

How to Boost Product Line Engineering with MBSE A Case Study of a Rolling Stock Product Line

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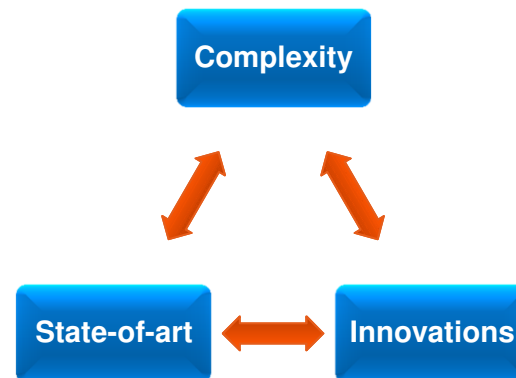


Content

- Introduction – towards a reuse strategy
 - The railway rolling stock context
 - Product Line Engineering & MBSE
- Three “generations” of reuse
- A Model-Based Product Line SE framework
- 2nd generation reuse strategy for a Metro product line
- Conclusions and future work

The railways rolling stock context

- Need for better, safer and more reliable systems developed at lower costs and shorter times-to-market



Practically no system is created “from scratch”

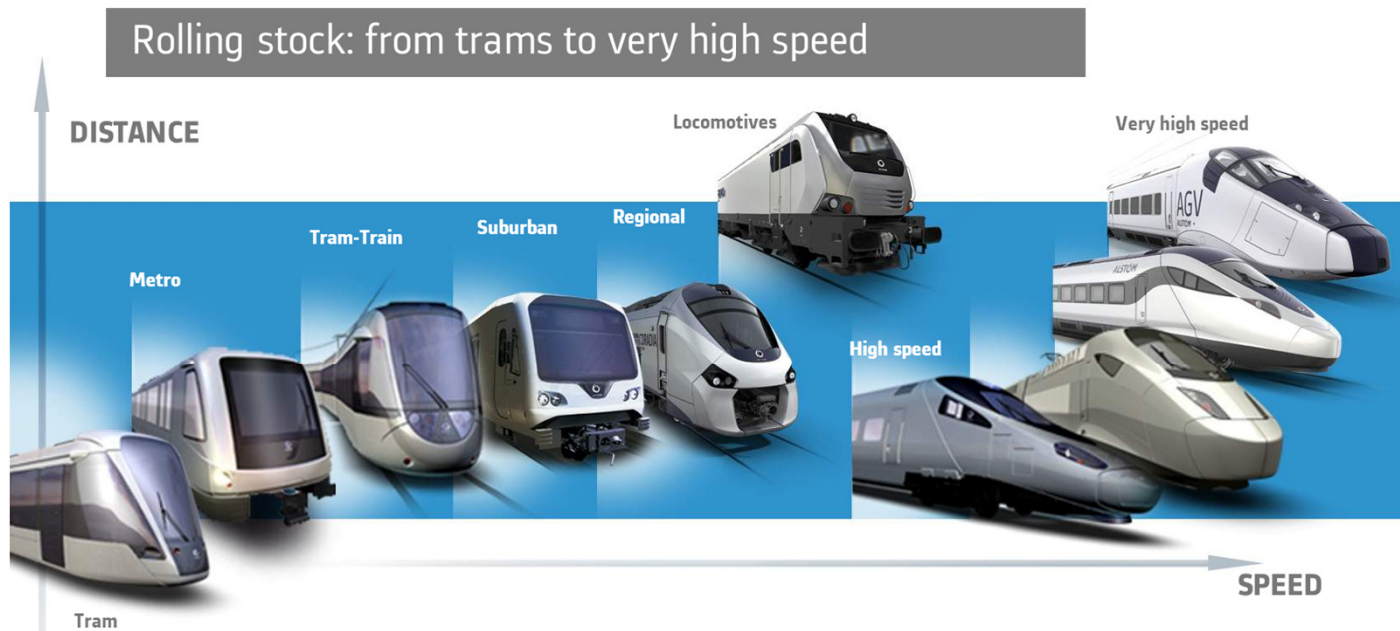
- **Reuse** to leverage previously developed assets into a new project in order to improve quality, cost effectiveness, time to delivery or risk mitigation

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

The ALSTOM RS context

- A wide range of product families



The ALSTOM RS context

- A system integrator role



Many potential sources of variation / diversity

Model-Based Systems Engineering

- MBSE is the application of modelling techniques to support the SE process activities
- MBSE shifts the nature of representation of systems from prose forms to explicit data structures and representations
- Expected benefits include improvement in quality and communication, costless traceability, increase of productivity
- MBSE is no panacea and its application and deployment in an organization requires deep reflection and (again) investment

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.

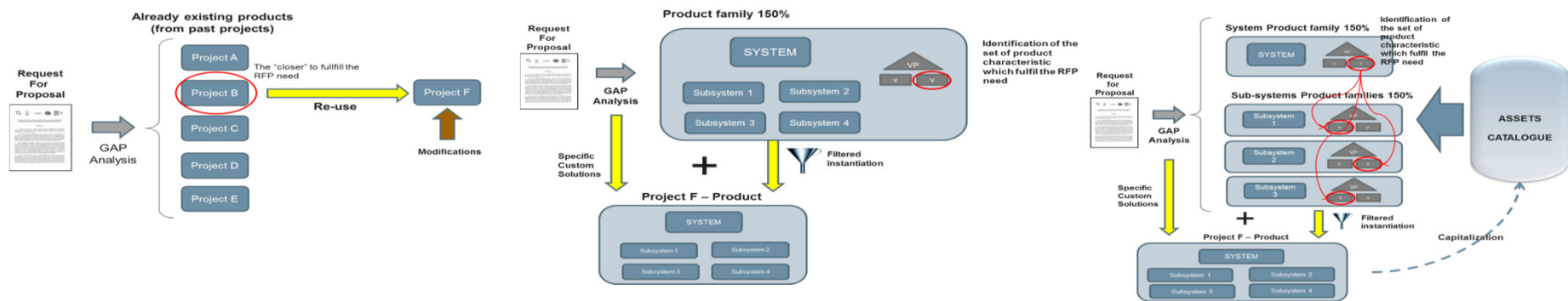
Improve our business (our profitability) by maximizing the benefits of reuse

Opportunistic & Strategic Reuse

- Opportunistic or “bottom-up” reuse is often the default strategy of organizations trying to obtain savings through reuse
 - Component reuse through architectural strategies (Platforms, Modular components...)
 - Manufacturing (flexible assembly lines)
- Strategic reuse is a more organizational, process-oriented approach
 - Greater expected benefits, but requires a different point of view on reuse
 - Can bridge the gap between customer needs or marketing offer and the final train production phase in plants
 - Focuses on the reuse of all systems life-cycle assets, but requires a mature asset repository and available resources to tailor assets to a particular project application

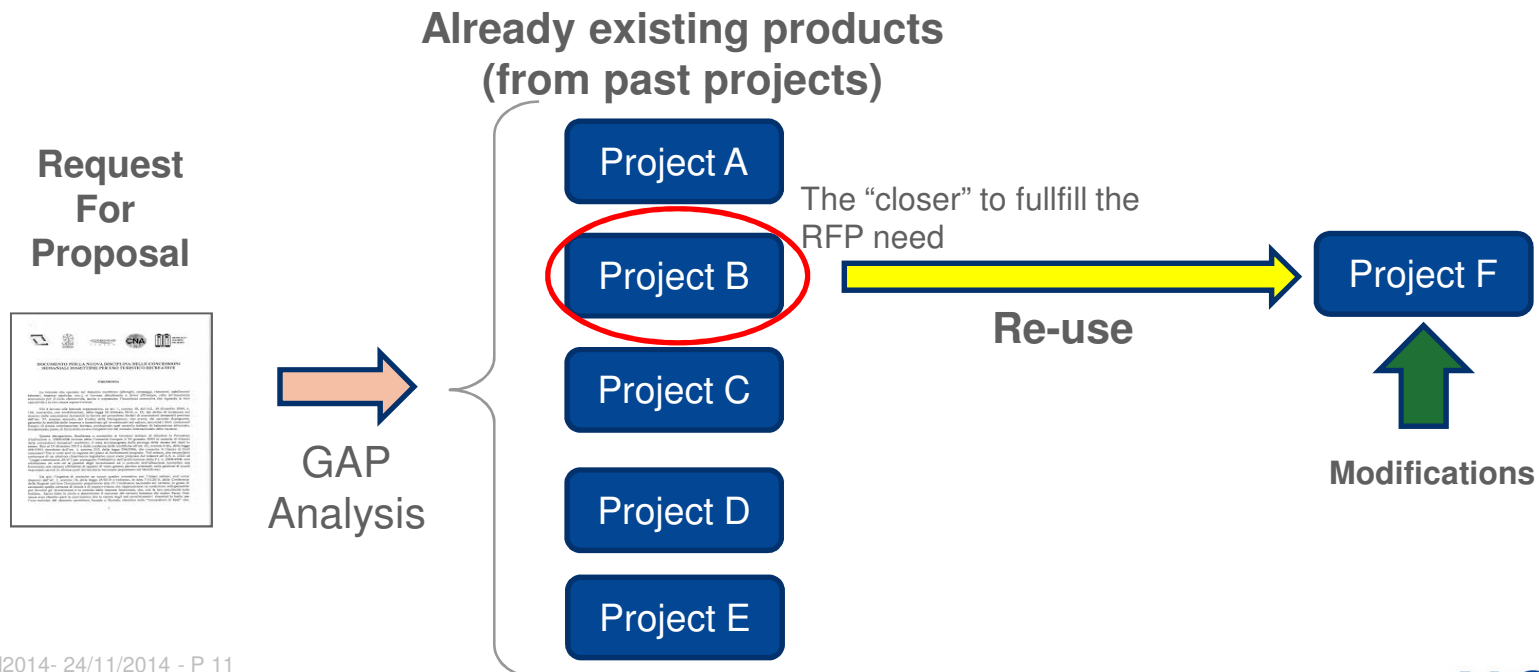
Defining the reuse strategy

A specific strategy according to the product line engineering level of maturity or business opportunity



First generation reuse strategy or “basic reuse”

First generation strategy, the « opportunistic » reuse: select the closest previous project, clone and modify



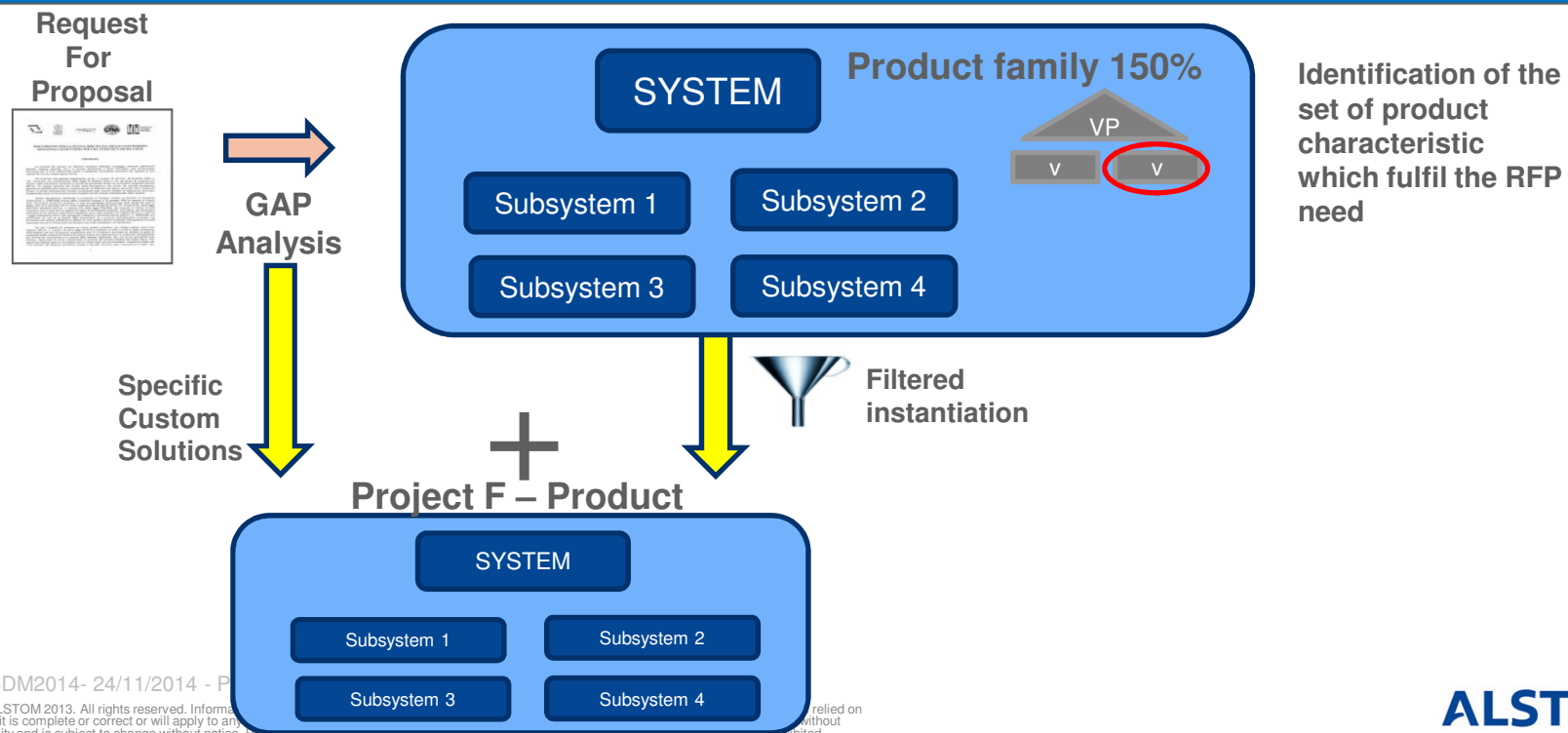
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Second generation reuse or “150%” rolling stock product family

Second generation strategy: create 150% product family and instantiate project by re-using the necessary part of the platform to answer customer needs



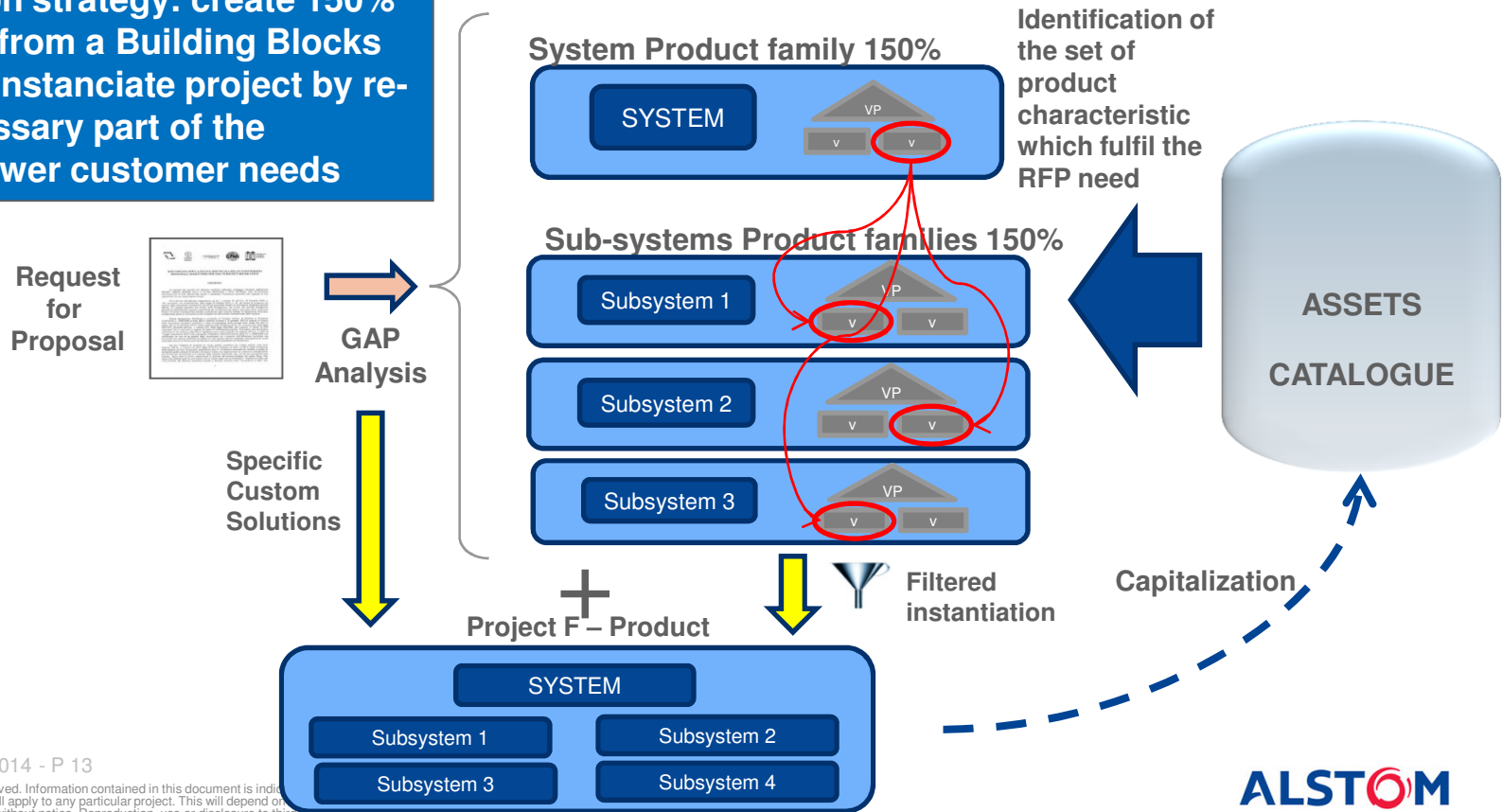
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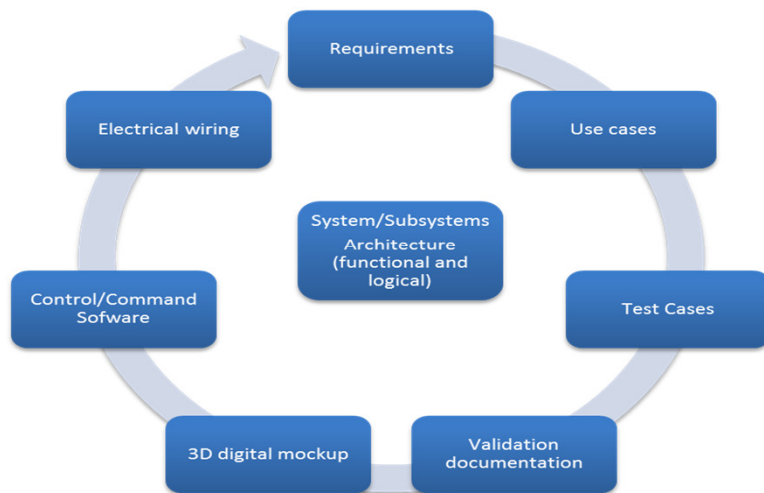
Third generation reuse or “System and Subsystems catalogue of buildings blocks”

Third generation strategy: create 150% product family from a Building Blocks catalogue and instantiate project by re-using the necessary part of the platform to answer customer needs

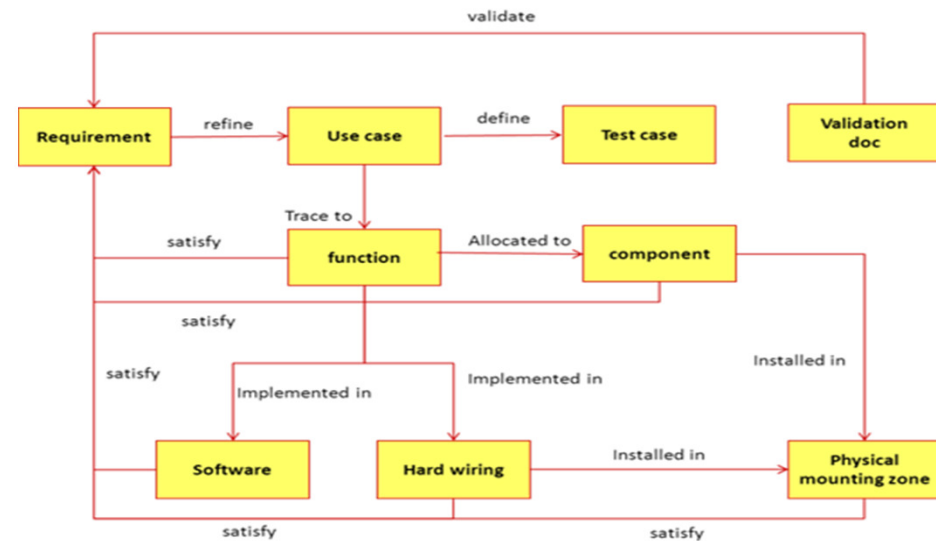


Model Based Framework for MBSE and PLE

A Product family is made of engineering artefacts, which shall be linked each other (meta model) in order to create a global coherency and consistency



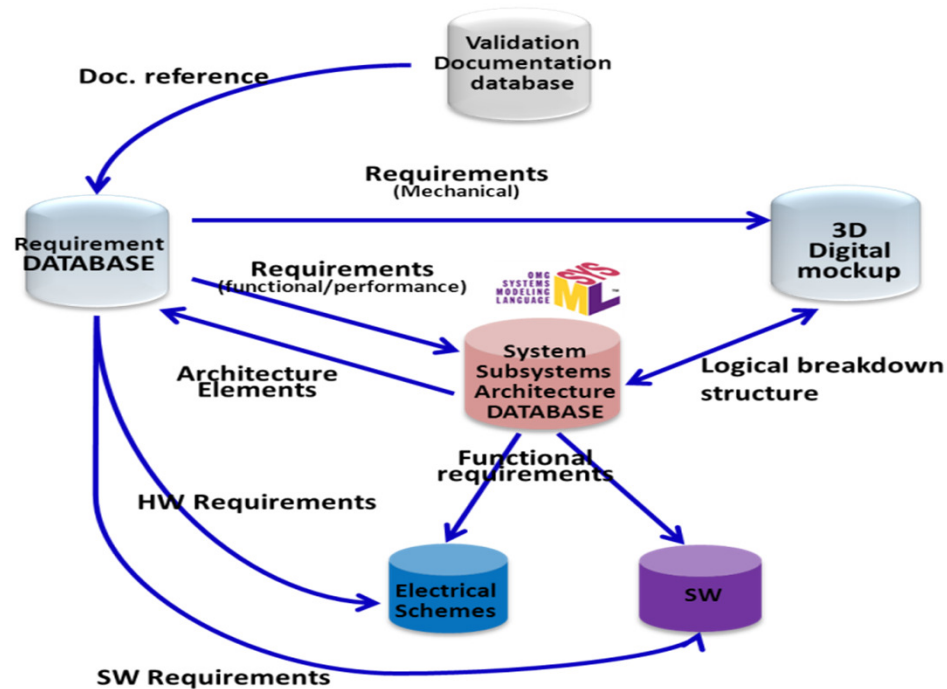
Engineering artefacts



Meta model

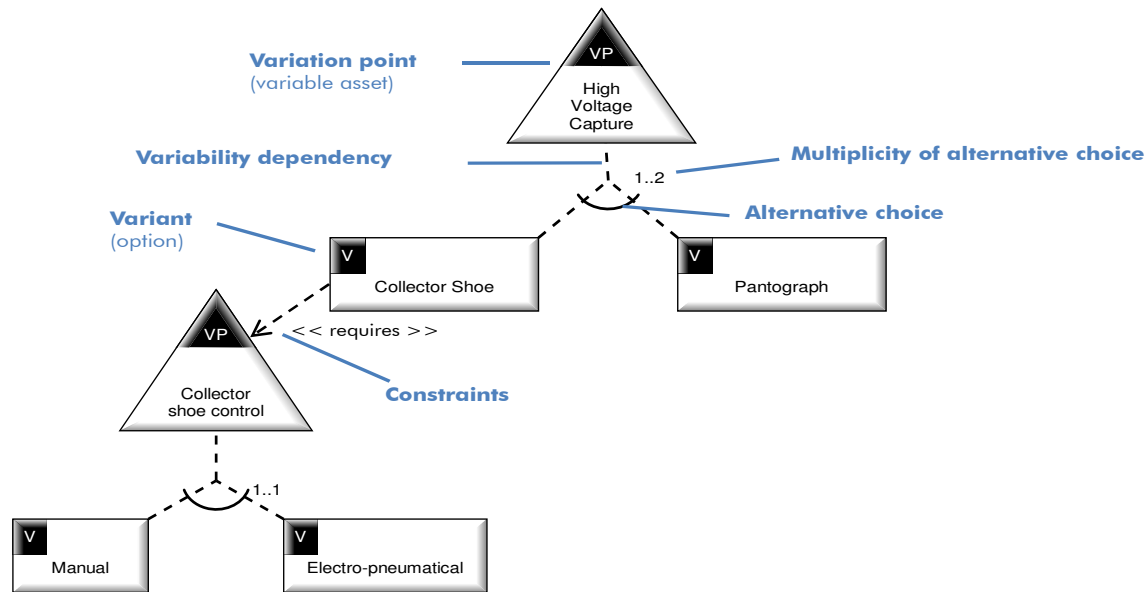
Model Based Framework for MBSE and PLE

Translating the meta model into links between databases which contain the engineering artefacts:



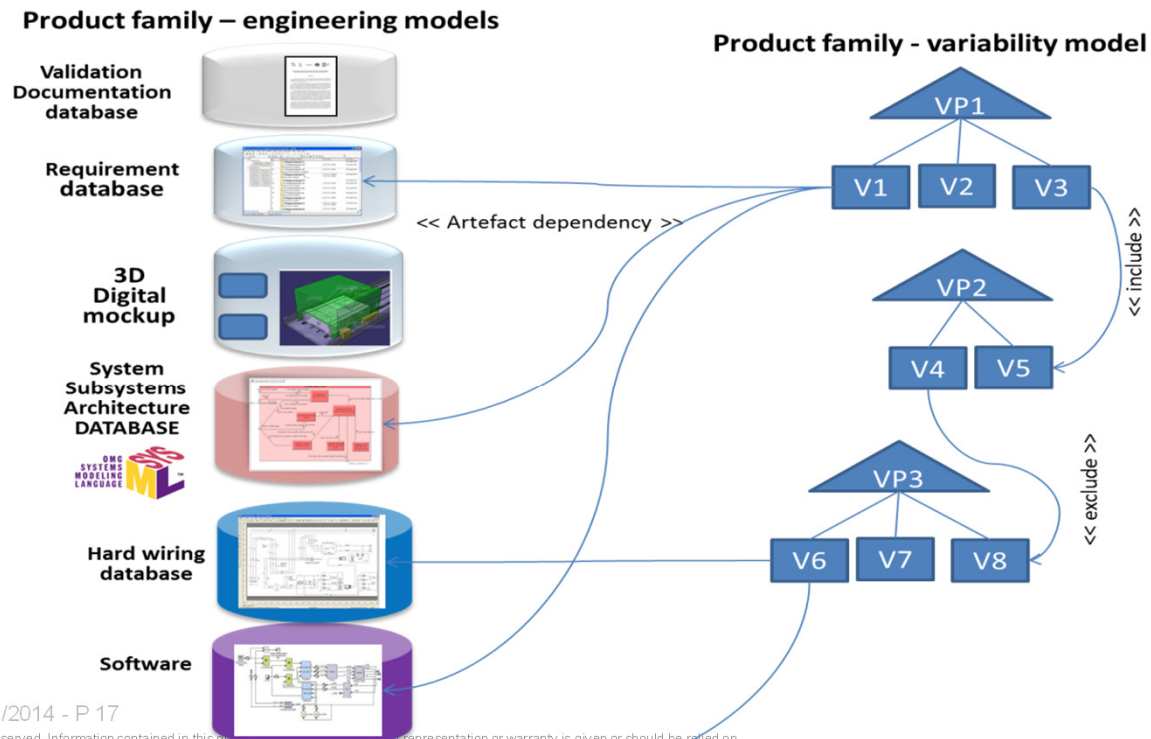
Model Based Framework for MBSE and PLE

To correctly describe the 150% product family, it's mandatory to describe the product variability. One possible solution is the OVM language.



Model Based Framework for MBSE and PLE

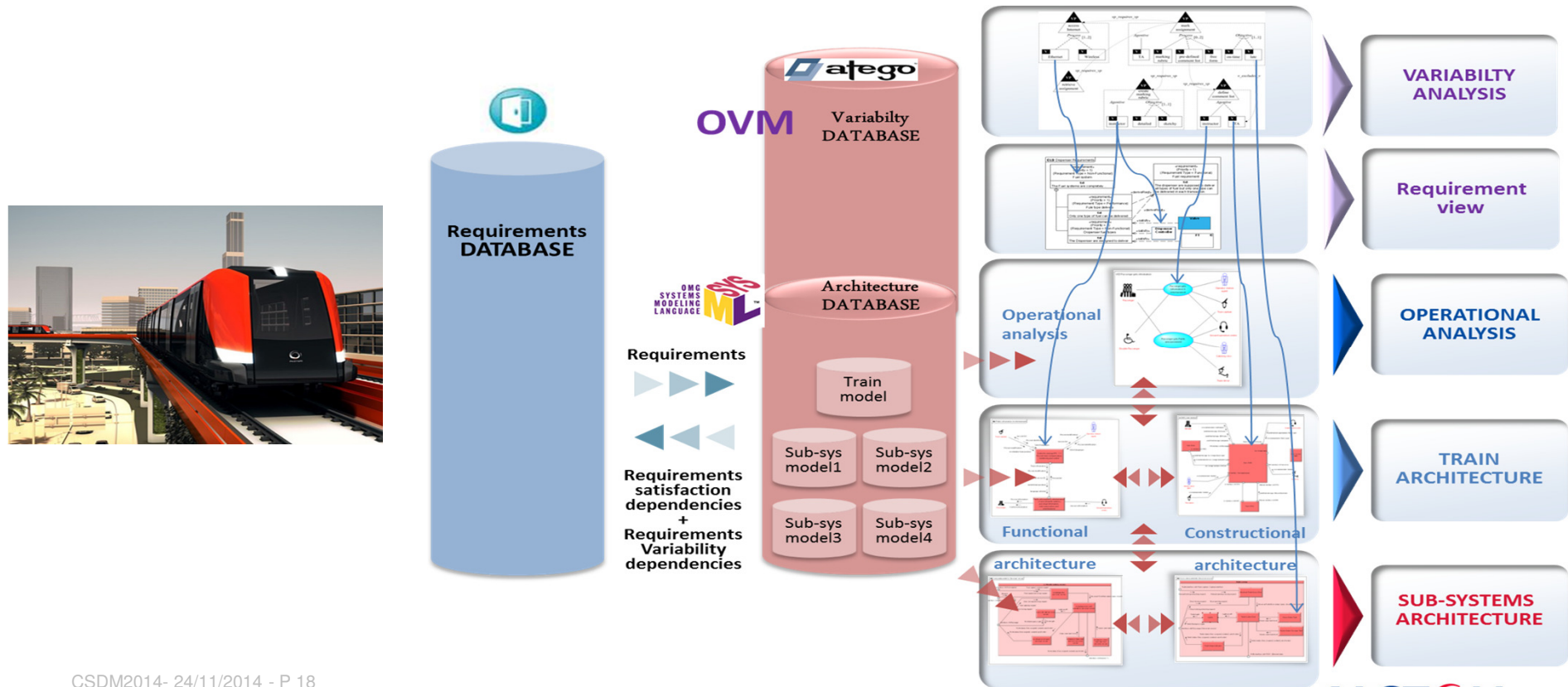
To correctly describe the 150% product family, it's mandatory to state the dependencies between variability and engineering artefacts. One possible solution is the use of artefact dependency links.



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

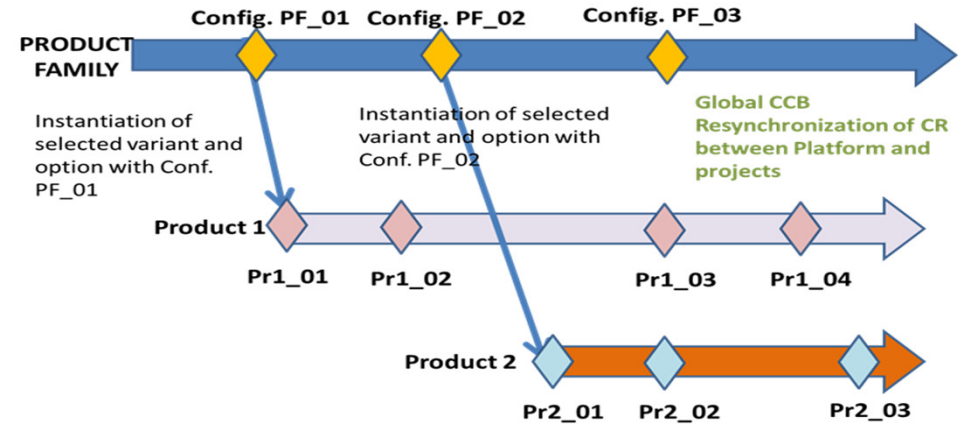
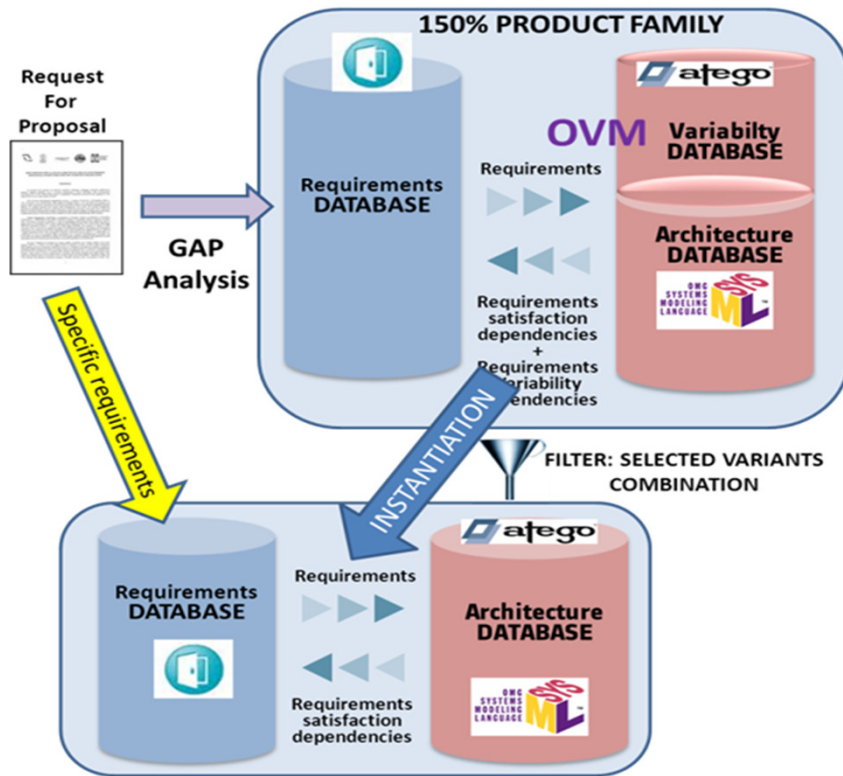


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Application of a 2nd generation reuse strategy to a Metro product family



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Results and Conclusions

- The application of this new approach resulted in the reduction of fixed engineering costs of about 50% during requirement development phase for an estimated 80% carry-over scheme
- Most of the variability sources in our product family belong to the system (train) level. Other than different options on technical solutions (mostly, solutions proposed by providers), little variability has been identified elsewhere at subsystem level
- Change and configuration management might become an issue when managing many products/projects in parallel

Results and Conclusions

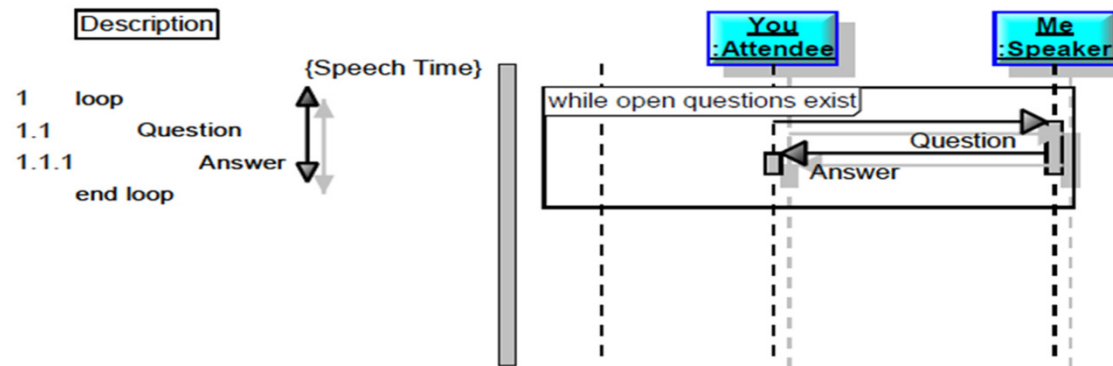
- Cultural background is a challenge for PLE and for MBSE
 - In the mind of most actors, reuse concerns only tangible final products
 - What about context analysis? Or modifications to the reused product?
 - What about less *tangible* products?
 - They must be formalized and then adapted to specific project contexts

- If PLE is understood and implemented poorly, the significant investments that are required will result in underachievement of expected benefits

Future work

- Definition and elaboration of a repository of “modular assets” and of “*composable*” train architectures
 - Modification of our modelling practices
- Definition of reuse efficiency measurements, which will be useful for supporting the decision making process for our projects
- Deeper reflection to move closer to a “Full Product Line” for Rolling Stock material
 - Commonality between product lines or product families

Questions & Answers



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