SysML & OVM:
Model-based Engineering of Product Lines

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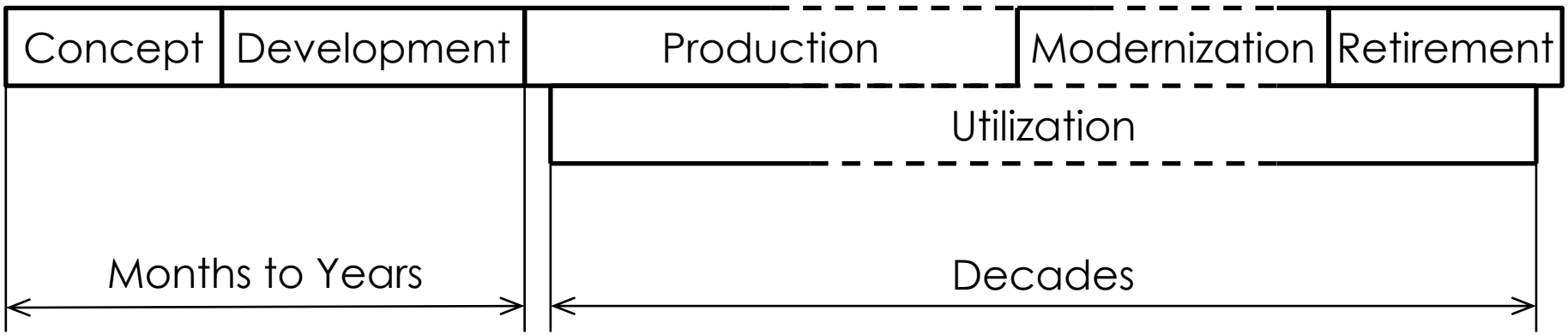
Overview

- Product Line Engineering
- An Elevator Example in SysML & OVM
- Summary

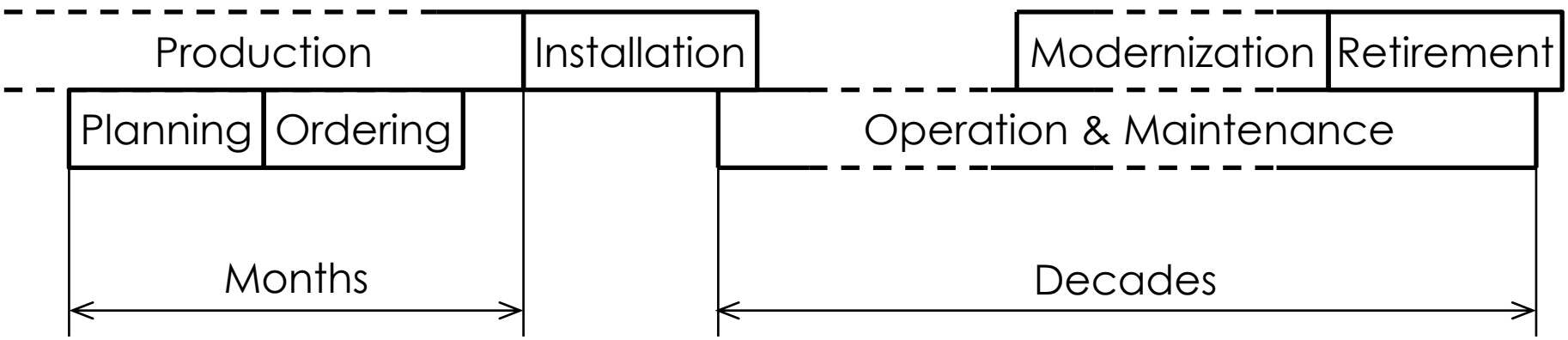
PRODUCT LINE ENGINEERING

Product Life Cycles

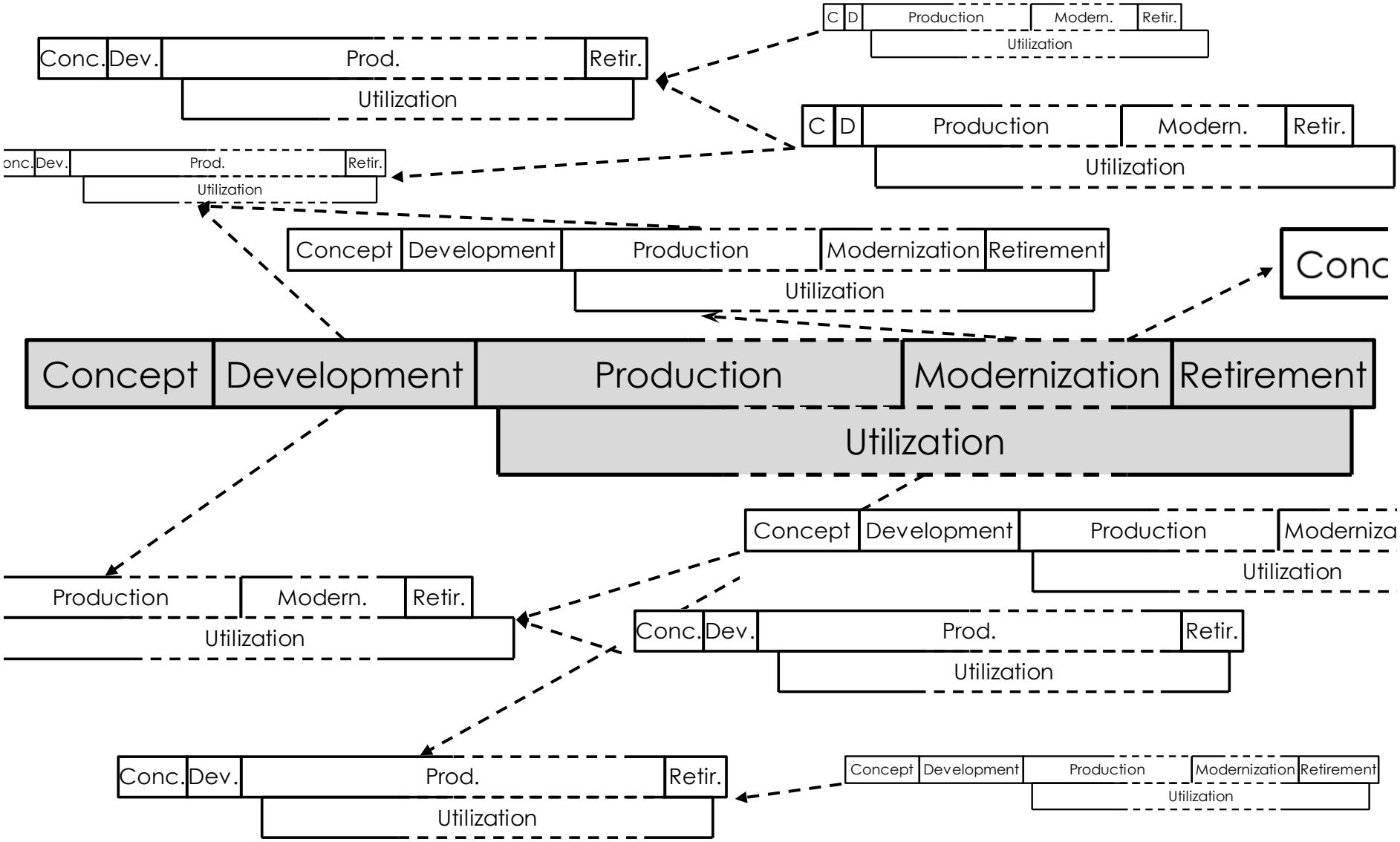
A Product **Type** Life Cycle



A Product **Instance** Life Cycle



System of Systems Life Cycles

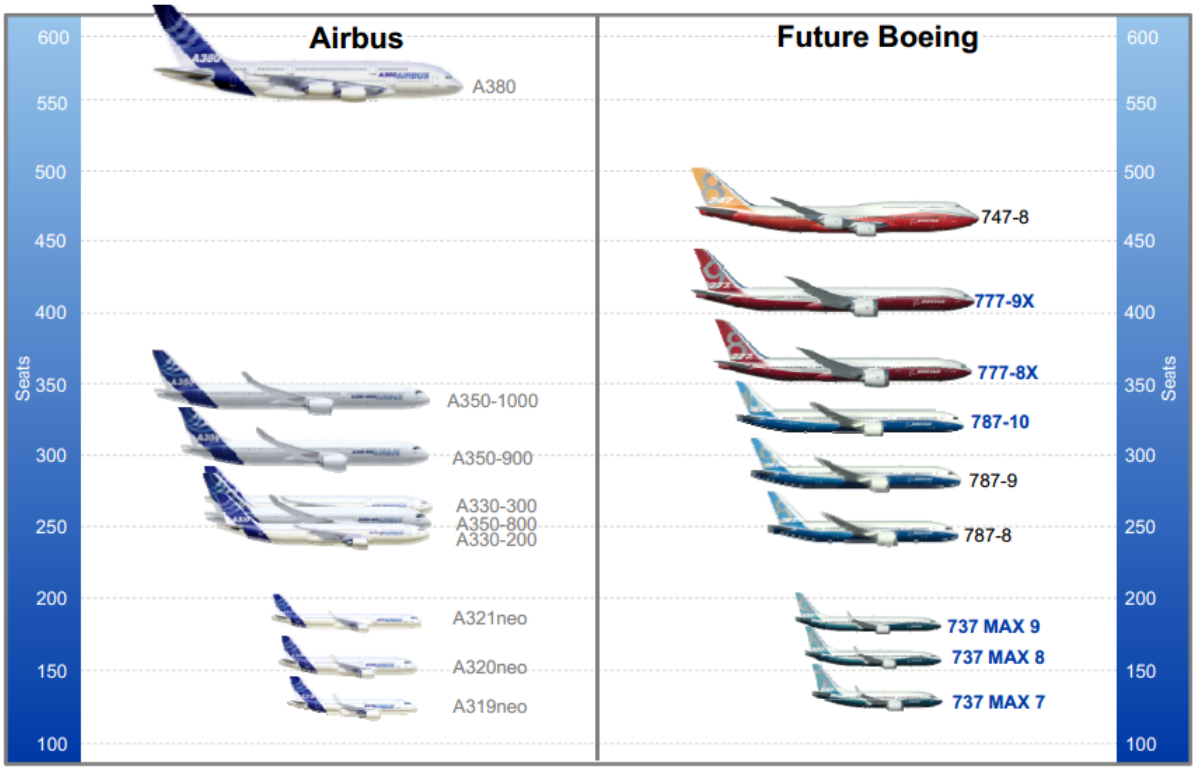


What is Product Line Engineering (PLE)?

Product Line Engineering (PLE) is a way to engineer a portfolio of related products in an efficient manner, taking full advantage of the products' similarities while respecting and managing their differences. This affects all activities involved in planning, producing, delivering, deploying, sustaining, and retiring products.

Typical applications:

- Automotive
- Aviation
- Engines/Machines
- Computers
- Buildings
- Banking products
- Standard Software
- …



Why Product Line Engineering (PLE)?

When PLE?

- Systems with shared components across variants
- Systems with optional/alternative or parametrizable components
- Complex dependencies between options

Benefits of PLE

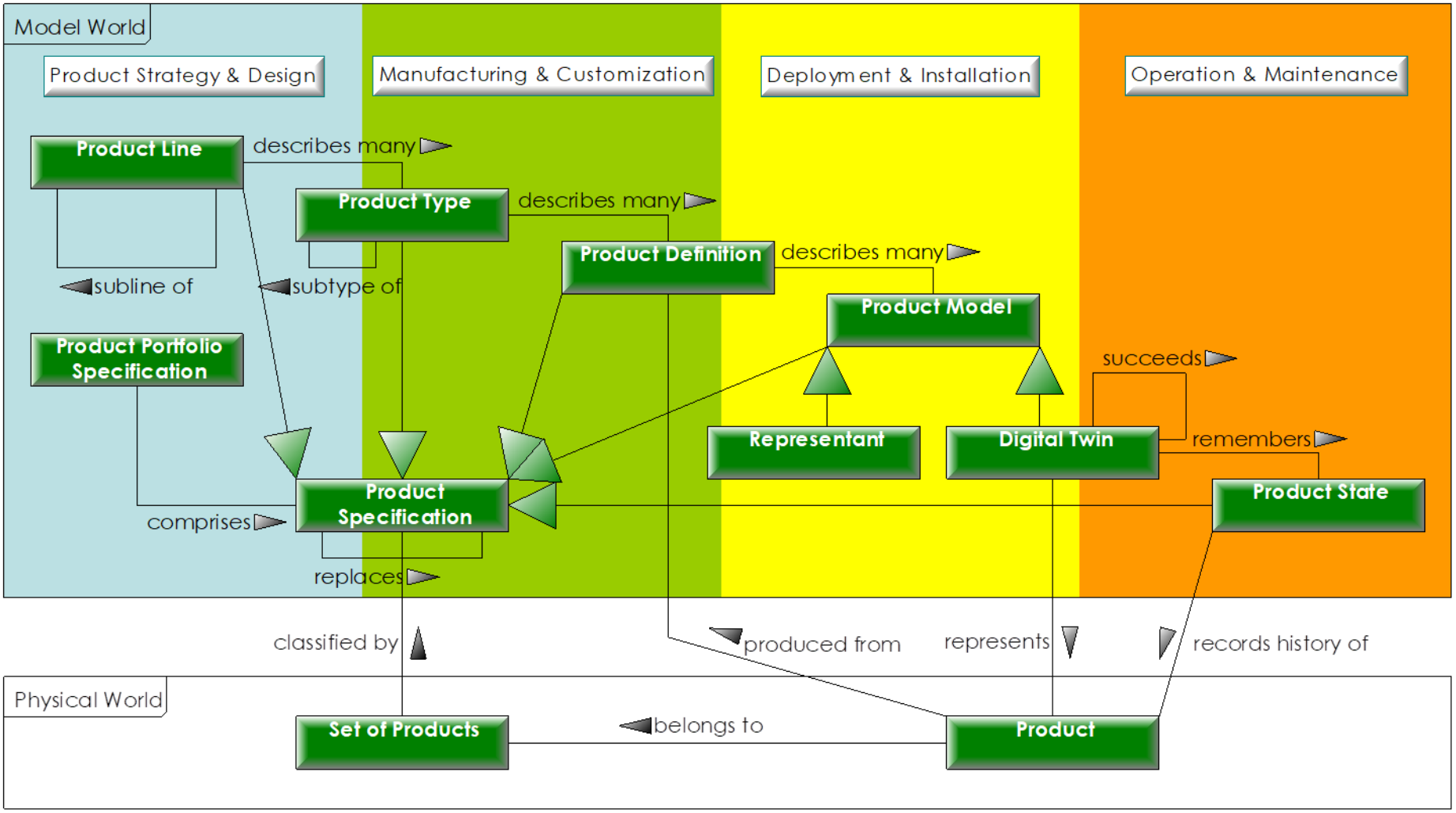
- Reduced time to market
- Improved quality through increased reusability
- Reduced complexity in stock-keeping

Subjects of PLE modeling

- Requirements & specifications
- Architectures & designs
- Validations & verifications
- Manuals & documents

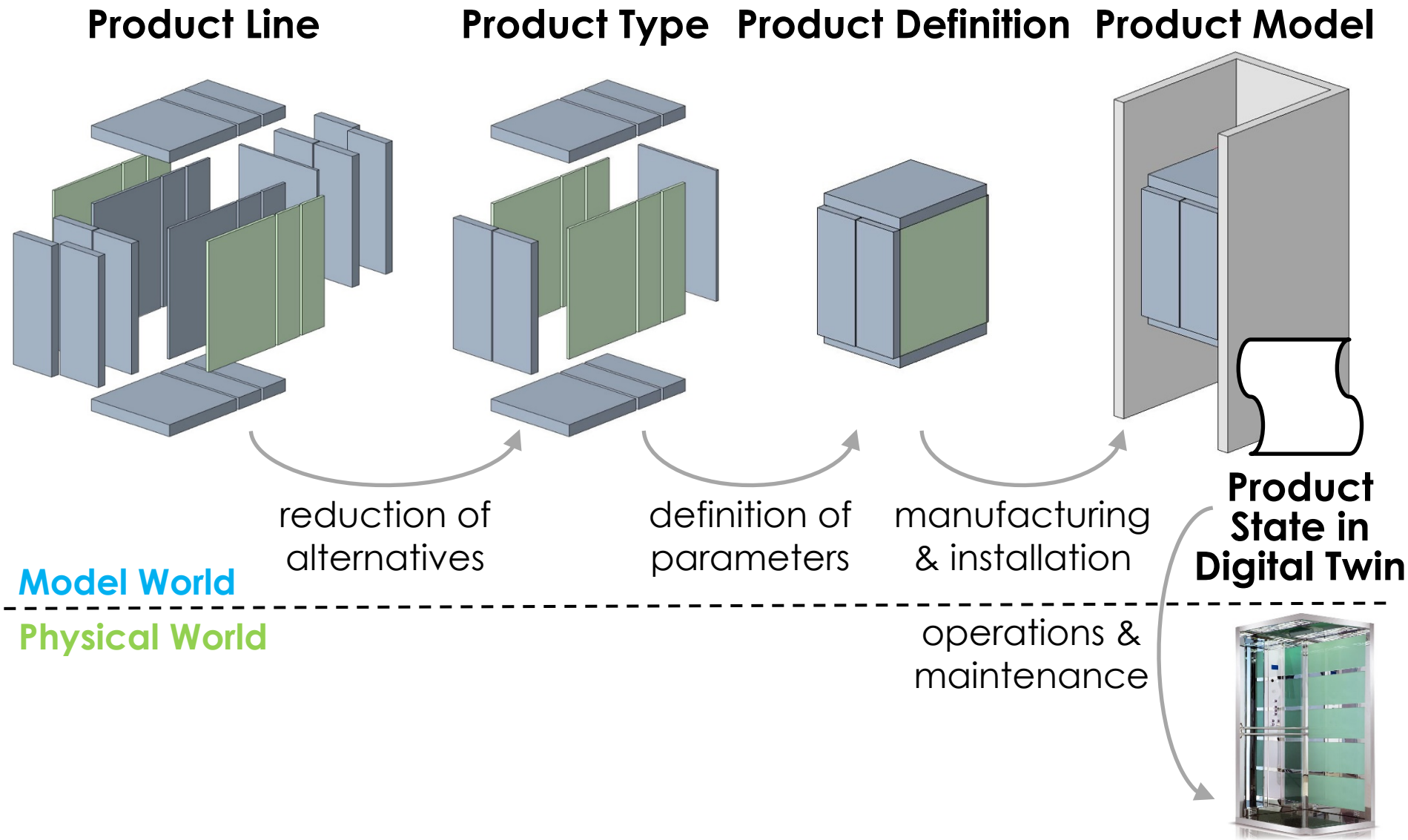
} of system components

PLE Concepts



AN ELEVATOR EXAMPLE IN SYSML & OVM

From Product Line to the Digital Twin



Orthogonal Variability Modeling (OVM)

OVM is PLE approach based on ISO 26550, that has originally been developed at the PALUNO Institute of University Duisburg-Essen.

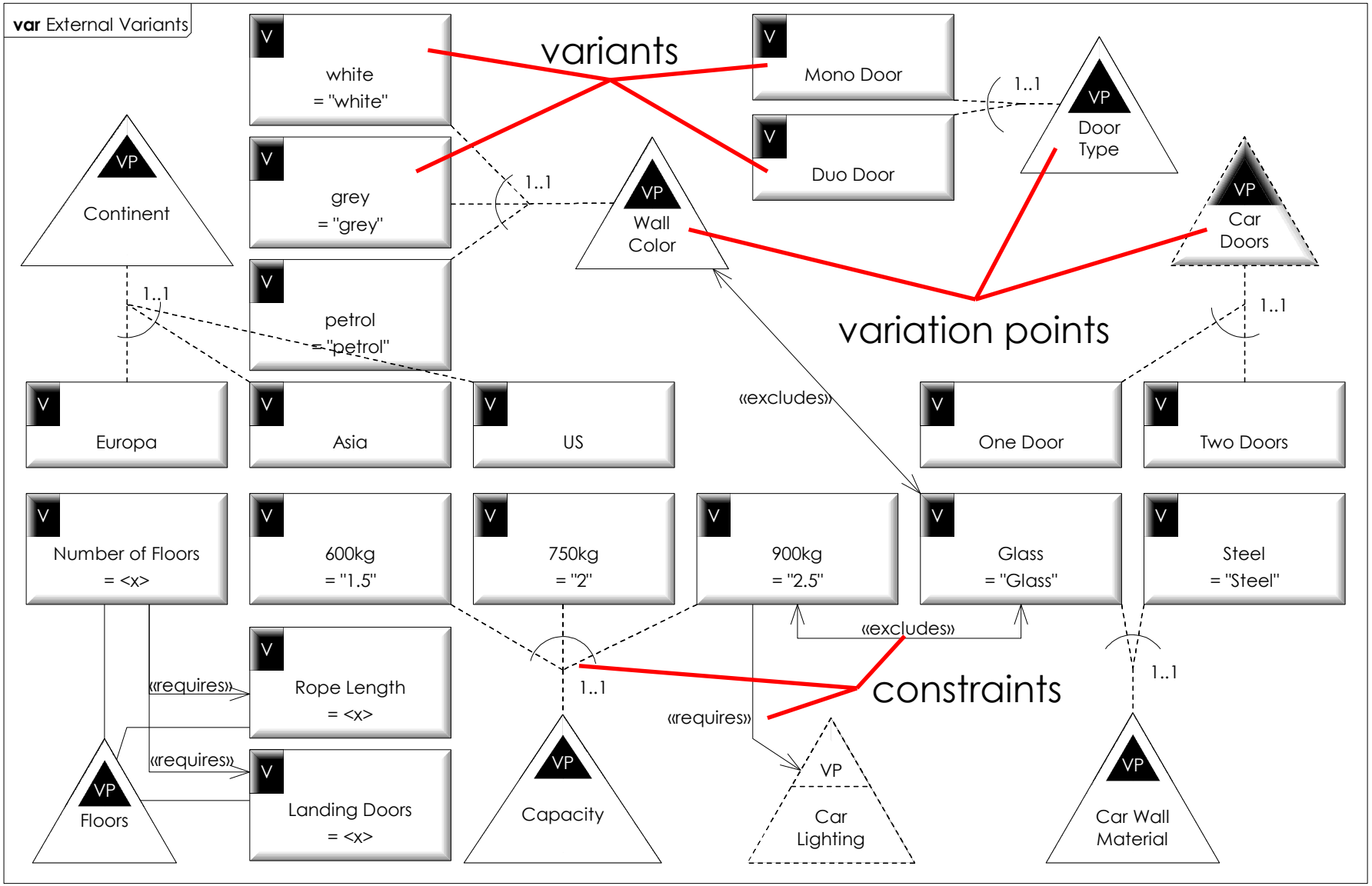
OVM distinguishes two **orthogonal** models:

- The **System Model** describes the components of a Product Line
- The **Variability Model** describes selectable Options of the Product Line as well as constraints among those options

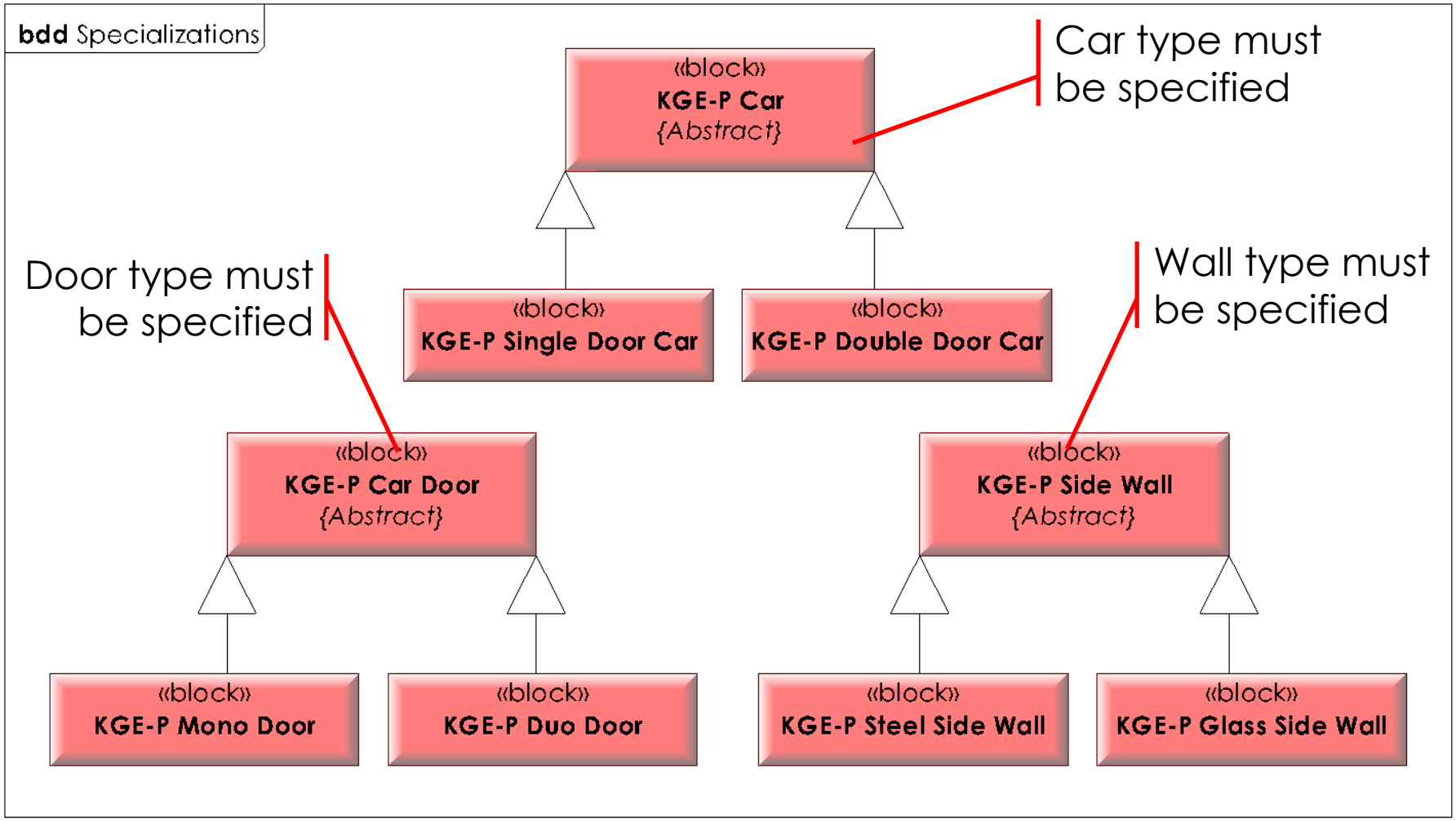
By defining dependencies between options from the variability model and model items in the system model, the system model may automatically be pruned from unnecessary model items after deciding the options.

⇨ **Applying variability decisions on a system model results in successive model transformations!**

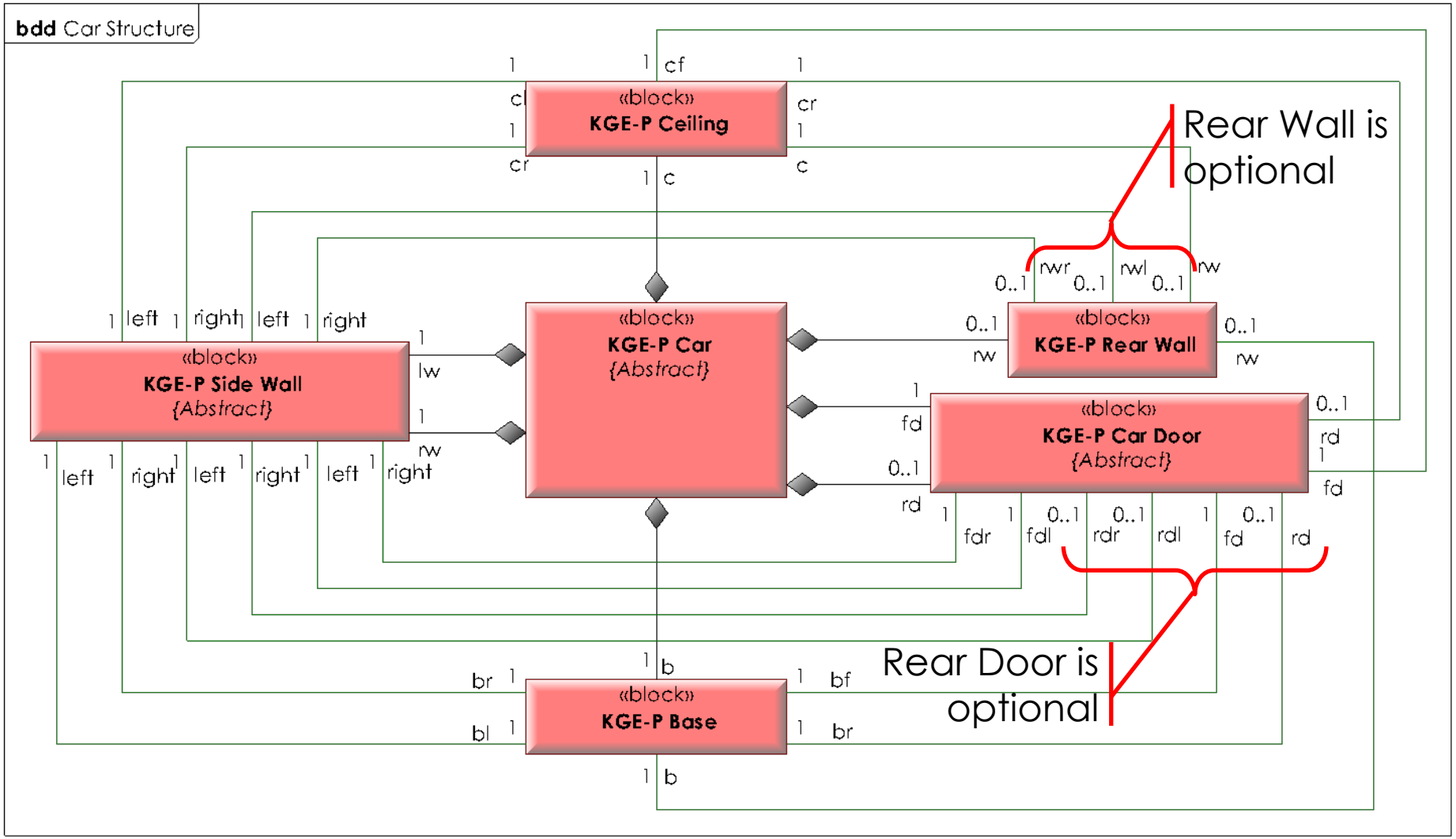
An OVM Variability Model



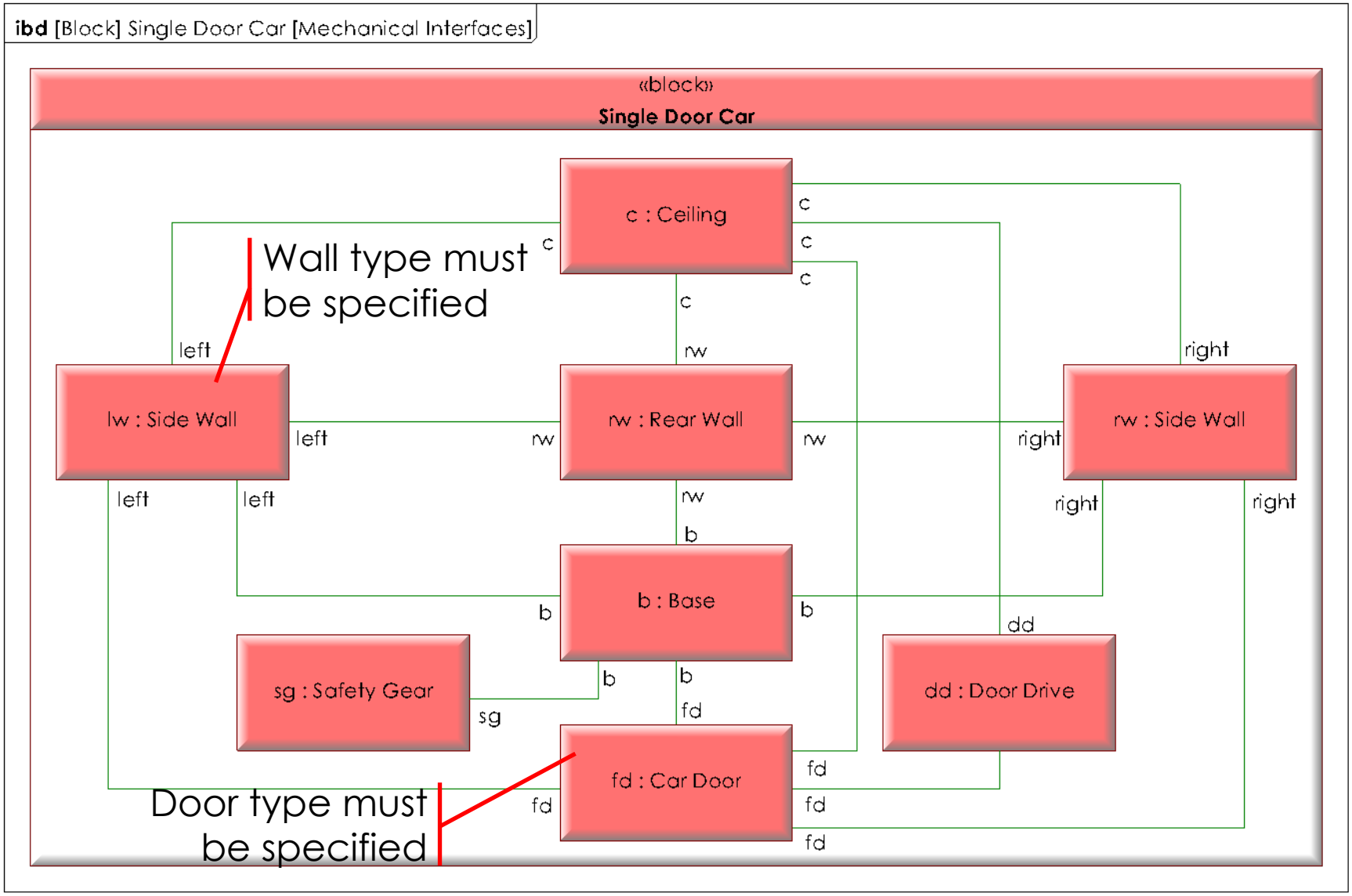
Product Line Model: Specializations



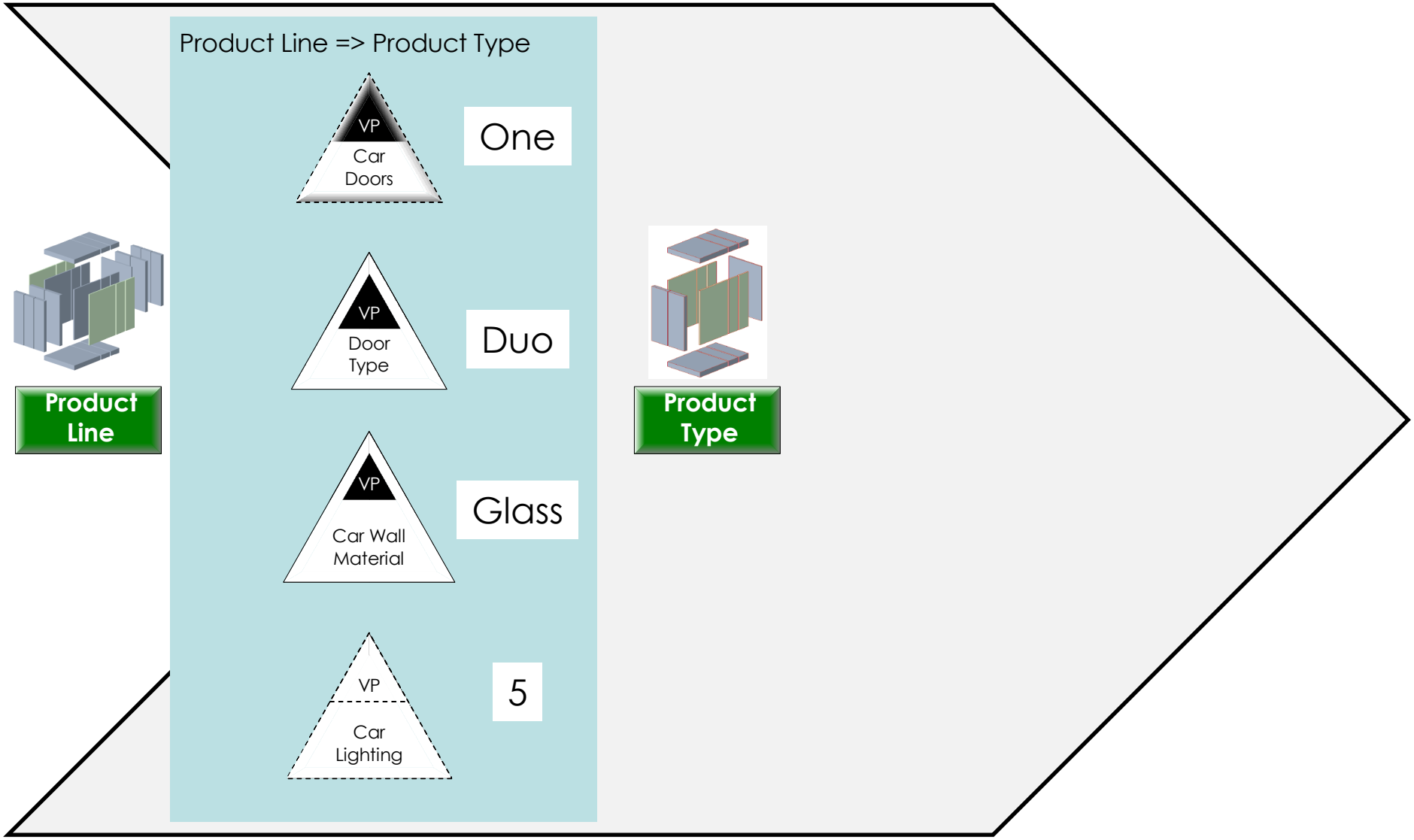
Product Line Model: Structural Variants



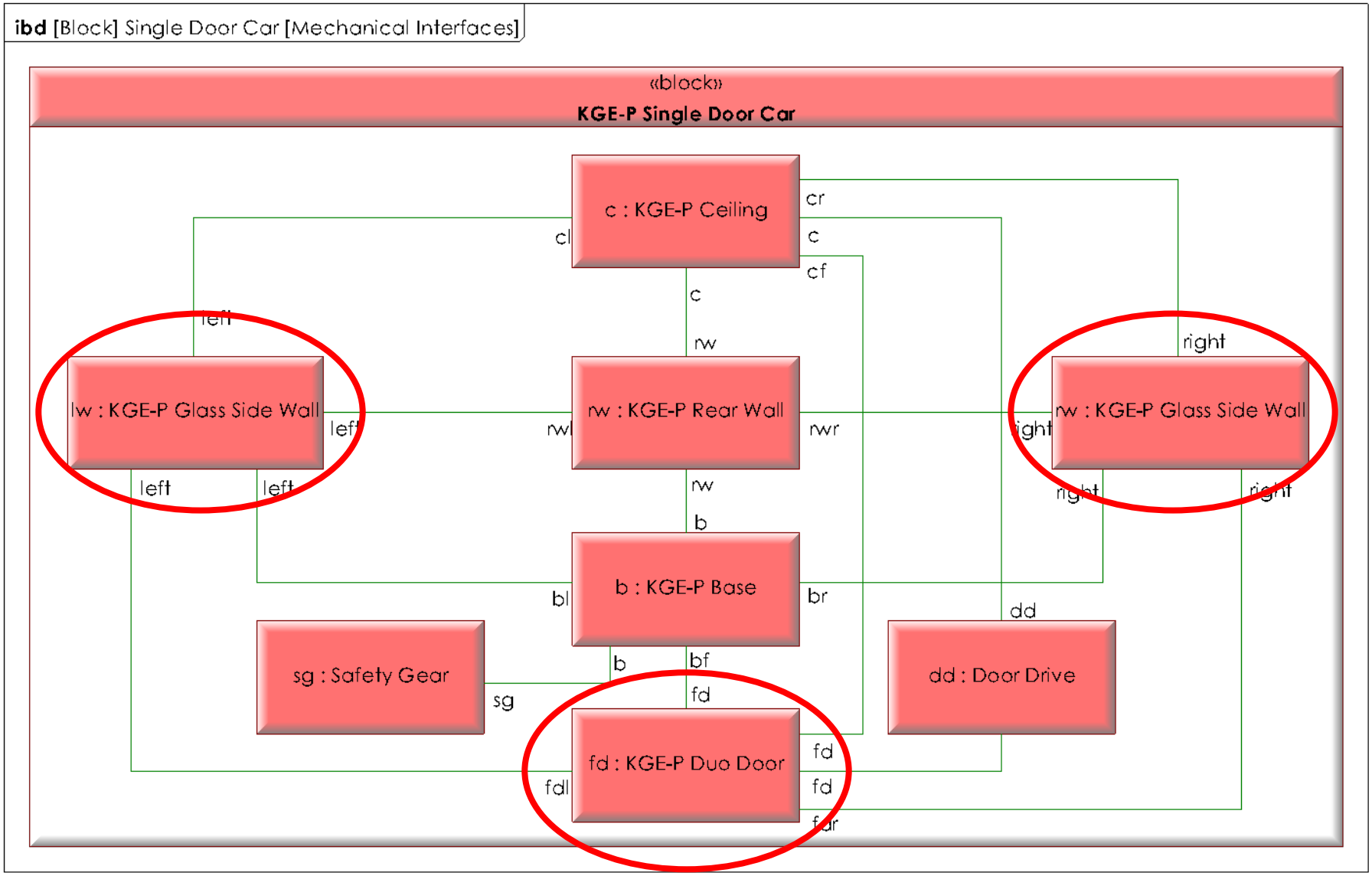
Product Line Model: Single Door Car



Multi-Level Instantiation – Step 1



Product Type Model:
Single Door Car with Glass Side Walls



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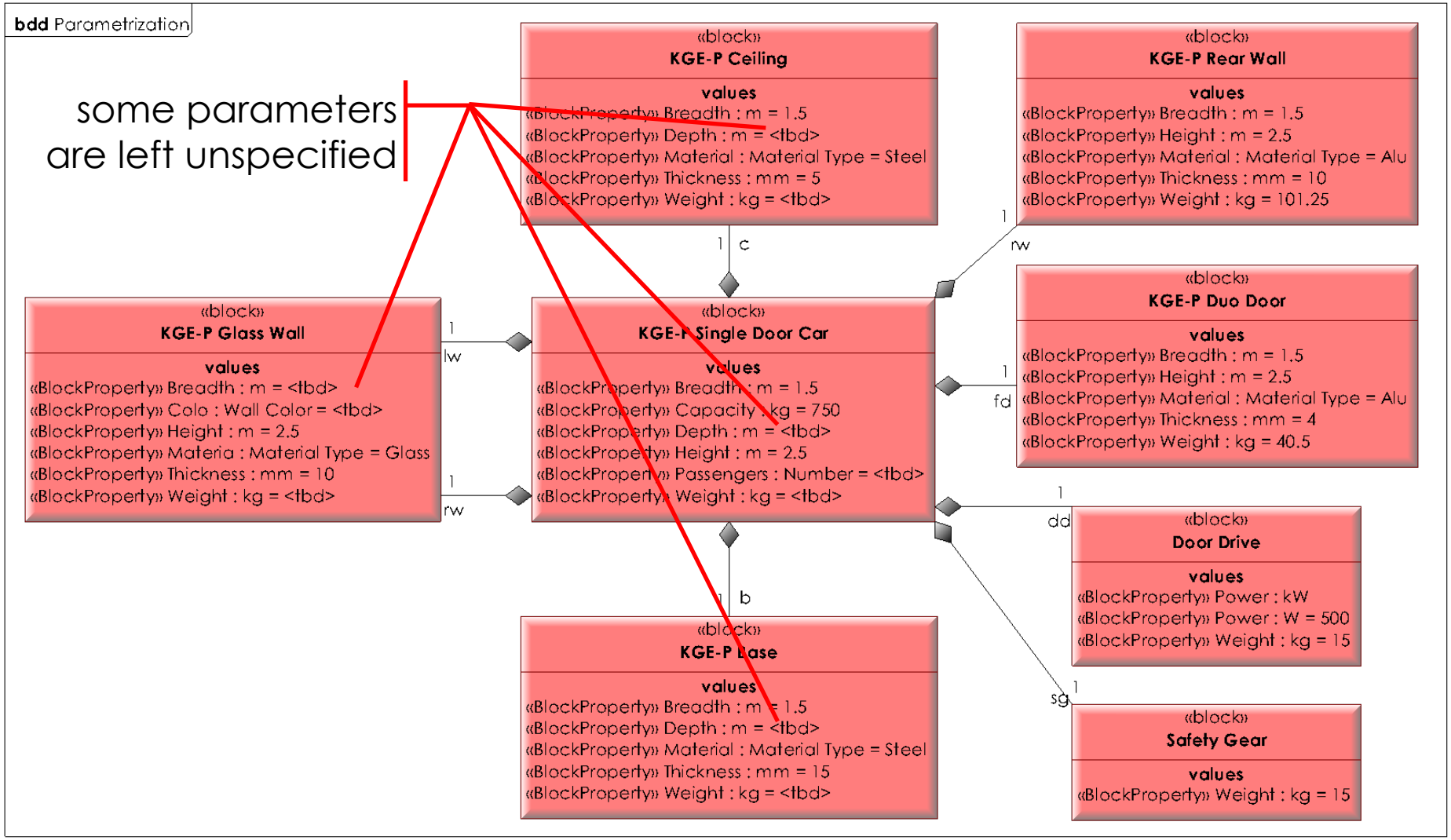
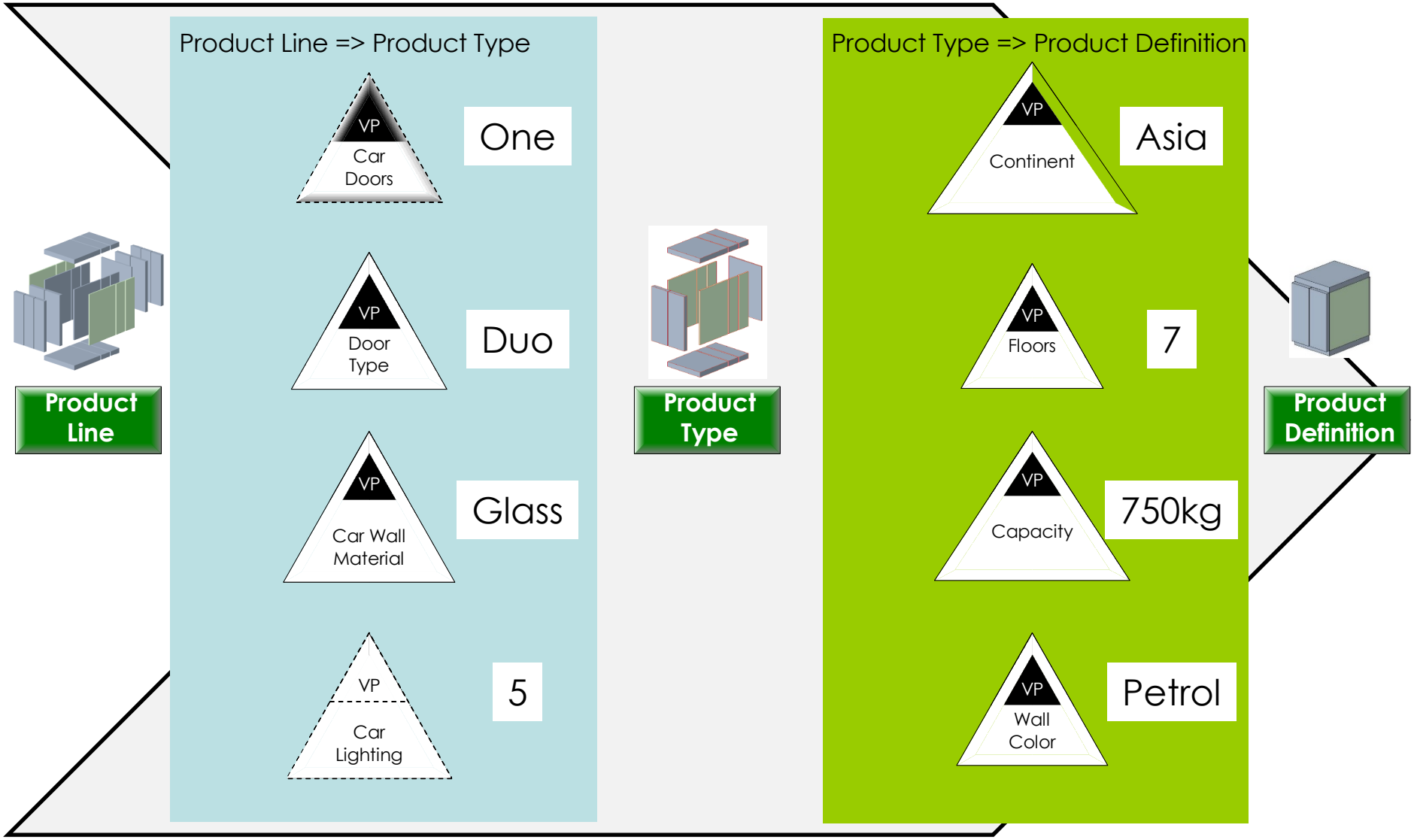
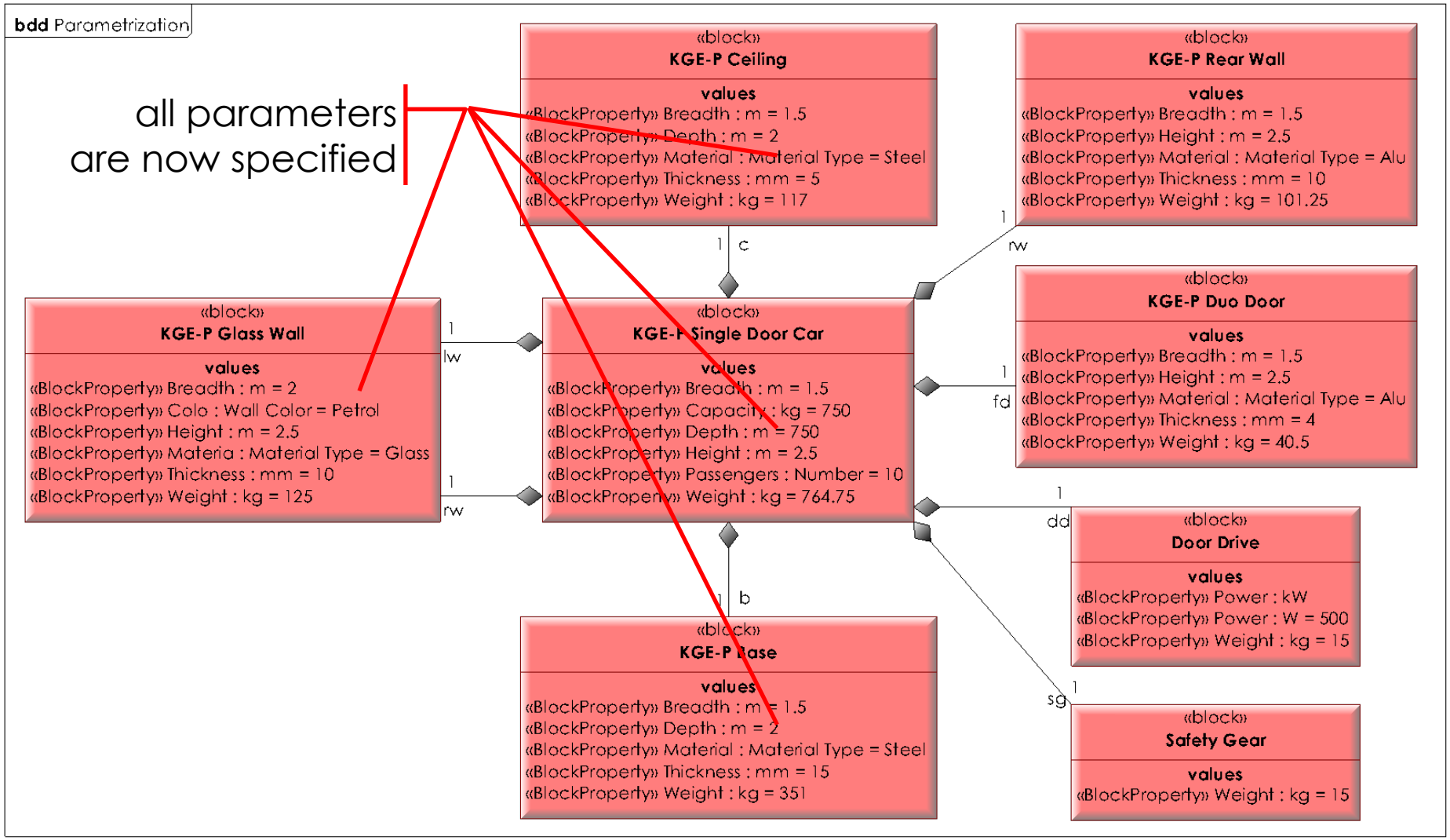


Multi-Level Instantiation – Step 2



Product Definition Model: Parametrized



SUMMARY

Summary

- Many of today's technical products…
  - are built as "system of systems"
  - support a high degree of variability
  - often have (very) long lasting life cycles
- Product models…
  - are specifications of products
  - are usually subject to many variant decisions
  - may be instantiated incrementally
- OVM orthogonally supplements SysML and other modeling languages by model-based variability

A Digital Twin results from the continuation of a Product Model into the "Operation" phase of the product.