

Return of experience on the implementation of the System Engineering approach in Alstom Transport

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PLAN NATIONAL DE FORMATION

FORMATEURS DE FORMATEURS EN SysML

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Table of contents:

1. Evolution of railway operators
2. Evolution of rolling stock
3. System Engineering Process: view points
4. System Engineering Process: a Top-Down approach
5. Requirement Based & Model Based System Engineering
6. SysML model
7. Gained benefits
8. Deployment state
9. Training
10. System engineering team feedback
11. Key points for the new approach deployment
12. Next steps

Evolution of Railway Operators:

Railway carbuilders shall develop a more structured design process in order to face the lack of technical background of the new railway operators

- Historically, railway traffic was operated by state owned national operators (SNCF, DB, Trenitalia, Renfe, ecc..) and they were mastering the full technical know-how to design a railway system. Carbuilder were just producing following the operators instructions...
- Today national railway operation market is formally open (in Europe due to a CEE directive) to other operators (private or not).
- New private operators have not any historical technical background and they're fully operational oriented
- Some Incumbent operators, are also changing their mind-set by becoming more operational oriented (and less technical) in order to be more competitive against the new private ones

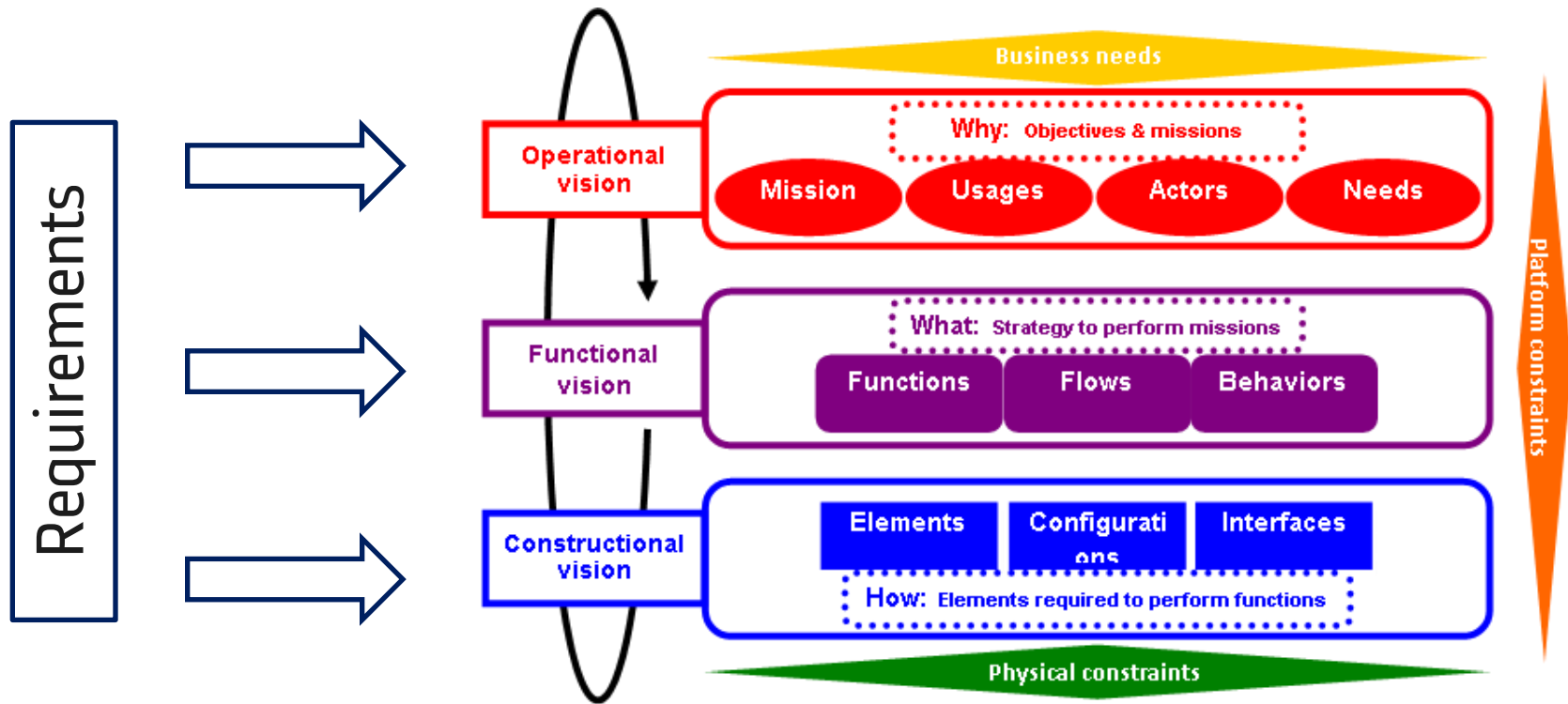
Evolution of Rolling Stocks:

Rolling stock systems have increased the level of complexity due to additional functionalities / services to be implemented and due to the introduction of the software

- Historically, railway vehicle were fully mechanical and once electronic appeared all the « non mechanical » functions to monitor and control the system were realized with wiring logic (relays logic).
- With the introduction of the “train control and monitoring system” some “not safety relevant” function were implement with software, and here the level of complexity arisen in a way to require a more structured approach
- Today the trend is to implement (when possible) more and more functionalities (also “safety relevant”) in software and in this case, to manage such complexity, it’s necessary to introduce a more robust system approach: **Alstom System Engineering Process**

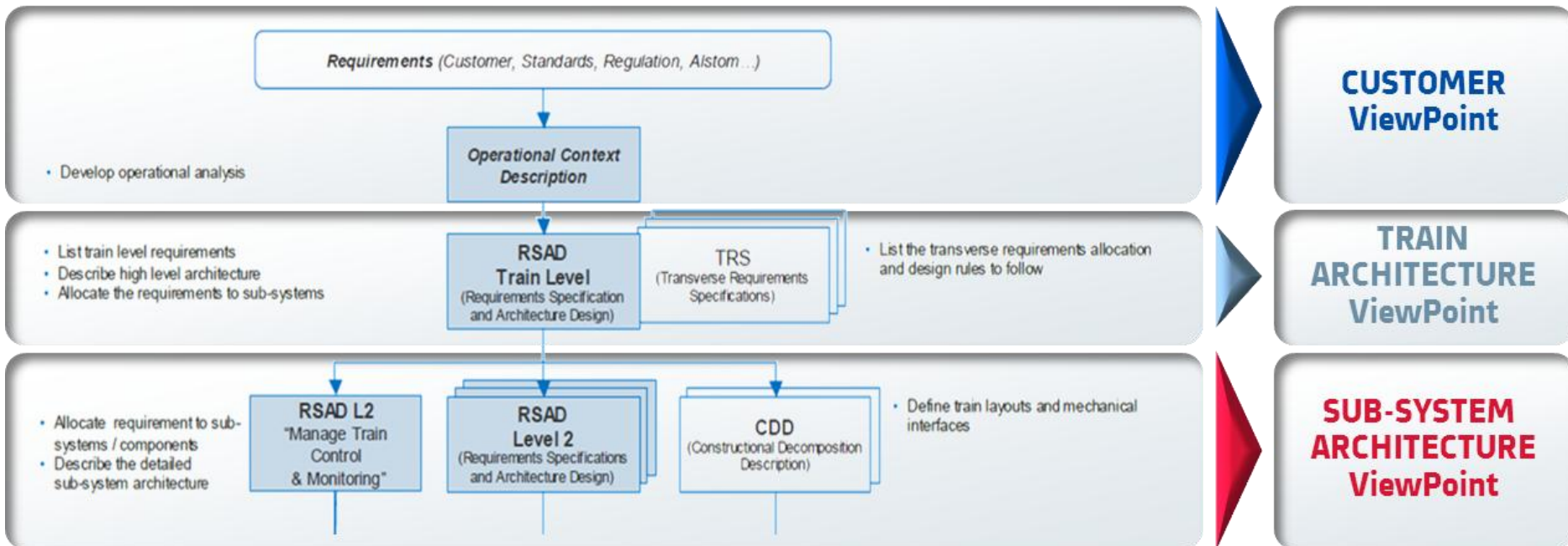
System Engineering Process: view points

Alstom Advance System Architect Program is the new Alstom System Engineering approach which aim to reduce the “problem” complexity



System Engineering Process: a Top-Down approach

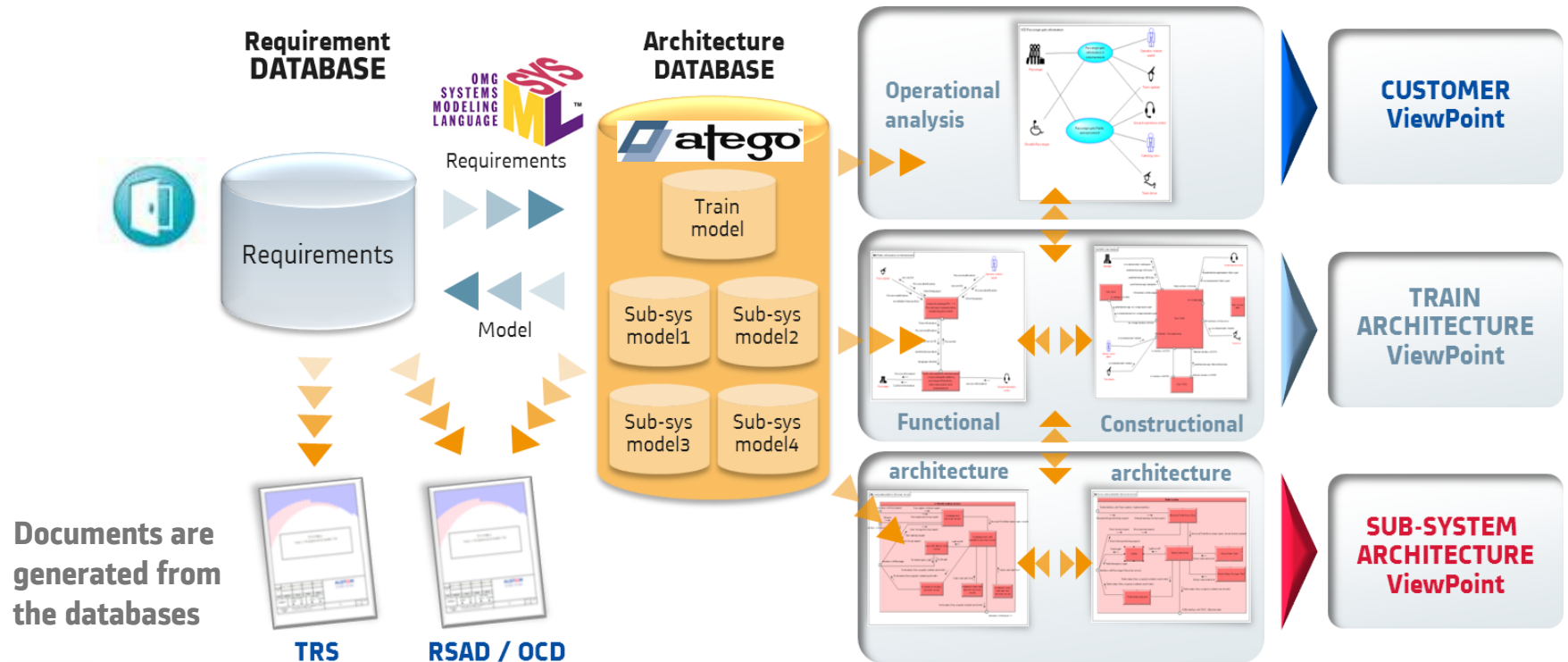
System views are developed using a Top-Down approach starting from reqs



MBSE tools architecture:

System model objects are stored in two synchronized database:

- Requirement database to enable requirement management and development activities in DOORS
- SysML system architecture database to enable operational analysis, functional and constructional architecture modelling in Atego Artisan



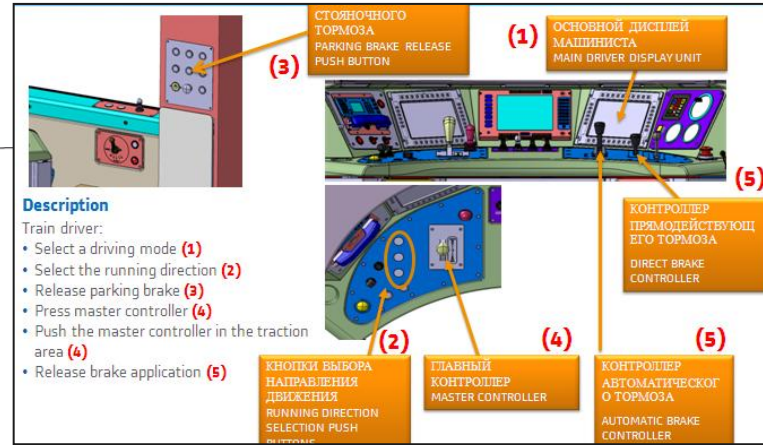
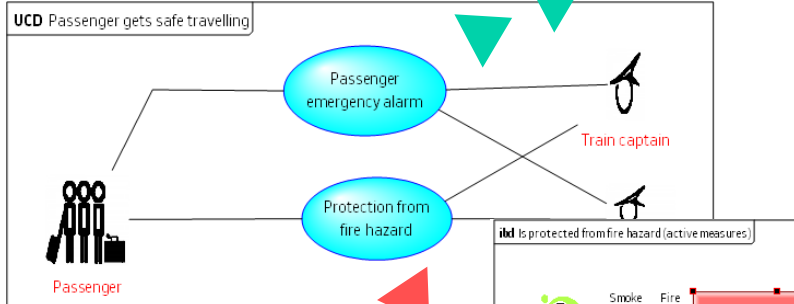
Documents are generated from the databases

TRS

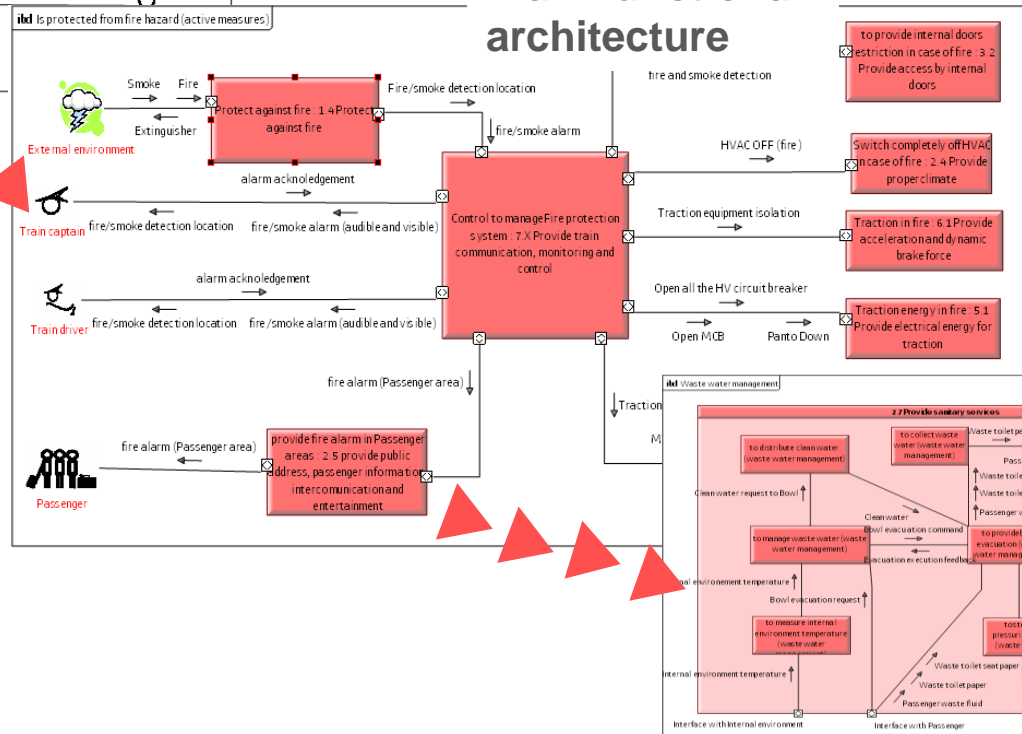
RSAD / OCD

SysML model:

Train operational analysis



Train functional architecture



Sub-system functional architecture

Gained benefits:

- **Improved design quality:**

- ✓ Rigorous traceability between requirements, their implementation into the systems architecture, Verification and Validation
- ✓ Enhanced design coherency and consistency (interfaces) between all the different subsystems
- ✓ Rigorous management of design change and system architecture configuration

- **Increased productivity:**

- ✓ Reuse of existing models to support design evolution
- ✓ Reduced errors and time during integration and V&V
- ✓ Enabled concurrent system architecture definition
- ✓ Documents generated automatically from the model

Gained benefits:

- **Reduced development risk:**

- ✓ Rigorous traceability between requirements, their implementation into the systems architecture, Verification and Validation
- ✓ Accurate system development cost estimation
- ✓ Accurate system architecture impact analysis versus requirements/need change

- **Enhanced communications:**

- ✓ Shared understanding of the system analysis and architecture across tile development team and other stakeholders
- ✓ Ability to integrate views of the system from multiple perspectives

- **Enhanced knowledge transfer:**

- ✓ System architecture and choices justifications are captured in a standard format that can be easily accessed

Deployment state:

On **Rolling Stock** product lines:

- first pilot project involved 8-10 system engineers for 6 months (September 2011 – February 2012) where the scope was to prove the feasibility of the approach and to refine the process
- Today several projects (R&D and running projects) are launched with the application of the full process, involving almost 30 system engineers

On **Information solution** product lines:

- first pilot project involved 5 system engineers for 1 year (September 2009) where the scope was to prove the feasibility of the approach and to refine the process
- Today several project (R&D and running projects) are launched with the application of the full process, involving almost 40 system engineers

The deployment is supported by an homogeneous IT infrastructure based on centralized servers (database and licences) and local host (users) client applications. To improve performance we are testing a Cytrix-based architecture.

Trainings:

Advances System Architect Program - SysML modelling

- Training program: how to act as system architect and learn basics of SysML, the modelling rules and best practices defined by Alstom Transport
- Trainees: around 250 trained people from 2009 up to today
- Trainers: 8 certified Alstom internal trainers

Requirement Management and Development

- Training program: understanding of different process area and process task of the Alstom requirement management and development process, learn how to use the tools to implement the process on a project
- Trainees: 200 people from 2012
- Trainers: 4 certified Alstom internal trainers

System engineering team feedback:

System Engineers which have worked following ASAP principles have perceived the **ADDED VALUE** and the **GLOBAL QUALITY IMPROVEMENT** improvement of their results.

Most of System Engineers trained with ASAP easily accepted the **System Approach** and the **SysML modelling** finding it as an **HIGH ADDED VALUE** way of working where the team working is boosted:

- all the architectural choices are discussed and agreed by the System Engineering team before to formalize them in the model, having a TSE (Train System Engineer) as responsible and “animator”
- Train and subsystem architecture definitions are done in parallel ensuring the consistency and the homogeneity
- Domains experts has injected their know-how in the model supported by the system engineers

Key points for the new approach deployment:

The key points to deploy the approach is to **CLEARLY COMMUNICATE** and **MANAGE THE CHANGE!**

The following are key factors to be carefully considered in order to efficiently drive the change:

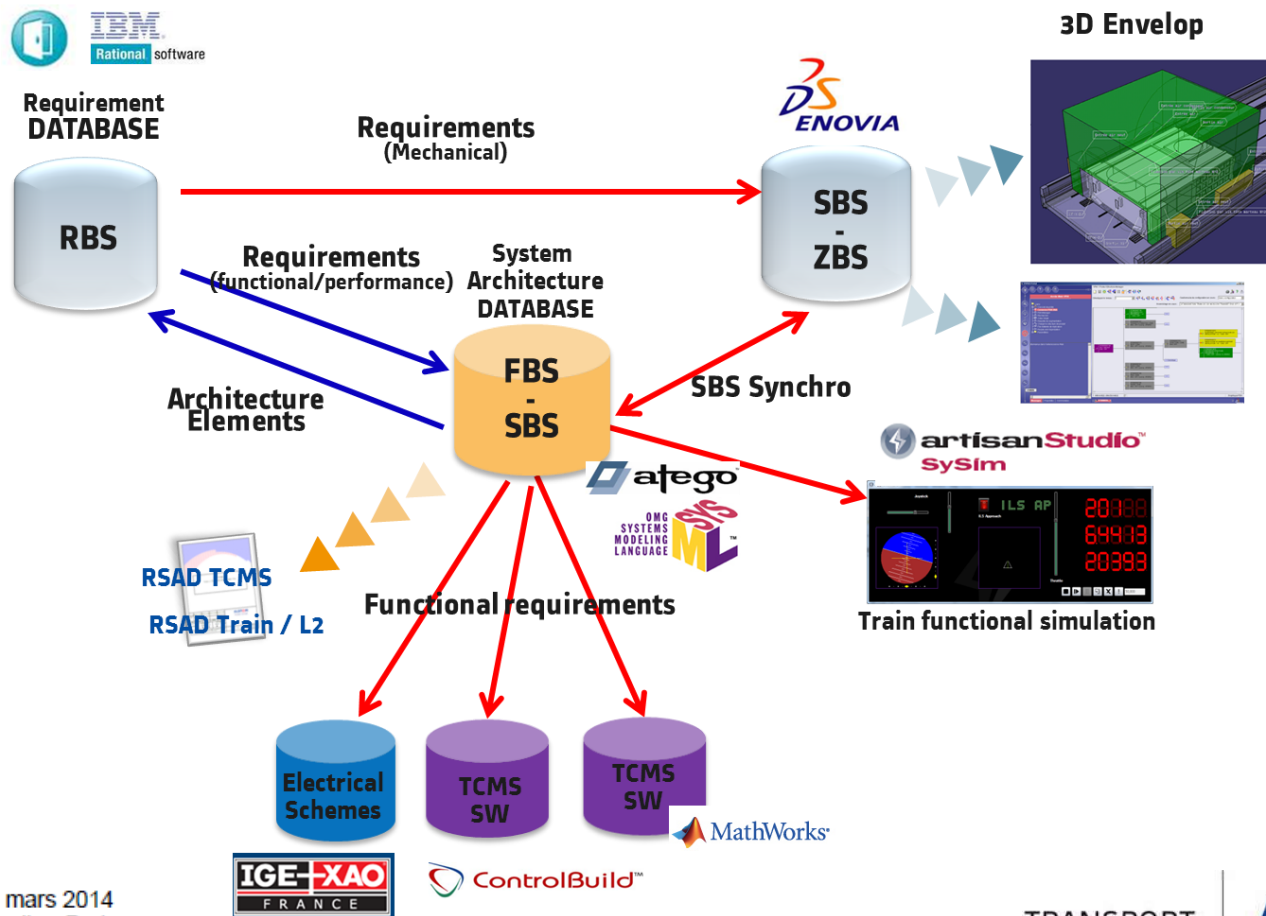
- Demonstrate the **feasibility** and the **benefits** of the new process with a real **full application** of the new methodology (pilot project)
- Provide a **well structured training**
- Provide a **strong support** during the deployment on site
- Management shall actively **support** the **change** of the way of working

Next Steps:

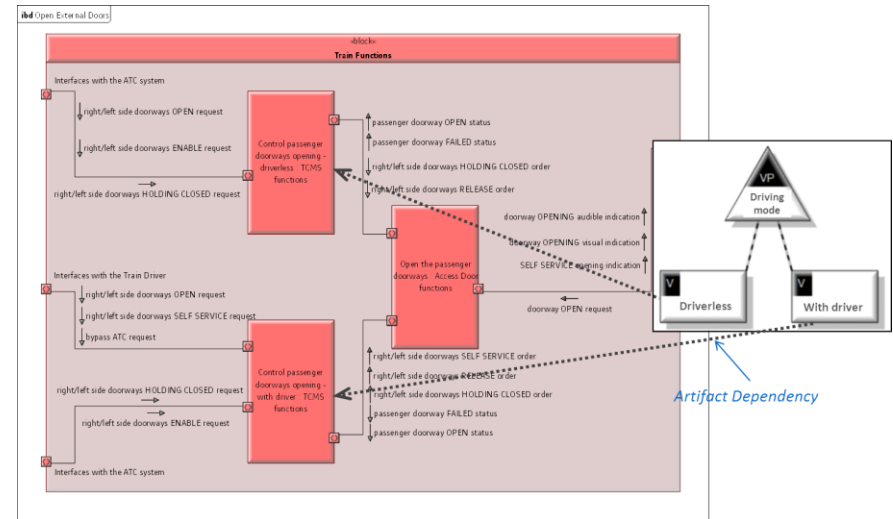
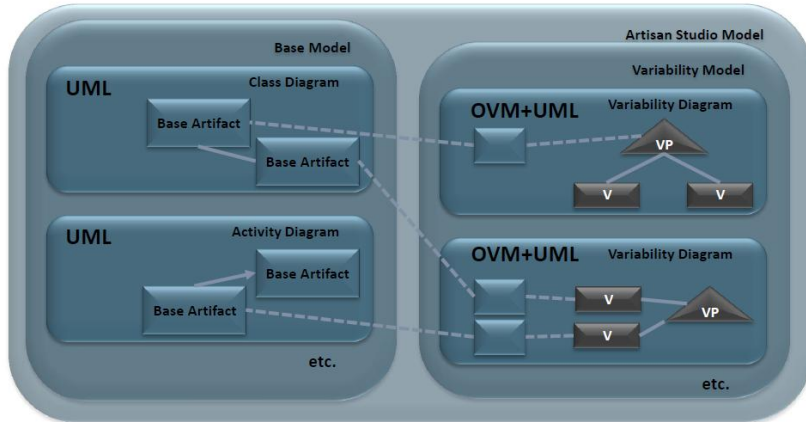
- Develop, **improve** and **integrate** the whole **system engineering processes** and between the different tools:
 - Improve integration with the System Architecture definition process with the System Implementation process (detailed design process, e.g. software generation)
 - Develop integration of the System Architecture definition with the mechanical integration process (Requirements and SysML model (physical architecture) with digital mockup model)
 - Simulate the SysML model to validate the architecture
 - Model Based - Product Line Engineering

System Engineering integrated processes and tools::

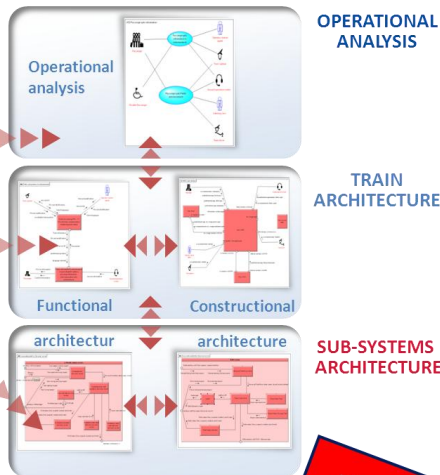
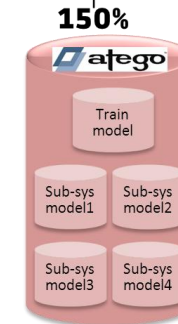
Implementation of System Lifecycle Management to enable coherent and consistent system design through the different engineering disciplines and related tools



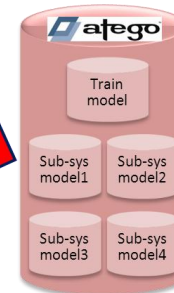
Model Based - Product Line Engineering through OVM:



PLATFORM Architecture mode



PROJECT Architecture model

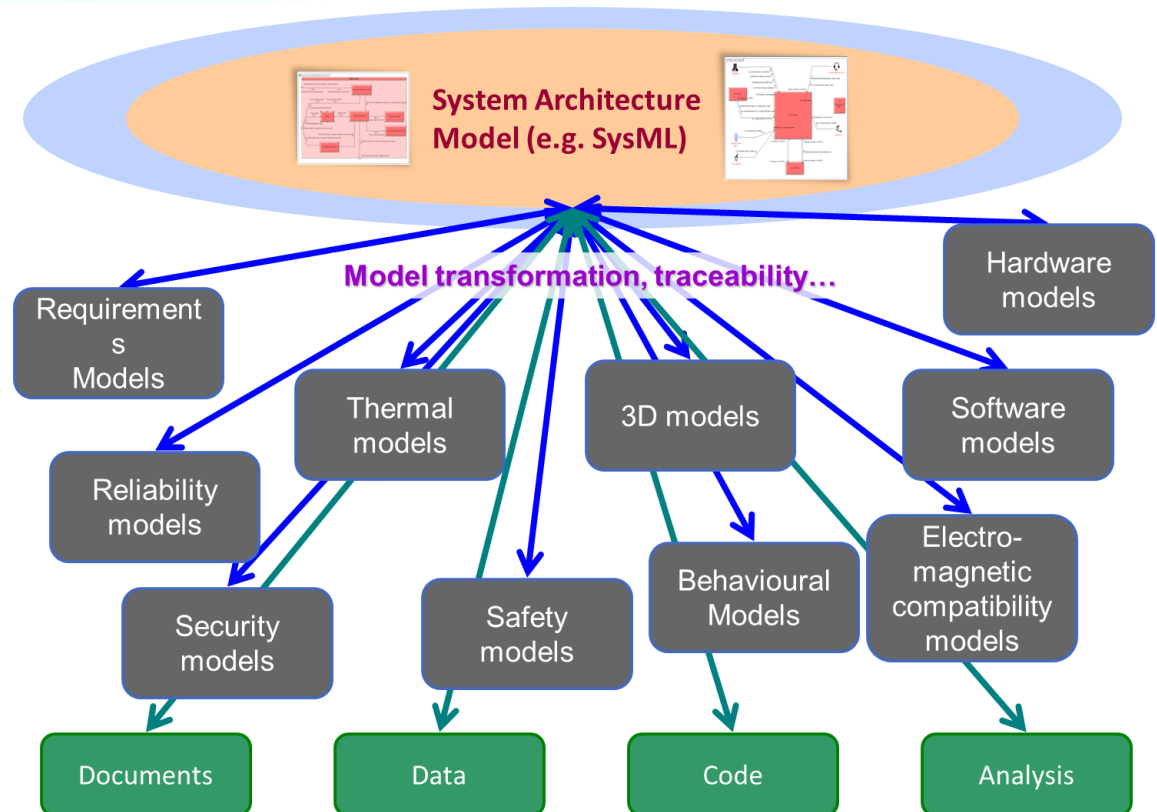


INSTANCE with **FILTER** on selected combination (configuration) of applicable variants and options

La "vision" du CT MBSE de l'AFIS:

"Model-based systems engineering (MBSE) is the *formalized application of modeling* to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases."

INCOSE SE Vision 2020 (INCOSE-TP-2004-004-02), Sept 2007



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