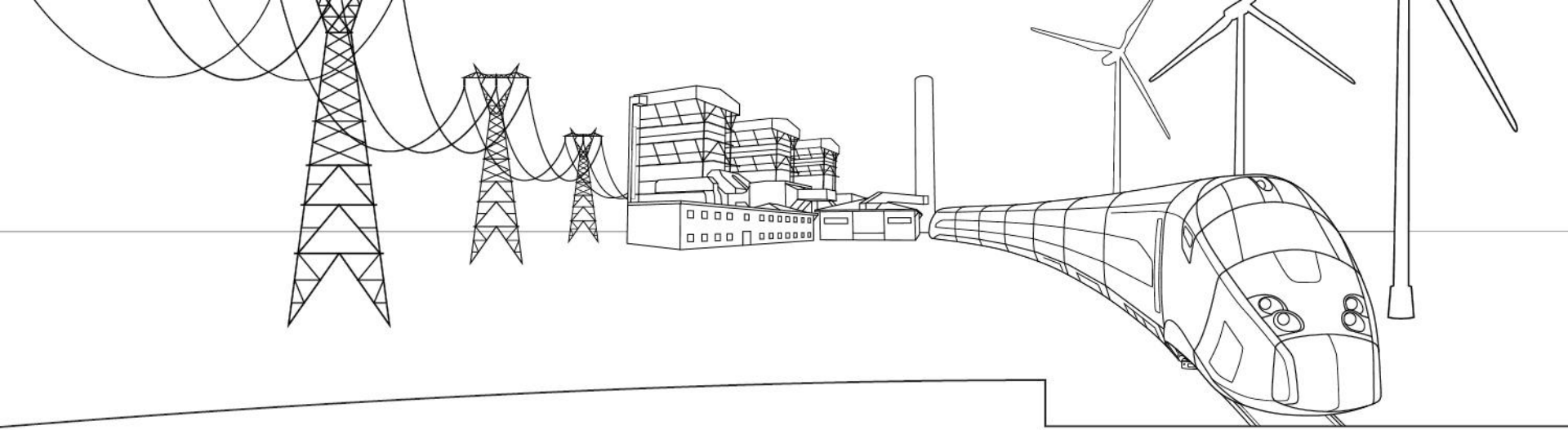


Systems Engineering for a Rolling Stock Product Line

Hugo Guillermo **Chalé Góngora**, PhD, CPRE – Train SE
Co-Chair INCOSE PLE International Working Group

IBM Symposium Systèmes – June 16 2015

The only railway multi-specialist

TRAINS

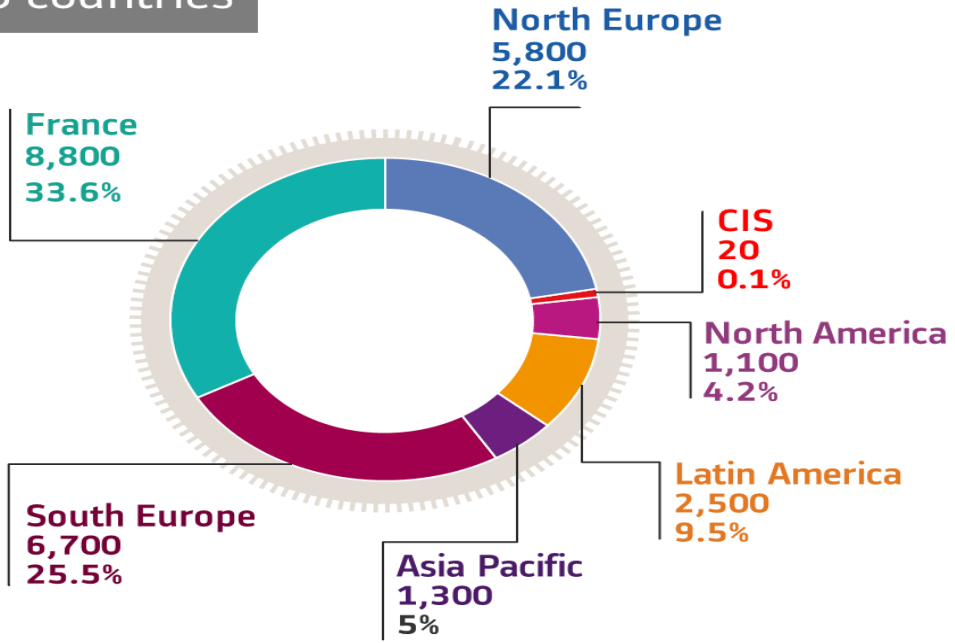
INFRASTRUCTURE & SYSTEMS

SERVICES

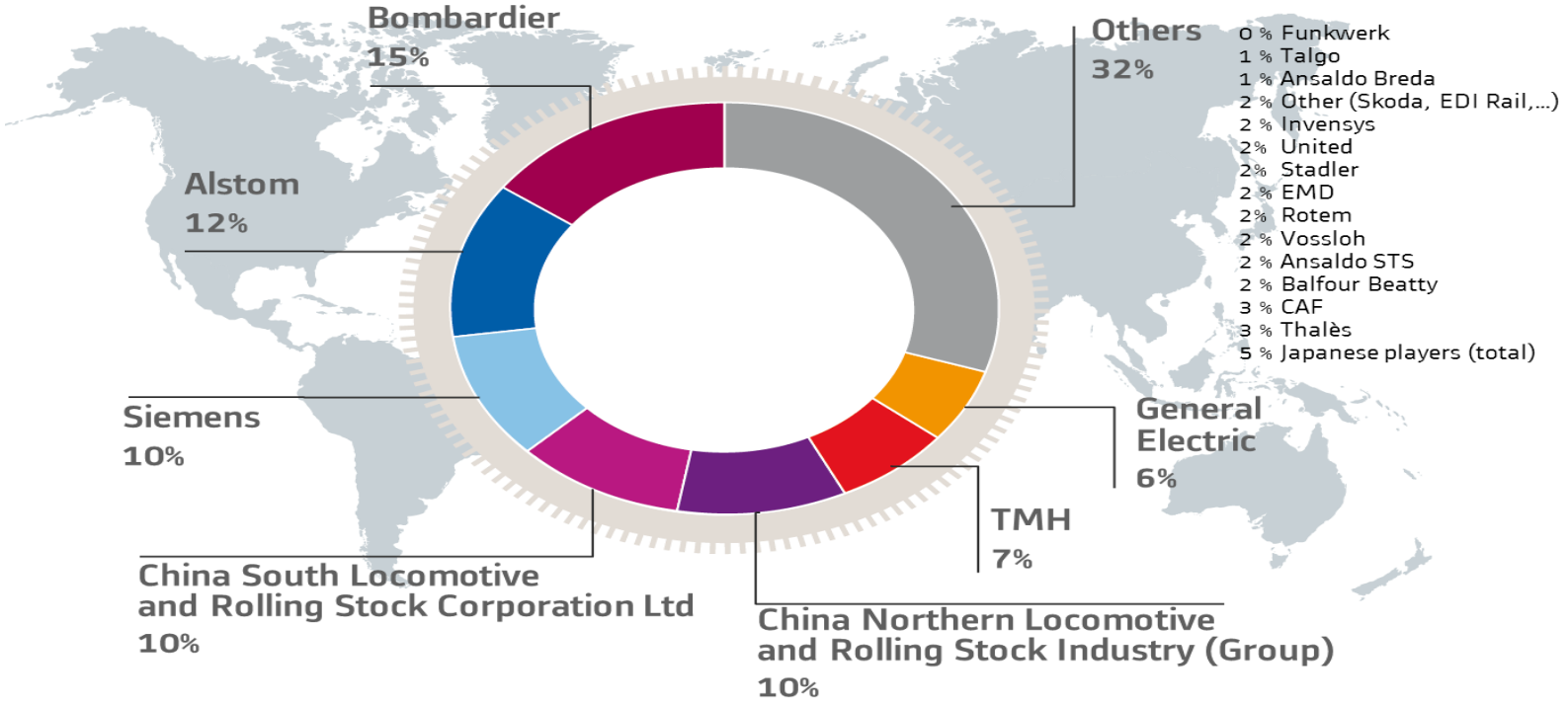
SIGNALLING

A worldwide company

25,500 employees in more than 60 countries



The second rolling stock manufacturer in the world

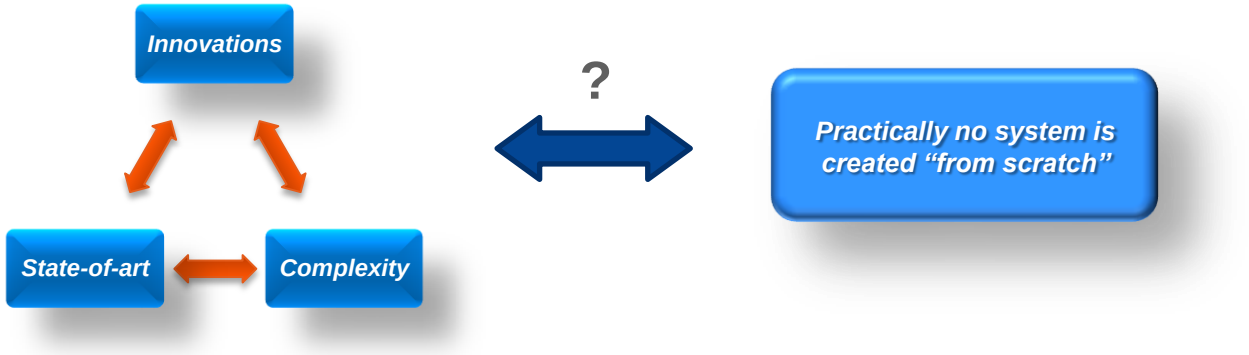


CONTENTS

The railways rolling stock context

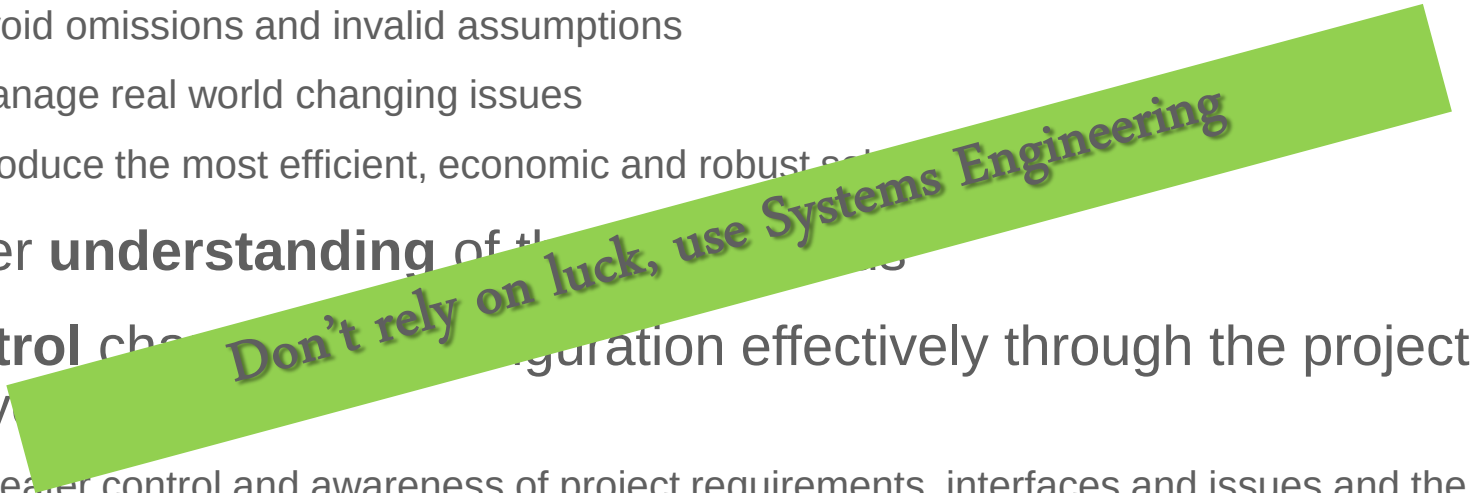
- An always increasing need for better, safer and more reliable systems developed at lower costs and shorter times-to-market

→ Engineers are likely to **reuse** previously developed assets into a new project … theoretically, in order to improve quality, cost effectiveness, time to delivery or risk mitigation



Why Systems Engineering (1)?

- Coping with **complexity**
  - Avoid omissions and invalid assumptions
  - Manage real world changing issues
  - Produce the most efficient, economic and robust so
- Better **understanding** of th
- **Control** cha guration effectively through the project lifecy
  - Greater control and awareness of project requirements, interfaces and issues and the consequences of any changes
- Research shows *effective* use of SE can **save** 10-20% of the project budget



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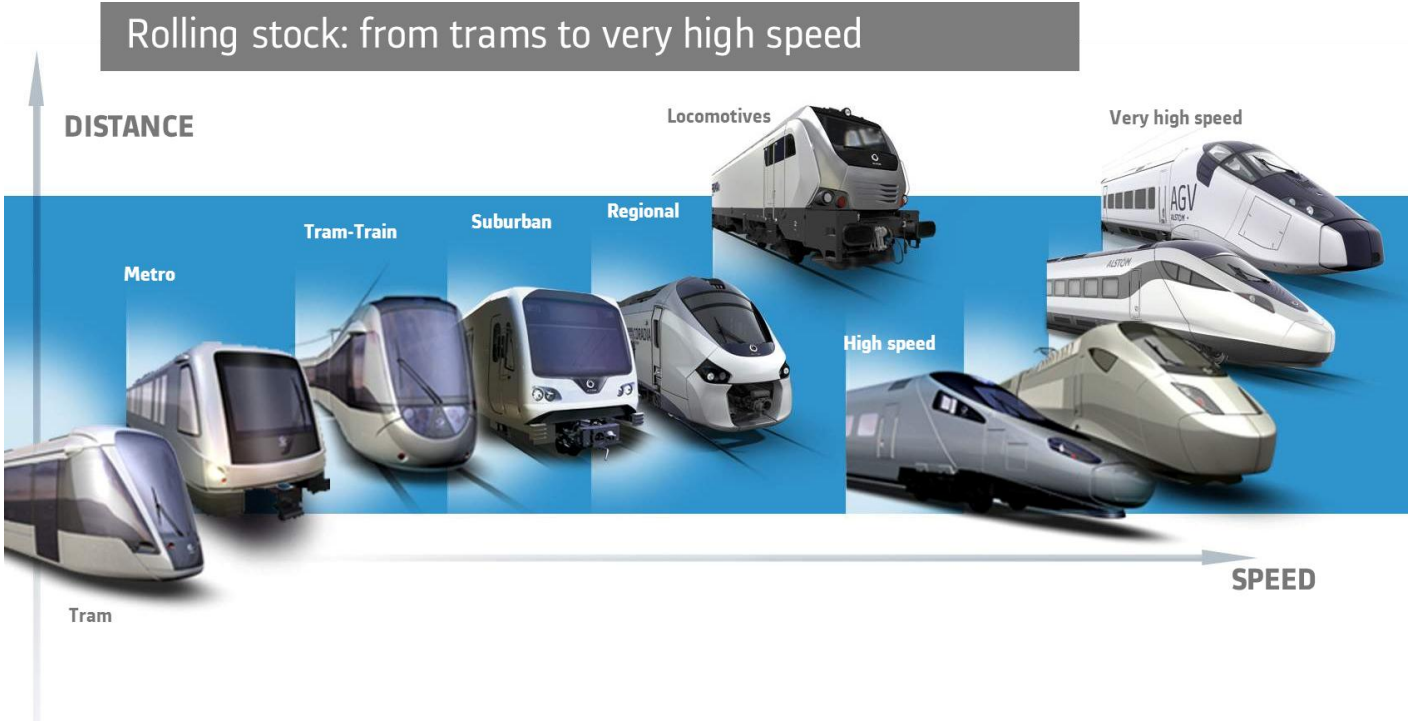
The ALSTOM RS context

- A wide range of product families



The ALSTOM RS context

- A system integrator role

CUSTOMERS

External need

(Input requirements)

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SUPPLIERS

Purchased Sub-systems

Subsystem specifications

Many potential sources of variation / diversity

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Why Systems Engineering (2)?

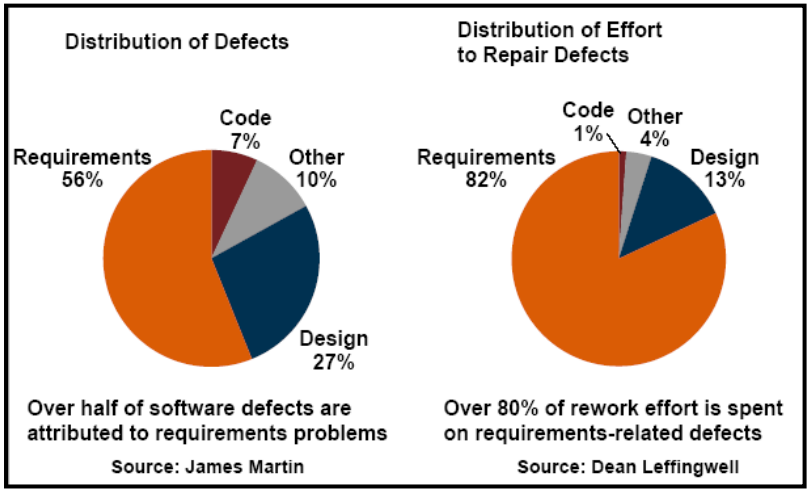
*"**Misunderstanding** is the most frequent form of **communication** between people"*

Peter Benary

Managing & Developing Requirements: Why?

- Many studies show the impact of Requirements on the Quality, Costs & Delivery Time of projects
  - The Chaos report, James Martin's "56%", Dean Leffingwell's "82%"...

CHAOS REPORT	Finished projects (overspent € or time)	Abandoned projects
Lack of user implication	**12,80%**	**12,40%**
Incomplete requirements and specifications	**12,30%**	**13,10%**
Requirements volatility	**11,80%**	**8,70%**
Lack of support from leaders	7,50%	9,30%
Technological Incompetency	7,00%	4,30%
Lack of resources	6,40%	10,60%
Unrealistic expectations	**5,90%**	**9,90%**
Poorly defined objectives	**5,30%**	**7,50% ***
Unrealistic time-schedule	**4,30%**	**8,10% ***
New technology	3,70%	6,20% *
Others	23%	9,90%



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Systems Engineering for ALSTOM

- "*SE is an interdisciplinary approach and means to* ***enable the realization of successful systems***"

- Very simple principles
  - Understand the problem – Investigate alternative solutions – Define and agree upon system architecture – Agree and manage the requirements – Agree and manage the interfaces – Prepare the test and support systems – Track progress against plan

Increasing project success, Reducing risks

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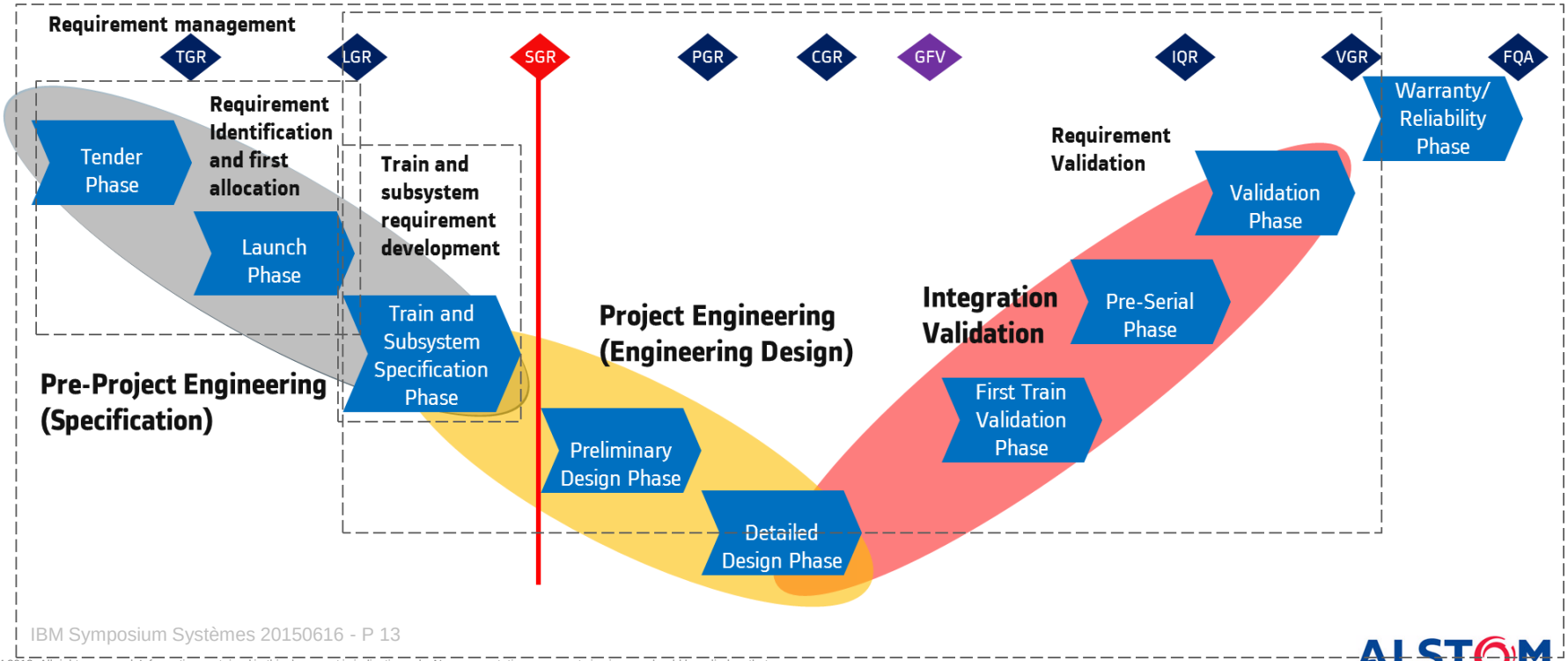
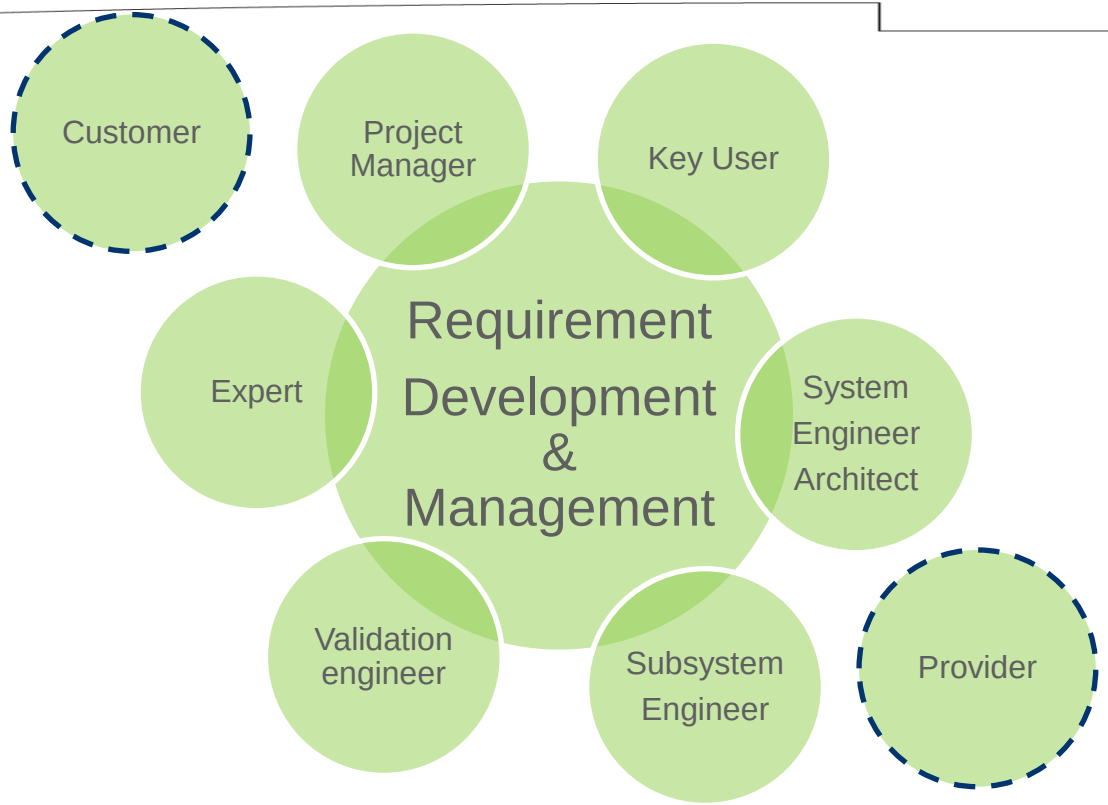
Current SE approach at Alstom RSC

Focus on Requirements Engineering

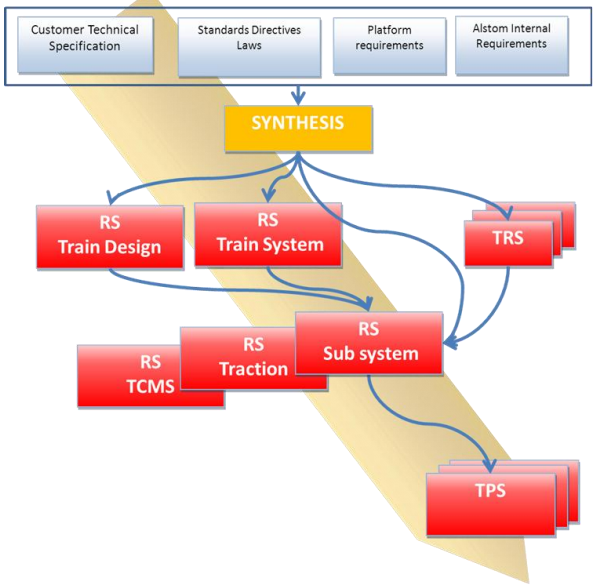


Roles and responsibilities

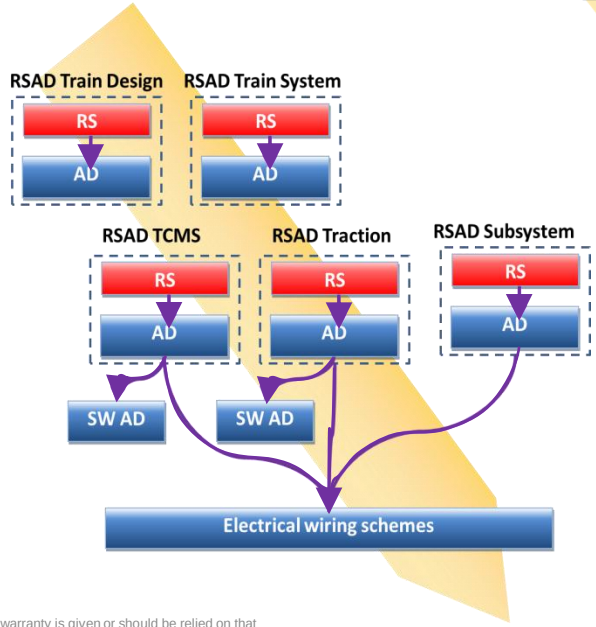


Full traceability process architecture

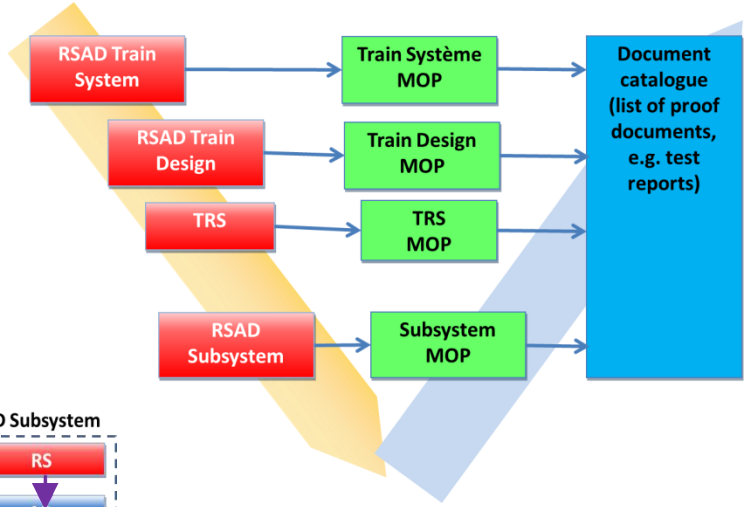
Requirement **DEVELOPMENT** traceability



SATISFACTION links

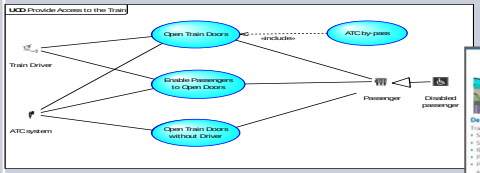


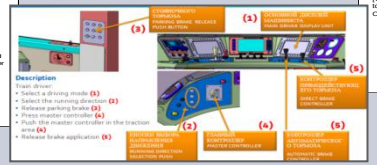
Requirement **VALIDATION** traceability

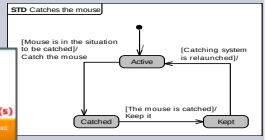


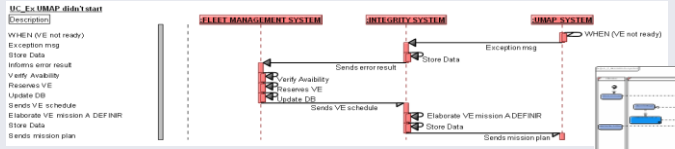
Focus on Architectural Design

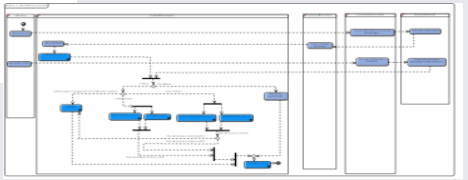
View Point	SysML Diagram
Operational	Use-case diagram Internal block diagram State Diagrams
Functional (train level)	Sequence diagrams or Activity diagrams
Constructional (train / subsystem levels)	Block definition diagram Internal block diagram

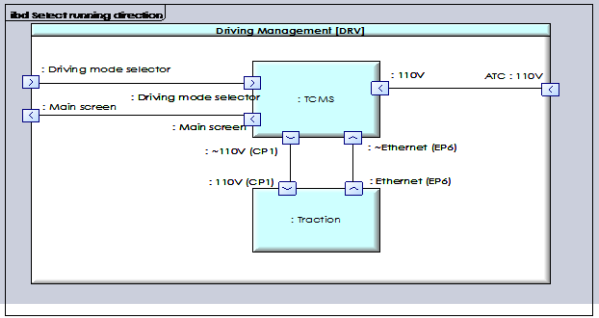




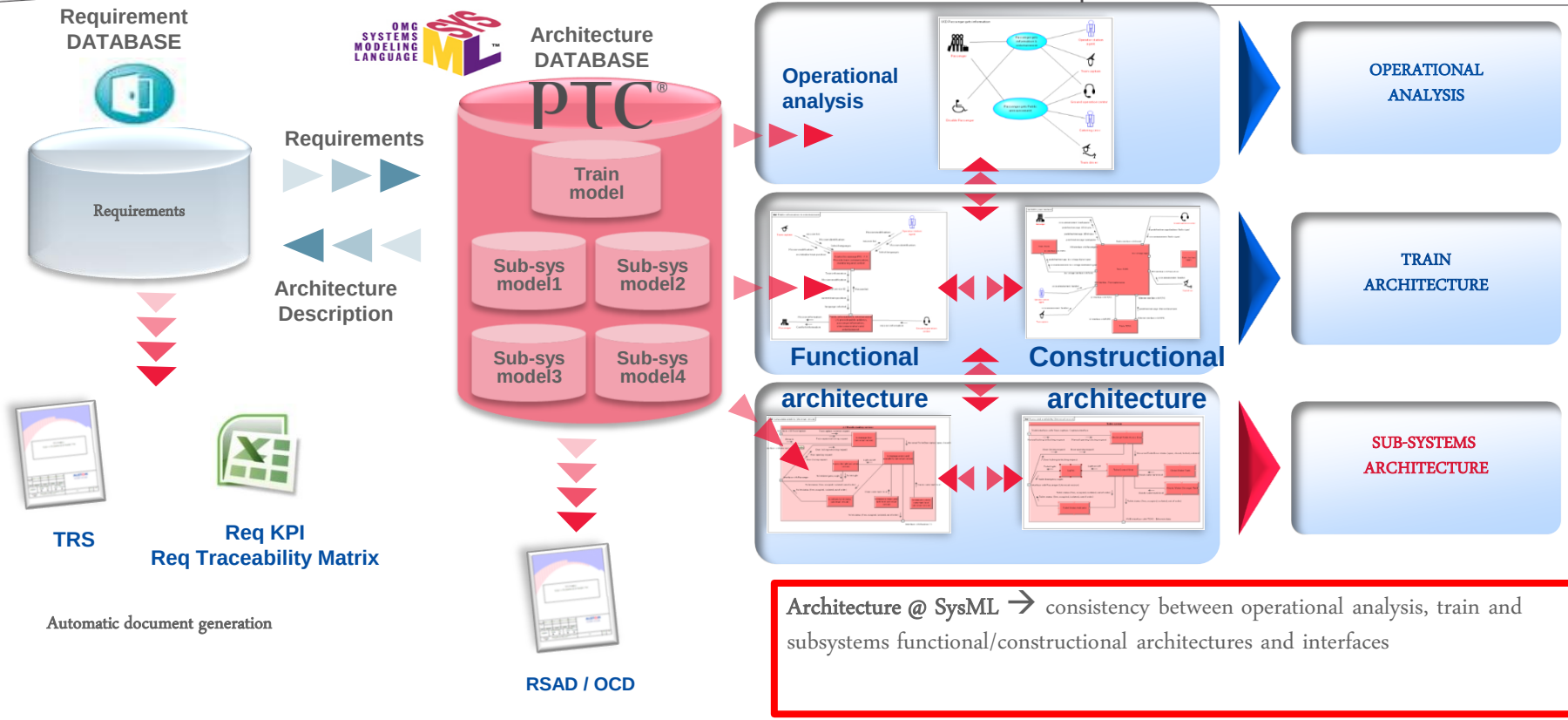








Current SE tool architecture at Alstom RSC



Architecture @ SysML → consistency between operational analysis, train and subsystems functional/constructional architectures and interfaces

Product Line Engineering & Reuse

- Reuse is related to concepts like **platform** engineering, **product family** engineering or Product Line Engineering (**PLE**)

- PLE defines a process to manage the underlying architectures of the product platforms (or portfolio) of an organization in order to maximize the benefits of reuse
  - “Architectures”: all kinds of structured, organized data used to characterize our systems in their entirety

- **Reuse** should be the result of a well-documented decision process

  → Implementing PLE requires upfront investment and thought

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Alstom Transport Vision on PLE

Combine MBSE and PLE into something like “MBPLSE” (Model-Based Product Line Systems Engineering) in order to yield even more benefits than each of these practices alone can.

Improve our business (our profitability) by maximizing the benefits of reuse

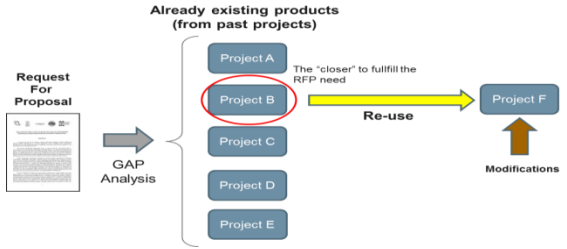
Defining the reuse strategy

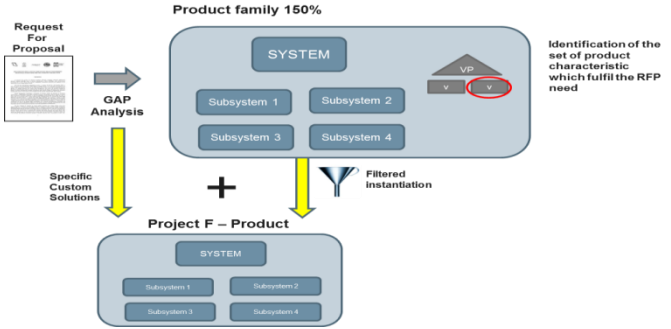
A specific strategy according to **business opportunities** and the level of "PLE maturity"

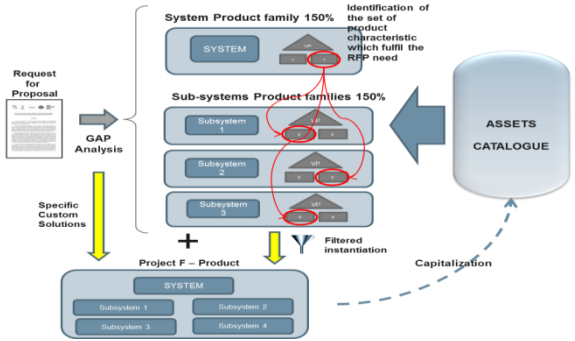
basic reuse

150%" rolling stock product family.

System and Subsystems catalogue of buildings blocks



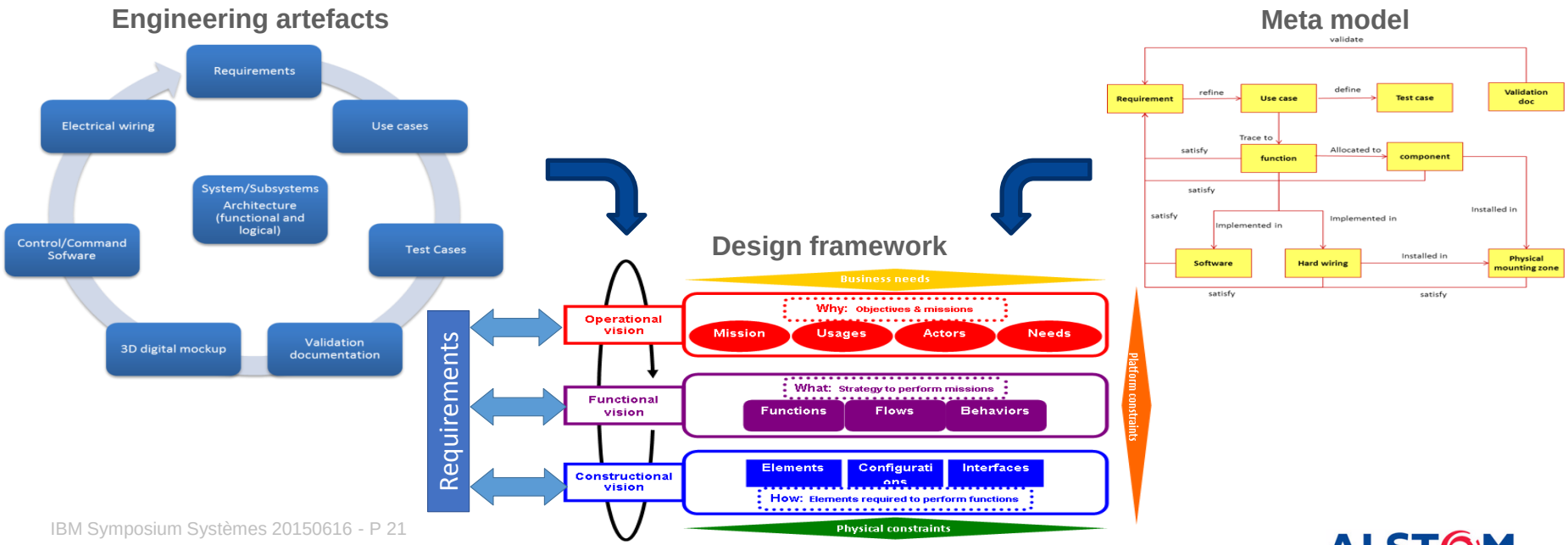




Model Based PLE Framework – Needs (1)

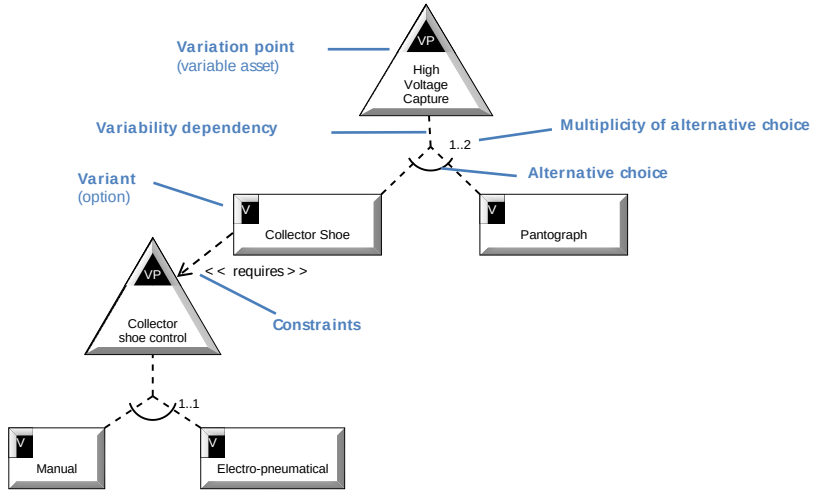
Upgrade the Engineering Artefacts must be

- Properly linked to each other: consistency of the problem and design spaces
- **Variability-ready**: possess a *configurability* capability



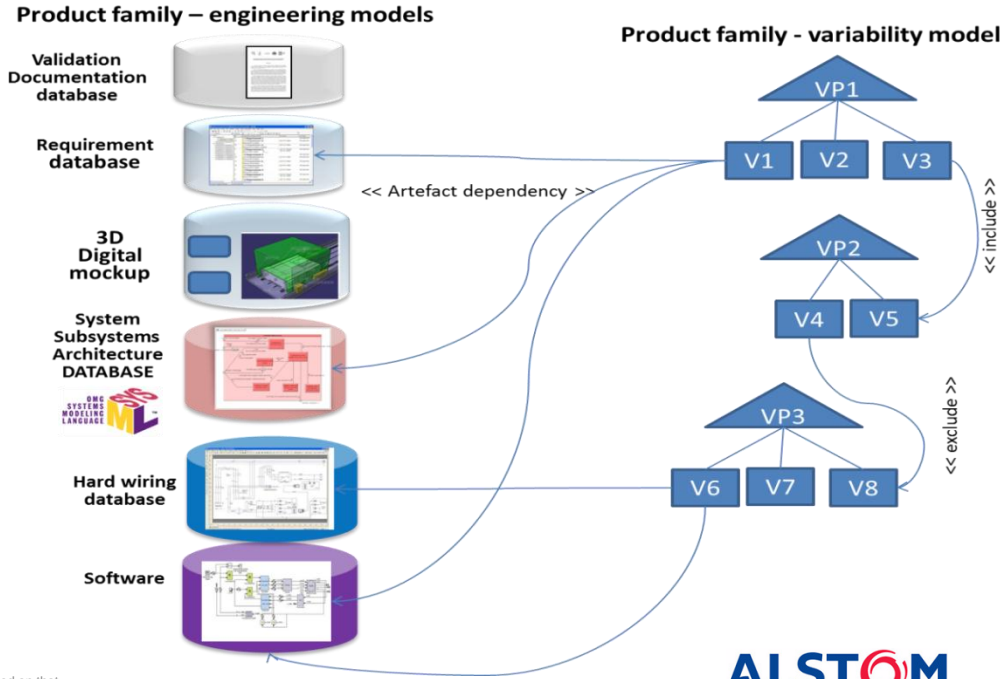
Model Based PLE Framework – Needs (2)

Describe the product line **variability** (e.g. using OVM*)

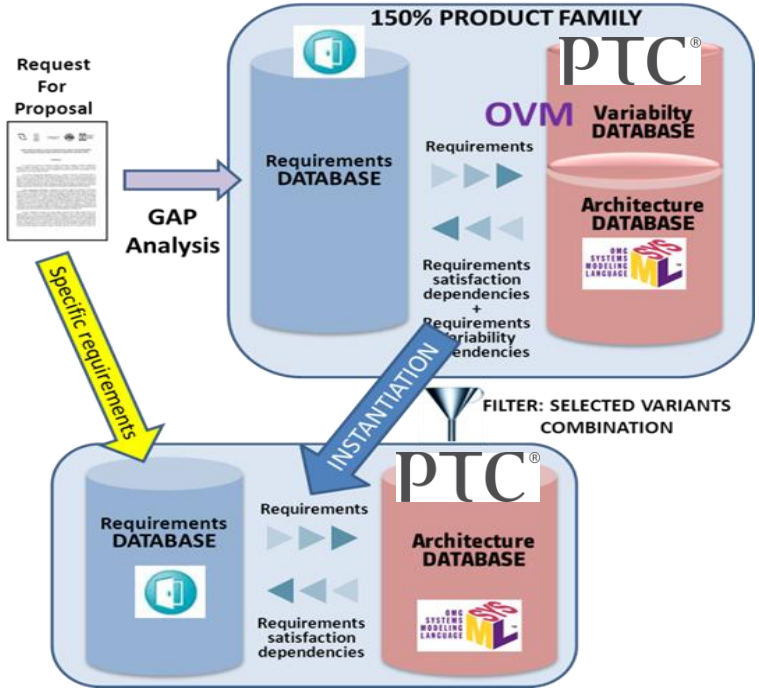


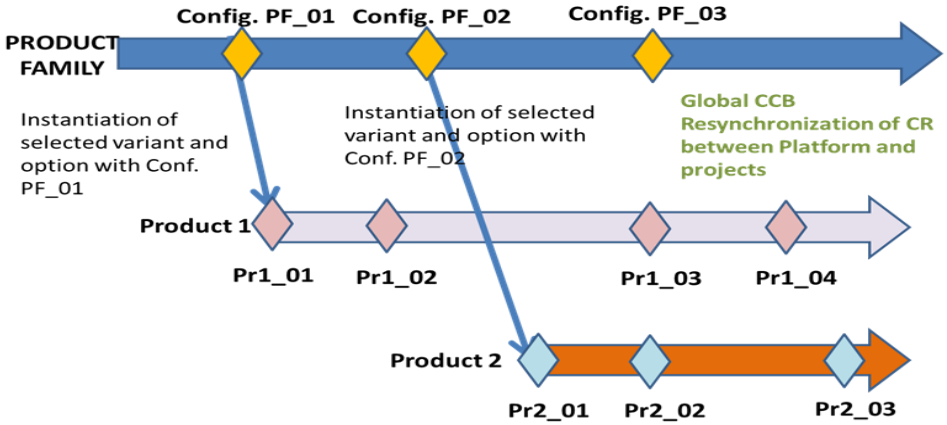
*Orthogonal Variability Model

State the **dependencies** between **variants** and engineering **artefacts**

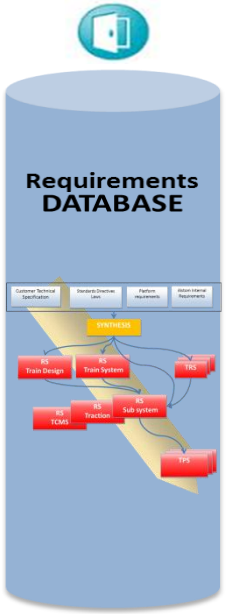


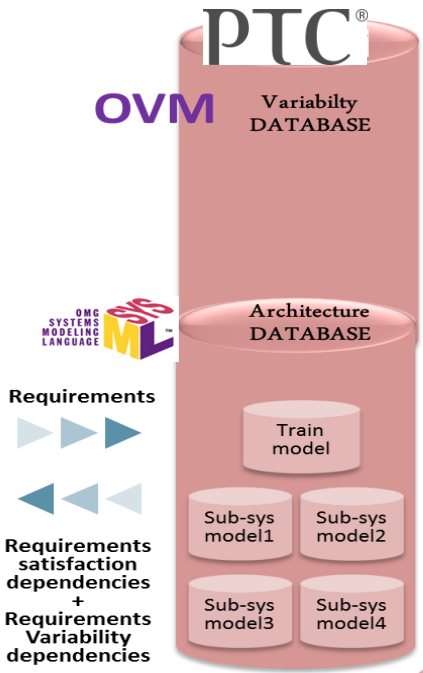
Change & configuration management on another dimension

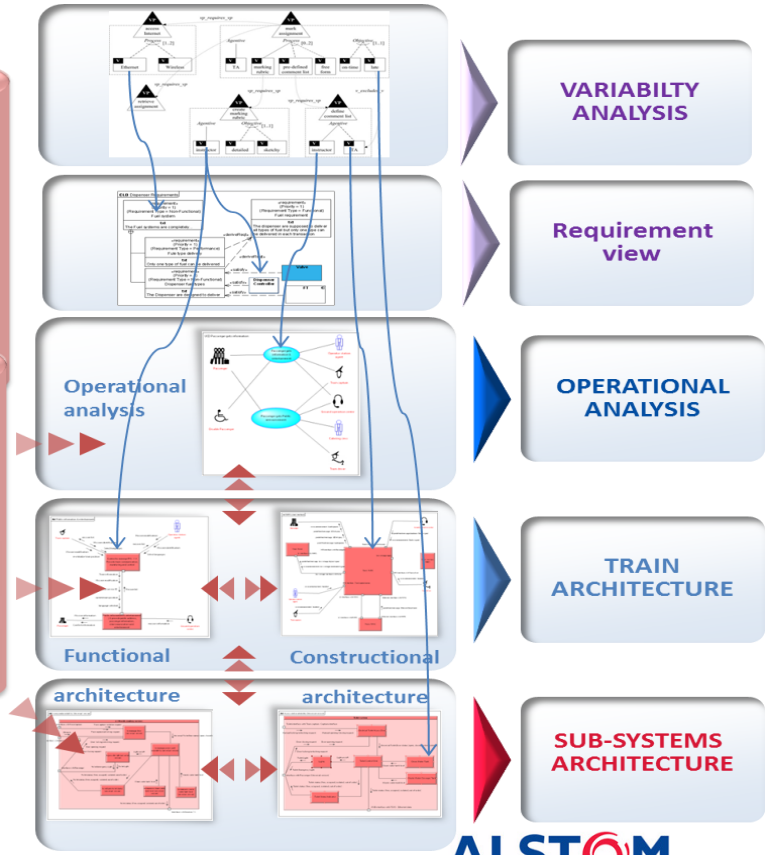




Application of a 2nd generation reuse strategy to a Metro product family







First results on PLE

- **1st project**. The application of the new approach resulted in the reduction of fixed engineering costs of about 50% during the requirement development phase for an estimated 80% carry-over scheme

- **2nd project**. Similar results: estimated benefit (50%), higher carry-over (nearly 95%) **but** in a completely different context (different team, novice users, off shore site, IT environment)

State of the SE deployment

On **Rolling Stock** product lines

- First pilot project involved 8-10 system engineers for 6 months in 2012 → Feasibility of the approach and process refinement
- **Today**
  - **~18** projects are using Requirement Management and Development process with DOORS, involving around 200 engineers
  - **3** major projects (+ 2 candidates) launched with the application of the full MBSE process involving around 40 MBSE engineers

→ **Standby**: rethink modelling rules, improve tooling and competency

On **Information solution** product lines

- First pilot project involved 5 system engineers for 1 year (September 2009)
- **Today** several projects (R&D and running projects) launched with the application of the full process, involving almost 40 system engineers

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Future work

- Repository of *modular assets* and *composable* train architectures
  - → Modify our modelling practices: ***design for variability & reuse***
- Define reuse efficiency measurements to support the decision making process in our projects
- Deeper reflection to move closer to a ***Full Product Line*** for Rolling Stock and Components
  - Commonality between product lines or product families

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Key points for the deployment of MBSE and PLE

COMMUNICATE CLEARLY and keep EXPECTATIONS and SCOPE under control. **Cultural Change is a challenge**

Other key factors to be carefully considered

- 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

It is all about people

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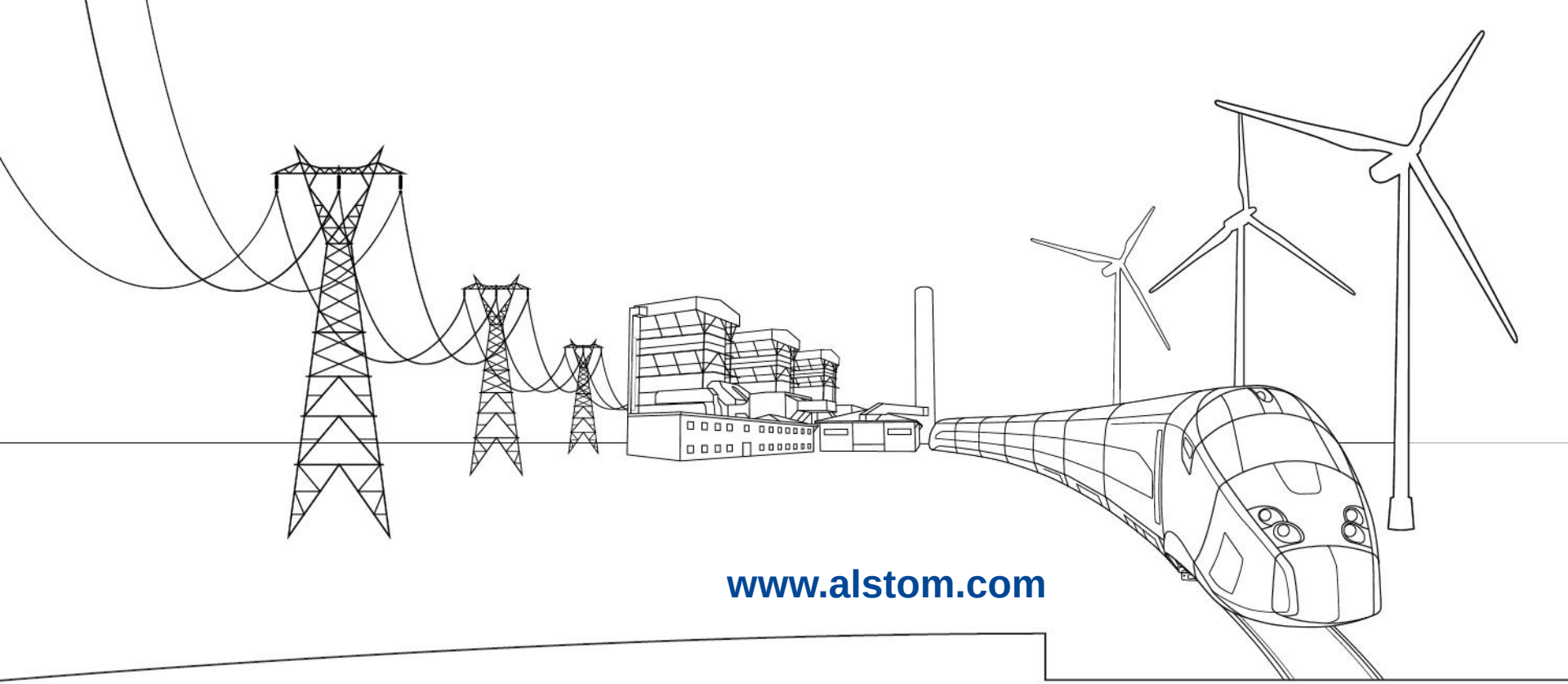

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