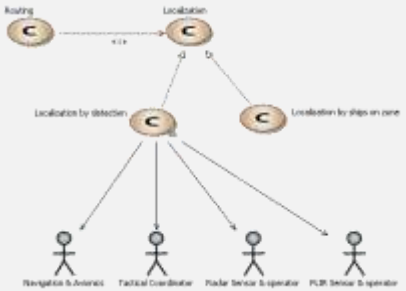
Market

- Systems are more complex
- Do more… cheaper and faster, with more constraints

Model-Based Systems Engineering

- Better quality of developed systems: Integration, seamlessness, consistency, traceability
- Early validation
- Better productivity of engineering activities
- Collaborative engineering
- Best practice & know-how capitalization





Arcadia : MBSE Scalable and Adaptable Method

How to improve quality, productivity, agility and flexibility of overall engineering?

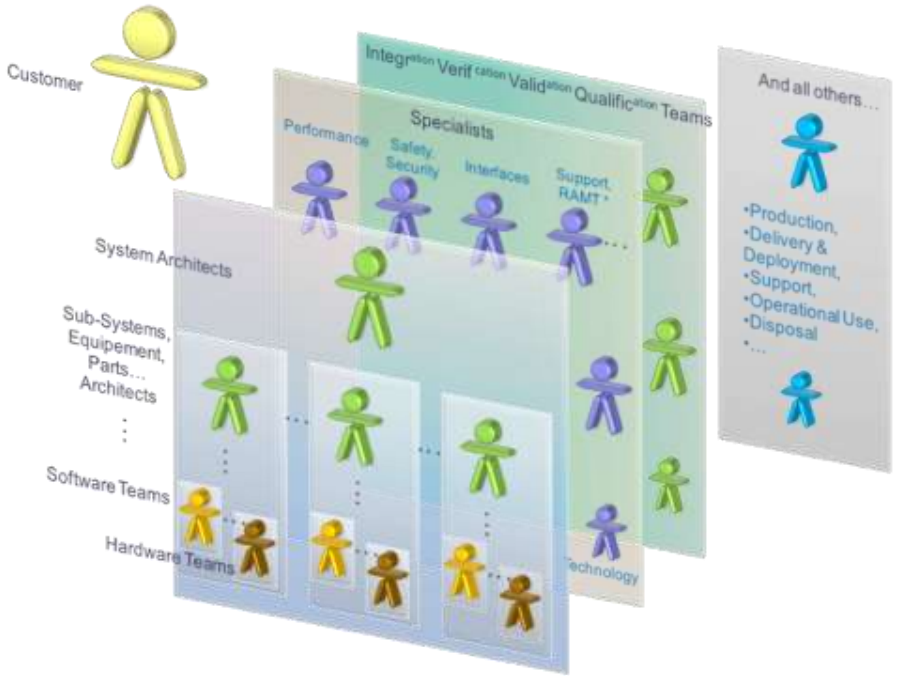
ARCADIA

Arcadia : MBSE Scalable and Adaptable Method

How to improve quality, productivity, agility and flexibility of overall engineering?

ARCADIA

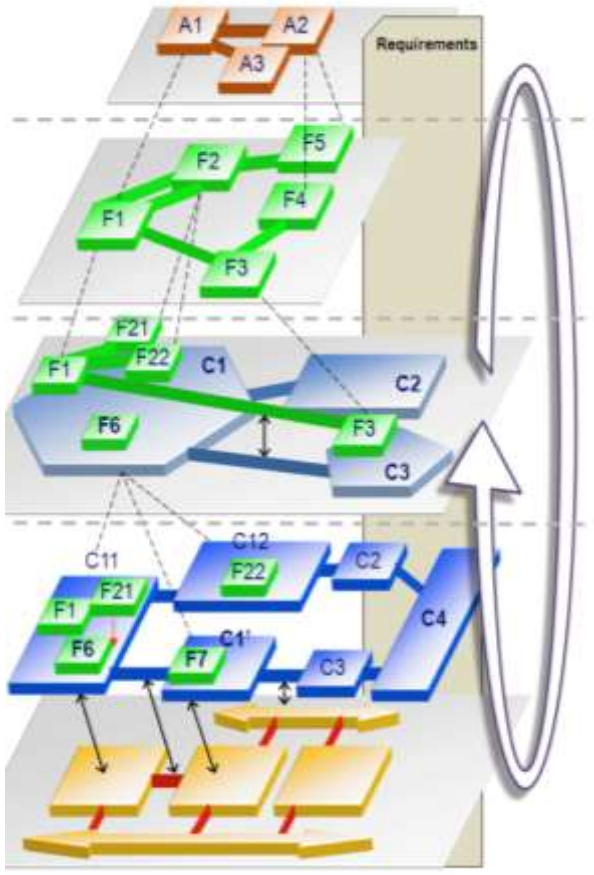
- Eco-system wide collaboration
  - A single architecture reference



Arcadia : MBSE Scalable and Adaptable Method

How to improve quality, productivity, agility and flexibility of overall engineering?

- Eco-system wide collaboration
  - A single architecture reference
- Complexity mastering
  - Multi-level engineering
  - Separation of concerns



Operational

Functional

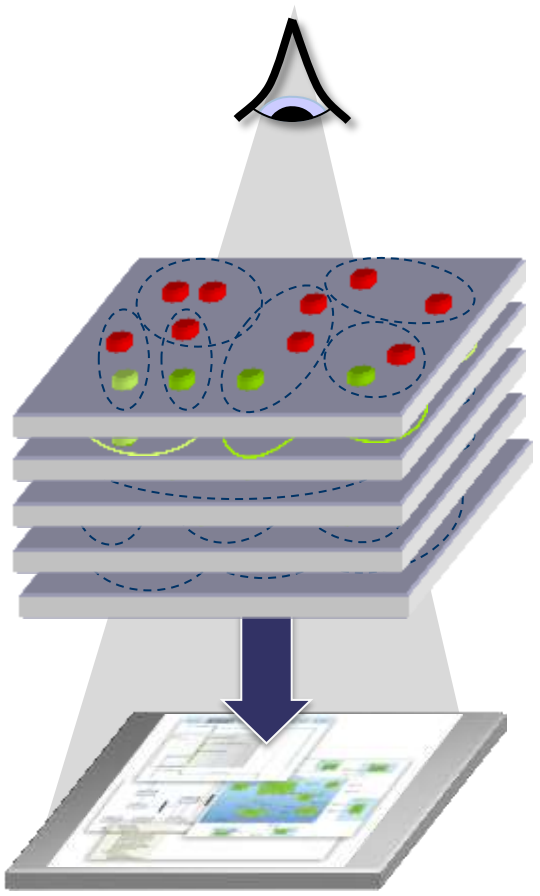
Logical

Physical

Arcadia : MBSE Scalable and Adaptable Method

How to improve quality, productivity, agility and flexibility of overall engineering?

- Eco-system wide collaboration
  - A single architecture reference
- Complexity mastering
  - Multi-level engineering
  - Separation of concerns
- Concurrent engineering
  - Integrated specialty engineering
  - Early validation
  - Trade-off analysis



ViewPoints

etc.

Product Line

Human Factors

Performance

Security

Safety

Evaluation Rules

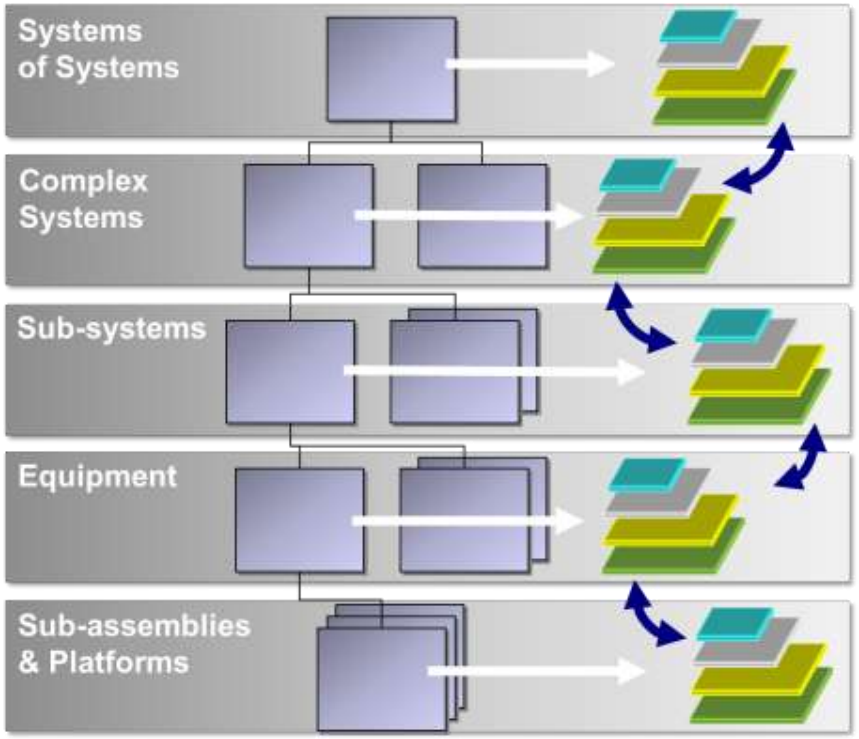
Solution Architecture

Arcadia : MBSE Scalable and Adaptable Method

How to improve quality, productivity, agility and flexibility of overall engineering?

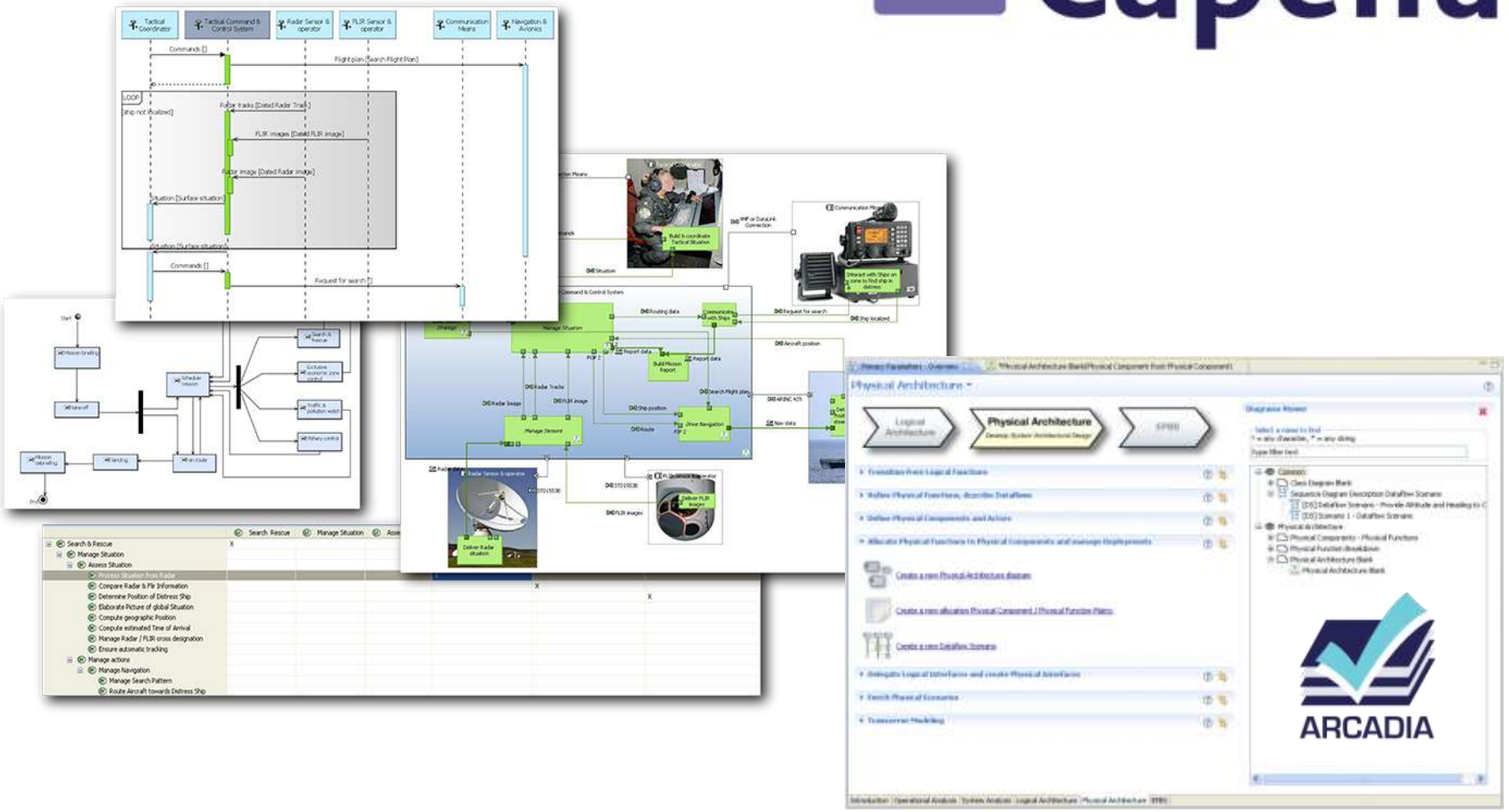
ARCADIA

- Eco-system wide collaboration
  - A single architecture reference
- Complexity mastering
  - Multi-level engineering
  - Separation of concerns
- Concurrent engineering
  - Integrated specialty engineering
  - Early validation
  - Trade-off analysis
- Mastering transitions
  - Information refinement
  - Consistency maintenance
  - Multi-level impact analysis



Capella : A Field-Proven Architecture Modelling Workbench

Capella



Capella : A Field-Proven Architecture 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]

Capella

First operational deployments in 2009

Now used on all major engineering projects

Currently being Open Sourced

MBSE Roll-out: A Major Engineering Transformation

MBSE Large-Scale Deployment

Initial Costs

Method & Tool Governance

Training & Coaching

MBSE Large-Scale Deployment

Initial Costs

- **Arcadia method and Capella core model**

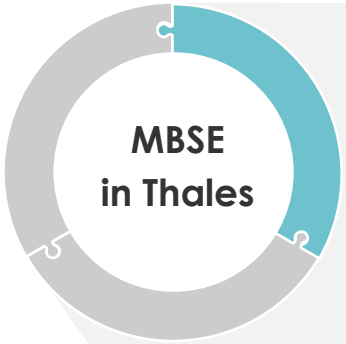
  2 years of intense workshops to get engineers from different domains with different backgrounds **speak the same language**.

- **Capella development**

  Joint effort between method experts, tool/modeling experts and operational practitioners.
  Focus on what was missing in COTS.

  100 my investment, 3-4 years of maturing
  Separation of business (Capella) and foundations (Sirius and Kitalpha)

MBSE Large-Scale Deployment



Method and Tool Governance

- **End-users as major actors of orientations**

  Clear need capture and collaborative priority definition processes

- **Low-to-high TRL transition process**

  Business-driven incubation of low-TRL solutions
  Gate-based industrialization process

- **Strong and active community of experts / users**

  Network of experts in business units & at Group-level
  Sharing of return on experience, tool add-ons, etc.

MBSE Large-Scale Deployment

Training and Coaching

- **Rich training offer**

  Group-funded training plan
  1000+ engineers trained in the past 5 years

- **Coaching**

  Training not sufficient: **Operational coaching is a key**
  Special focus on flagship projects
  Definition of modelling strategy, stopping criteria, guidelines

Return on Experience
Return on Investment

Qualitative ROI

High momentum of adoption worldwide in Thales: MBSE meets expectations and fills gaps

First time a brand new engineering approach is adopted so quickly in all Thales Units.

Indicates a real need.

Enhanced collaboration and understanding between engineers from different domains

Goes beyond architecture design: Favours technology incubation and helps define Group-wide solutions for Product Line management, IVV management, etc.

Qualitative ROI

MBSE allows to tackle engineering weaknesses

Justification of interfaces (acknowledged by certification authorities on some projects)

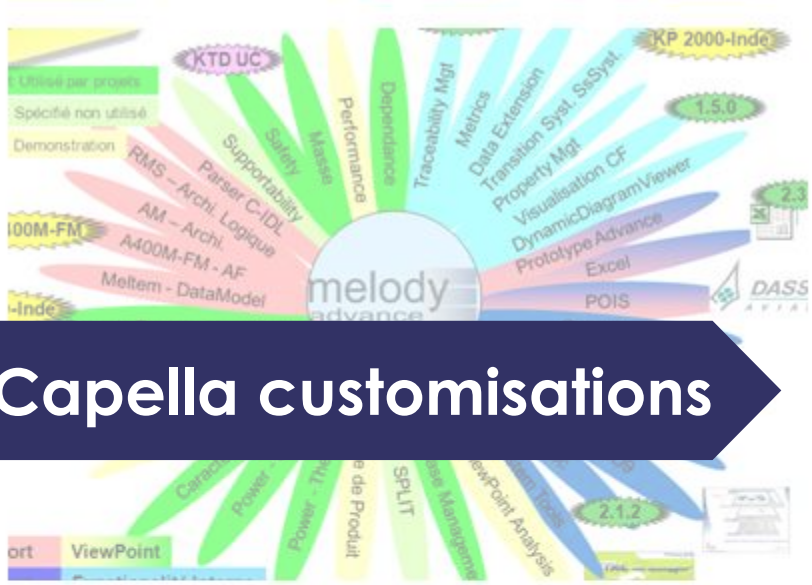
Mastering the ups and downs of IVV

Document generation, Code generation in many cases

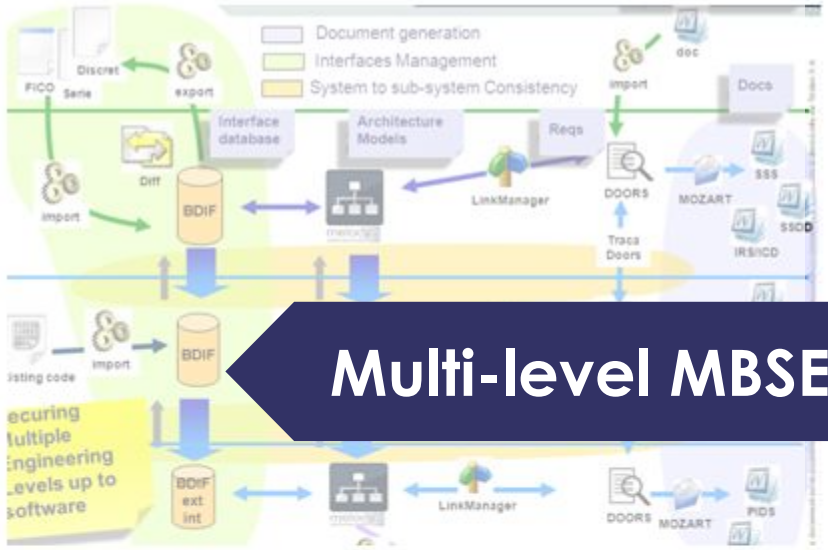
Improved productivity and quality

Certification authorities start to require MBSE

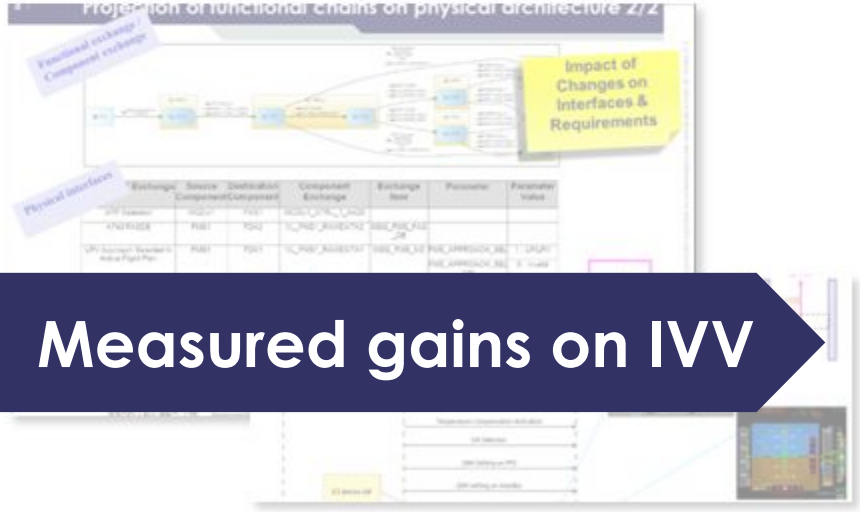
Real world examples



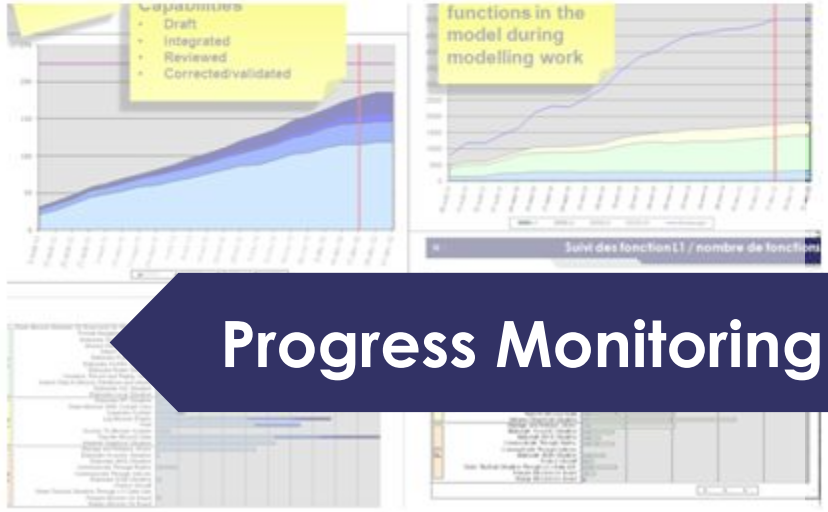
Capella customisations



Multi-level MBSE

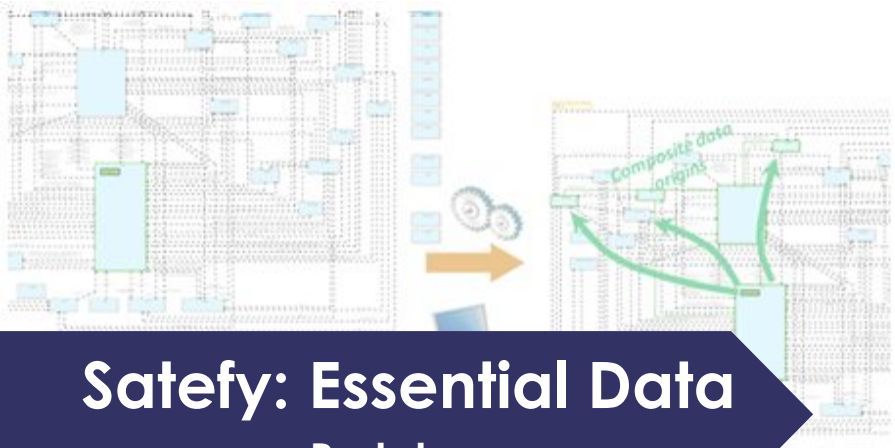


Measured gains on IVV

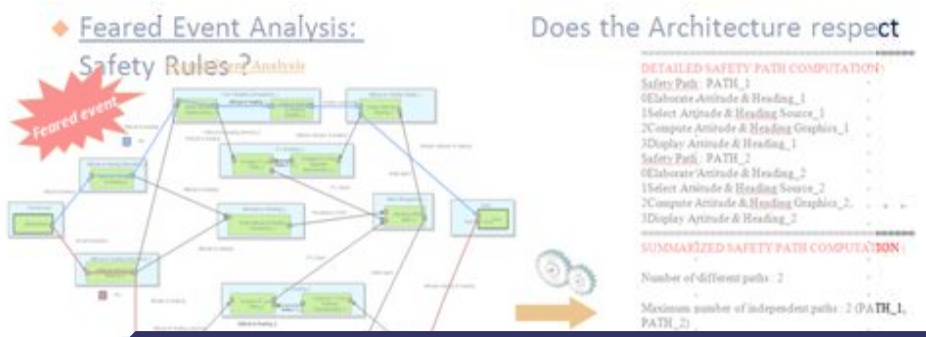


Progress Monitoring

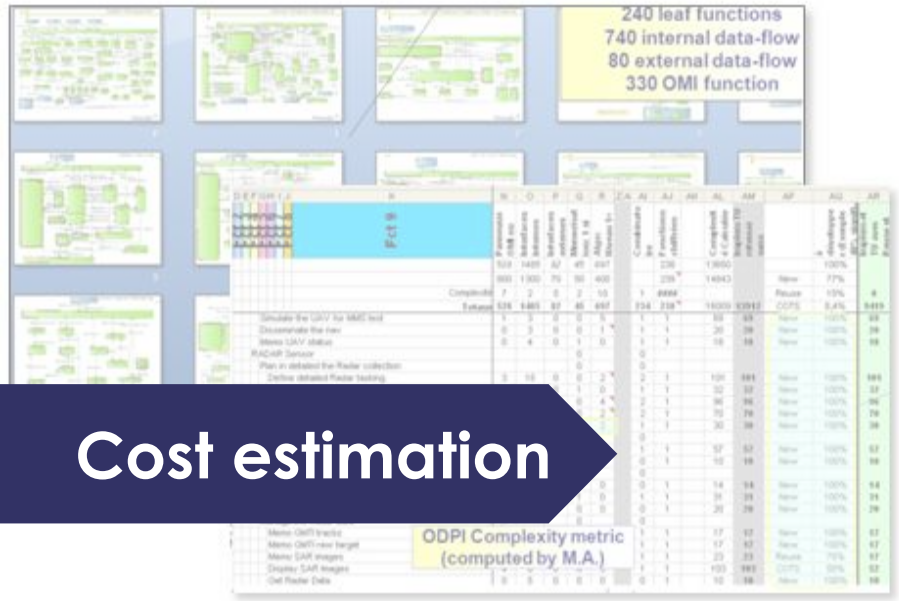
Real world examples



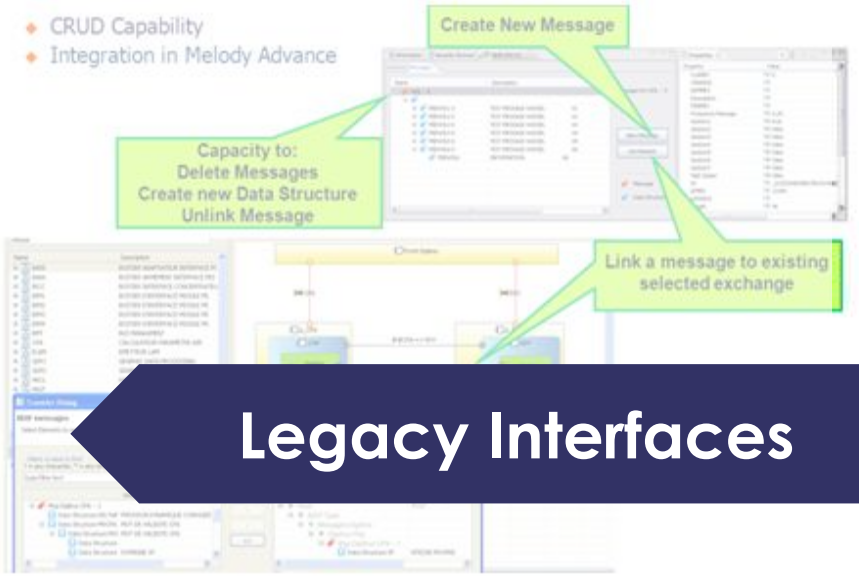
Satefy: Essential Data
Prototype



Safety Rules verification
Prototype



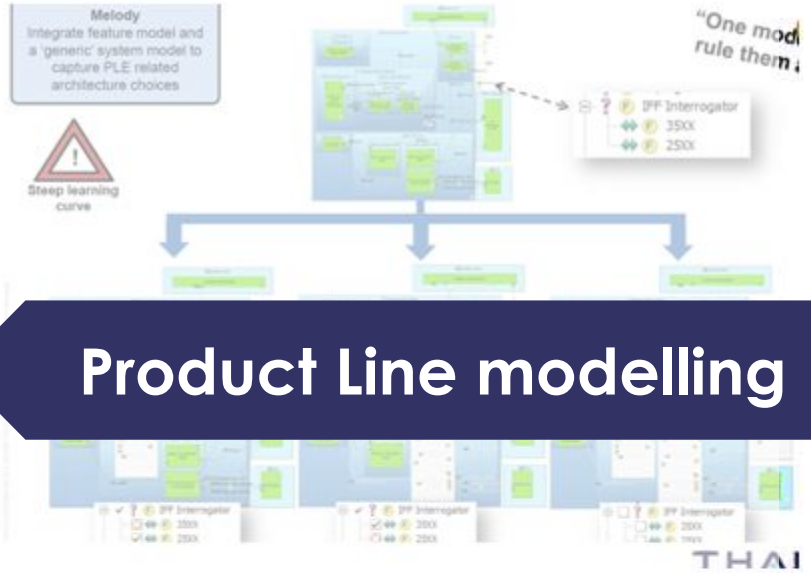
Cost estimation



Legacy Interfaces

Real world examples

Code generation



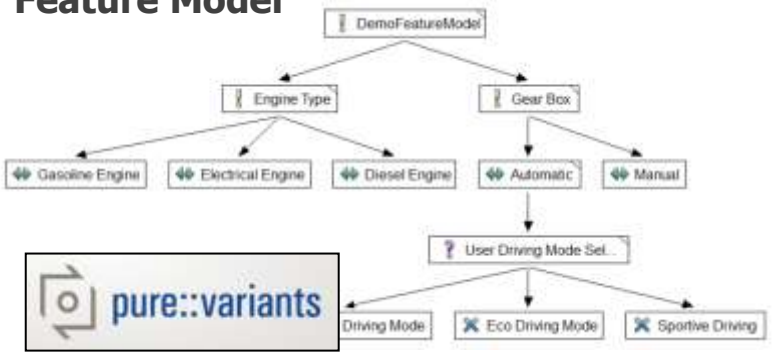
Product Line modelling

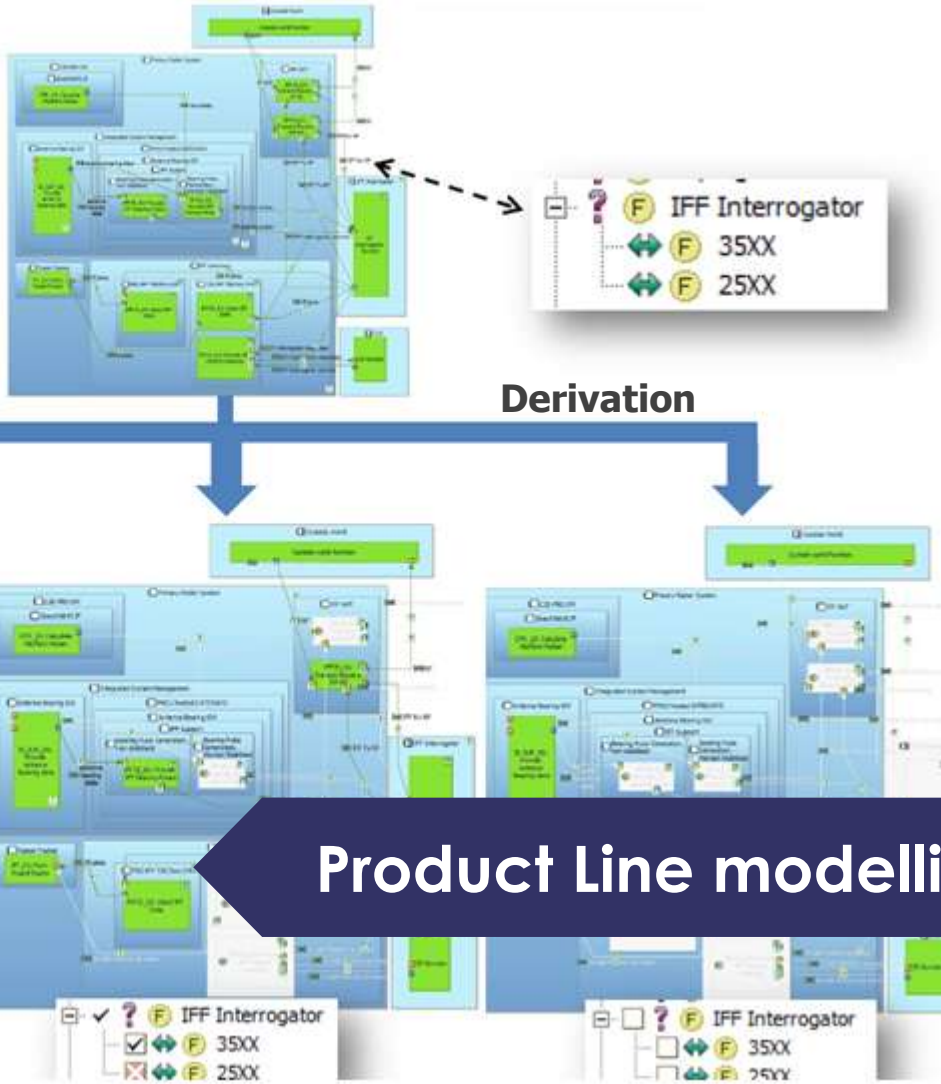
Model-driven IVV

Performance analysis

Real world examples

Feature Model





Product Line modelling

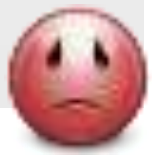
Examples of DOs and DONTs

BEST PRACTICES

- **Have clear modelling objectives**
- **Share models with all stakeholders, make them THE reference**
- Define and share guidelines
- **Organize regular model reviews**
- Measure model progress
- Give different purposes to diagrams: Model building, communication, documentation, model analysis, etc.
- **Involve lower-level engineering teams in co-engineering**
- …

PITFALLS

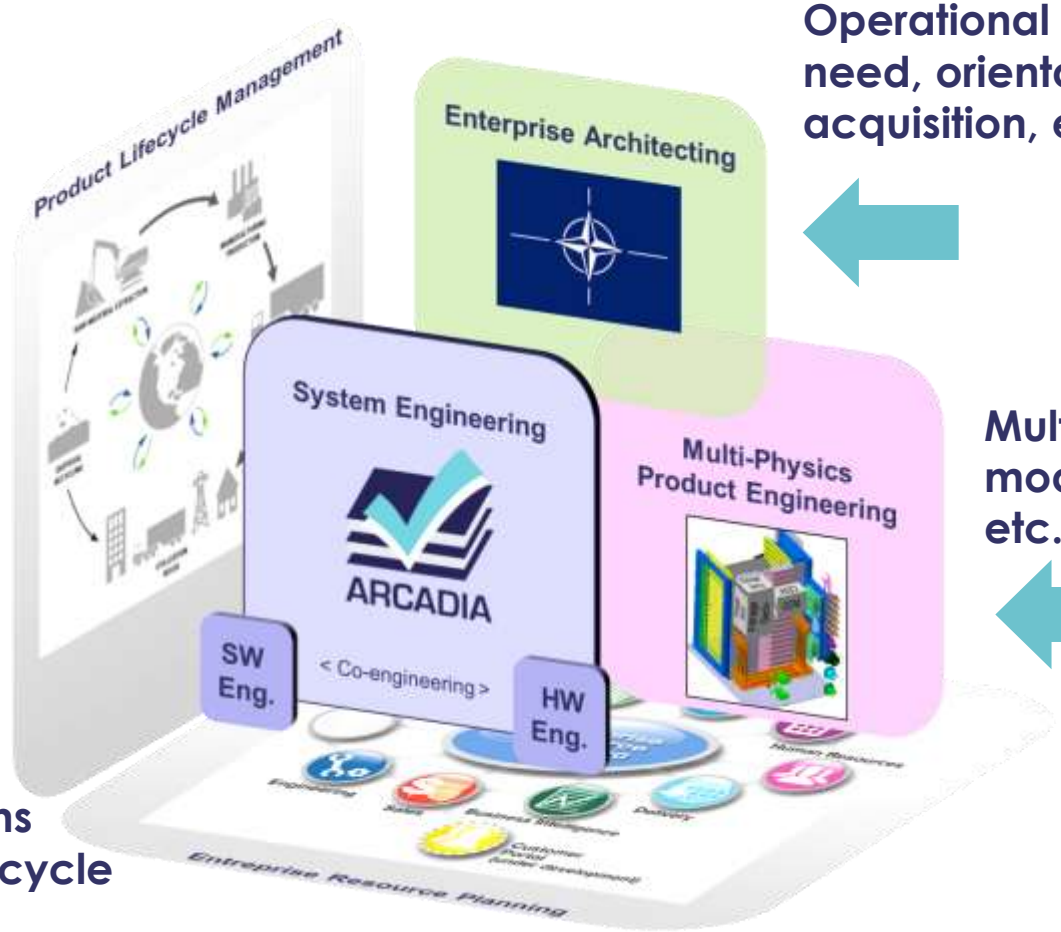
- **Have no efficient tool and methodological support**
- **Have no stopping criteria**
- No separation between need and solution modelling
- **Keep several engineering levels into one single model "for the sake of simplicity"**
- Use textual descriptions to describe complex behavior
- Structure architecture into components based on functional tree only (and vice-versa)
- …



MBSE & Acquisition Agencies

Situation of Arcadia in a wider Ecosystem

Operational capabilities and need, orientations, conditions of acquisition, etc.

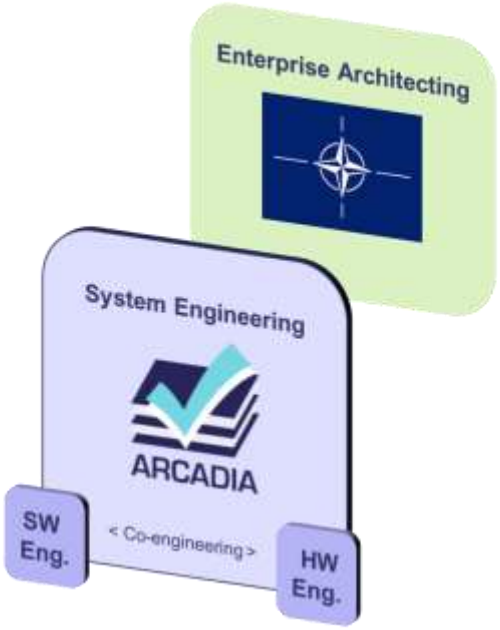


Multi-Physics: 3D, power models, thermal models, etc.

Missions, solutions and services lifecycle

Solution Architecture fits in a wider ecosystem and must contribute to it

Customer Enterprise & Supplier Solution Architecture



Models can play a key role as a support for discussions between Customer and Supplier

Models illustrate the definition of the need / clarify the requirements

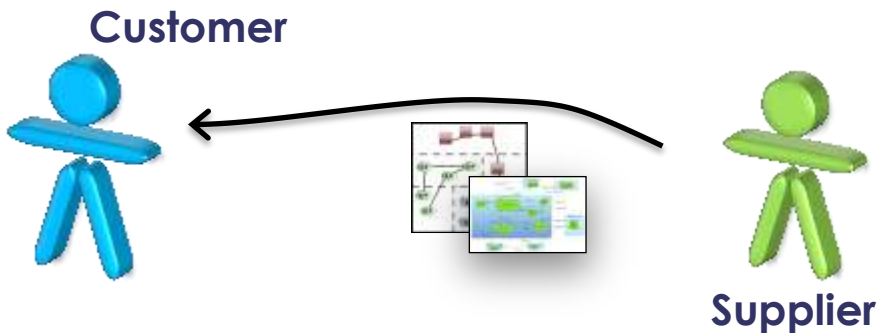
Models and requirements are both necessary

3 different schemes experimented in Thales

Customer Enterprise & Supplier Solution Architecture

Using Models to support discussions Customer / Supplier

- System design models showed by Supplier to Customer to explicit the vision / understanding of the need



Share actual models AND tools? Filtering necessary.

Share model HTML-like outputs? (Thales with ESA)

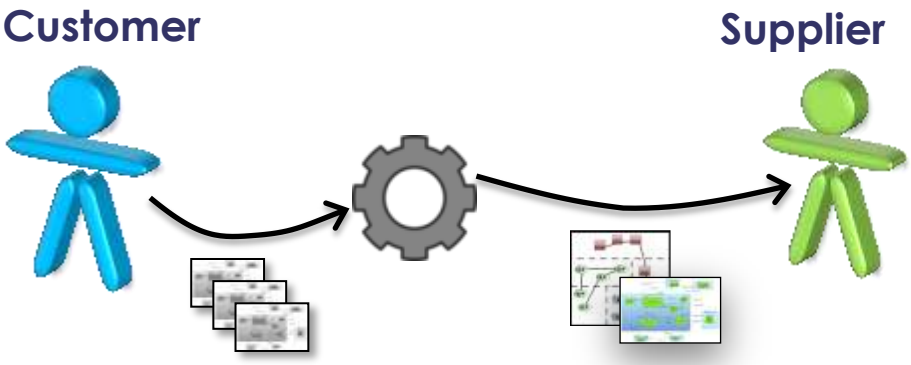
Model shown as a support for operational scenarios discussions (Thales with ATR)

Customer Enterprise & Supplier Solution Architecture

Using Models to support discussions Customer / Supplier

- System design models showed by Supplier to Customer to explicit the vision / understanding of the need

- Customer models used as inputs to initialize the System design models and ensure traceability



Adaptation of modelling habits necessary on both sides (Thales with Dassault)

Diff-based workflow possible

Configuration management!

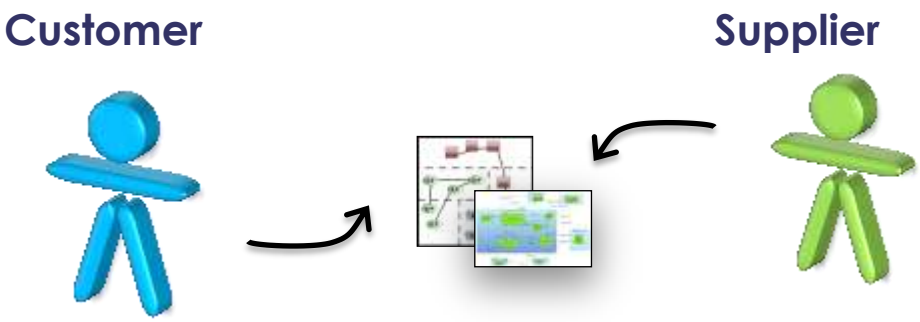
Customer Enterprise & Supplier Solution Architecture

Using Models to support discussions Customer / Supplier

- System design models showed by Supplier to Customer to explicit the vision / understanding of the need

- Customer models used as inputs to initialize the System design models and ensure traceability

- Co-engineering: Joint elaboration of the solution



Responsibility in case of problems?

Configuration management!

Next Steps

Next Steps for MBSE in Thales

Integration of variability with Modelling

First solution available in Thales with a coupling Pure::Variant / Capella. The seamless integration of Product Line aspects in the global Systems Engineering lanscape

Continuum Enterprise Architecting – Solution Architecture

Optimization of the transition Architecture Framework – Arcadia (method & tool perspectives)

Other ongoing investigations & incubation

Better formalisation of design alternatives evaluation

Integration simulation / system-level models (consistency checking, sizing, etc.)

Early safety analysis (feared event impact analysis, safety rules verification, essential data analysis, etc.)

MBSE, Backbone of the Thales Engineering Manifesto

Thank you for your attention!

Any Questions?

Arcadia and Capella on the Field: Real-World MBSE Use Cases

[Stéphane Bonnet, Fabrice Lestideau]

Focus on 4 different examples of MBSE usage in Thales

The challenges of deploying MBSE solutions

[Fabrice Lestideau, Stéphane Bonnet]

2 hours workshop dedicated to discussing the challenges of getting MBSE adopted in organisations