“Advancing Traffic Efficiency and Safety
through Software Technology”

Managing Complexity of Automotive Electronics Using the EAST-ADL

UML & AADL Workshop, July 14, 2007

P. Cuenot, DJ Chen, S. Gérard, H. Lönn, M.-O. Reiser, D. Servat, C.-J. Sjöstedt, R. Tavakoli, M. Törngren, M. Weber

Outline

Part I. Overview of ATESST Project

Part II. Overview of EAST-ADL

Part III. Variability Management in EAST-ADL2

Part I
Overview of ATESST Project

What is ATESST?

Advancing Traffic Efficiency and Safety through Software Technology

in EU 6th Framework Programme, DG Information Society Technologies

Specific targeted research project, STREP

2006 – 2008 Q1

Scope:

- Model-based development for embedded automotive systems
- Definition of an architecture description language and methodology

ATESST Partners

Vehicle Manufacturers

- **DaimlerChrysler**
- **Volkswagen/Carmeq**
- **Volvo Cars**
- **Volvo Technology (coordinator)**

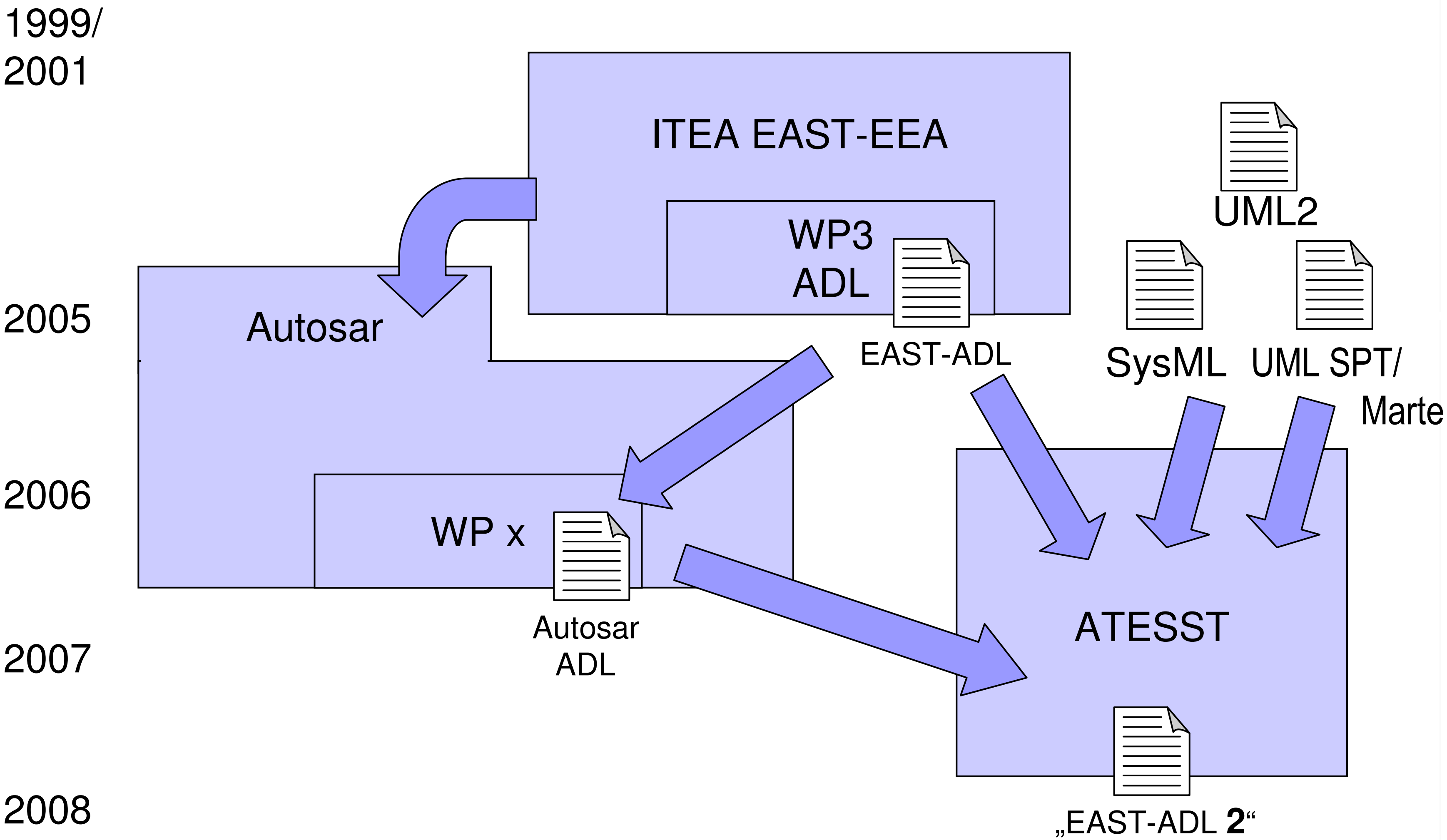
Suppliers/Tool Vendors

- **ETAS**
- **Mecel AB**
- **MentorGraphics**
- **SiemensVDO**

Academic

- **CEA**
- **KTH**
- **TU Berlin**

History


1999/
2001
2005
2006
2007
2008
ITEA EAST-EEA
WP3
ADL
EAST-ADL
UML2
SysML
UML SPT/
Marte
Autosar
WP x
Autosar
ADL
ATESST
„EAST-ADL 2“

Objective and Outcome

Objective of ATESST

Definition of a comprehensive, standardized ADL for the automotive domain based on the existing approach EAST ADL, including …

- Software & Hardware Components, Communication
- Environment modelling
- Requirements and V&V
- Variant handling and product families
- …

Outcome of ATESST

- Architecture Description Language
  (Revised EAST ADL as UML2 profile)
- Documentation and methodology
- Prototype tool
- eSafety demonstrator

EAST ADL 2.0

EAST-ADL Motivation

Product Aspects

- Functionality increase
- Complexity increase
- Increased safety-criticality
- Increased infra-structure complexity
- Increased coupling between vechicle functions and vehicle-to-vehicle interaction
- Quality concerns

Development Aspects

- Supplier-OEM relationship
- Multiple sites & departments
- Product families
- Separation of application from infrastructure / function orientation

Re-inventing The Wheel?

Why Not UML?

- ATESST works with a specialization of UML2

Why not SysML?

- ATESST is a specialization of applicable SysML concepts

Why not Autosar?

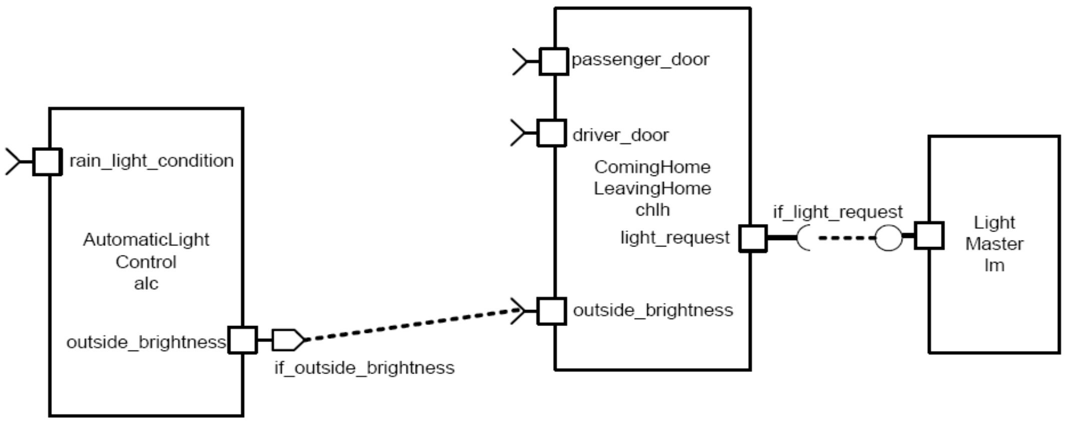
- ATESST Complements Autosar with VFM, functional architecture (abstract and concrete), requirements, V&V, variability management, environment modeling

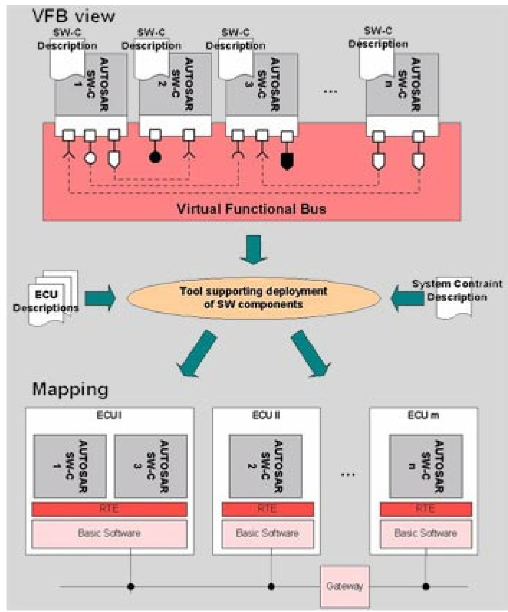
Why not proven proprietary tools (Simulink, Statemate, …)

- ATESST integrates external tools and provides an information structure for the engineering data regardless of tool

ATESST and AUTOSAR

"AUTOSAR prescribes everything that is needed to allow several AUTOSAR Software Components to be integrated correctly in an infrastructure consisting of networked ECUs."

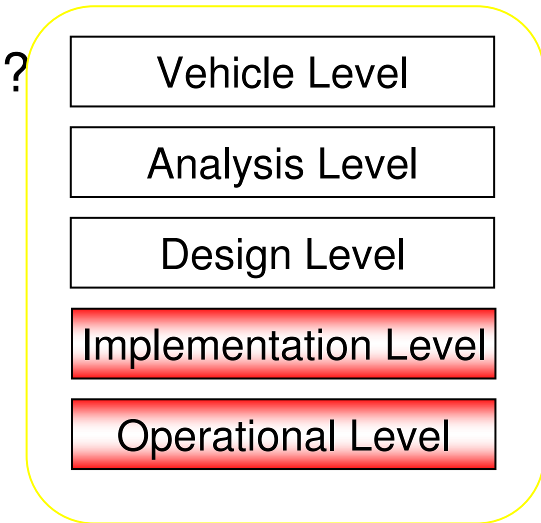




ATESST and AUTOSAR

ATESST Contribution

- What were the requirements ?
- What are the user level features (vehicle configuration) ?
- What about the abstract functional content ?
  How are the SW components' functions related ?



Conclusion:
AUTOSAR concepts are integrated on implementation level and down

ATESST Tool Prototype

Eclipse based

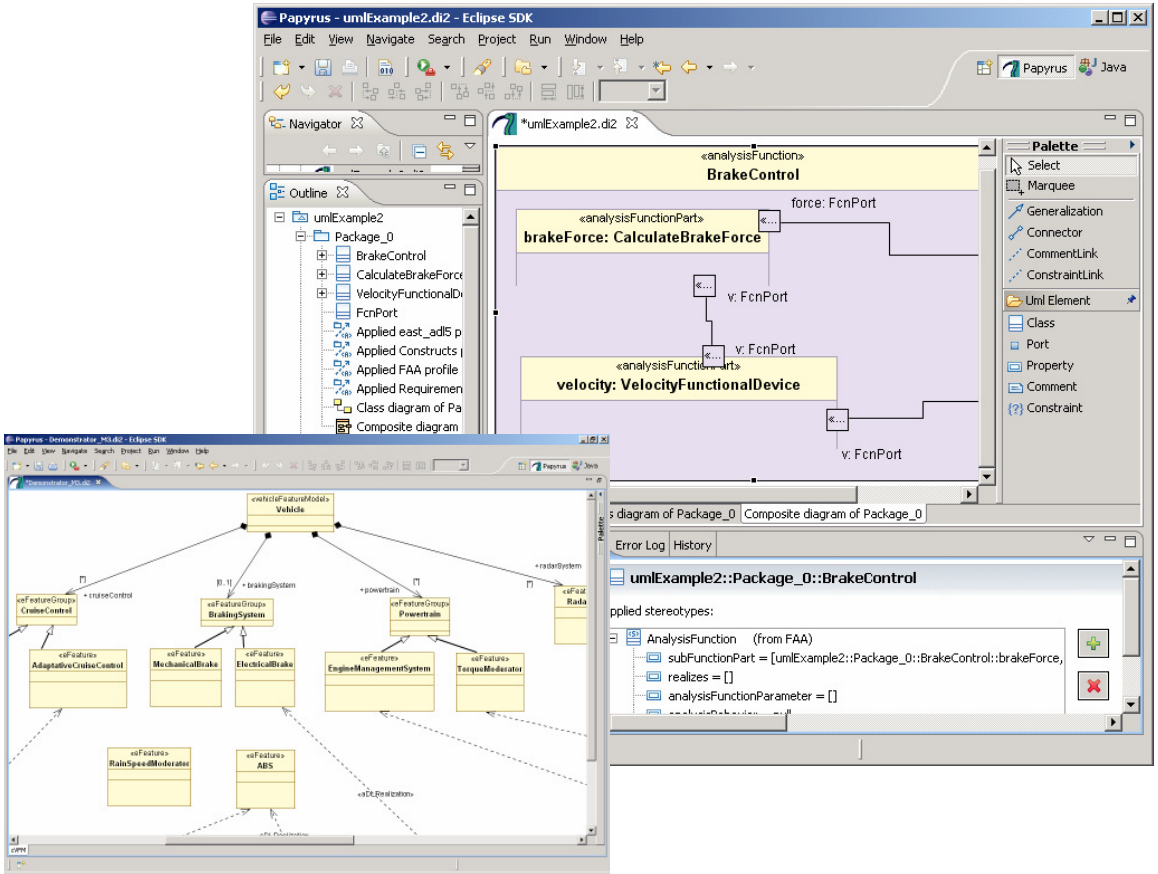
- Eclipse EMF/UML2

Built on Papyrus
(UML Modeling Tool)

Open Source

Plug-ins planned for

- Variability
- Requirements
- Analysis / Derivation



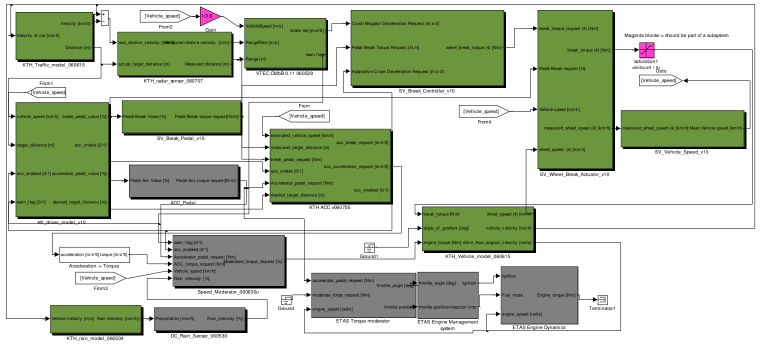
ATESST Demonstrator

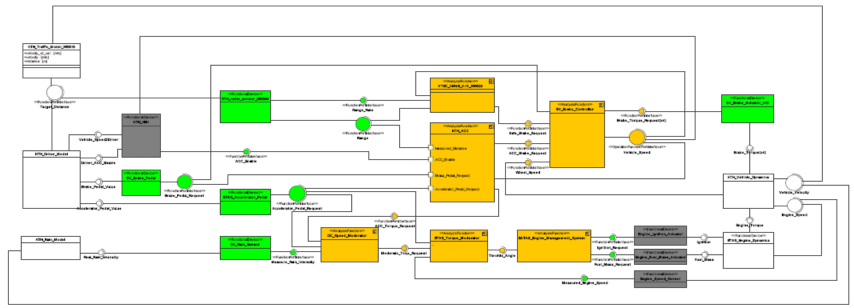
Active Safety Application

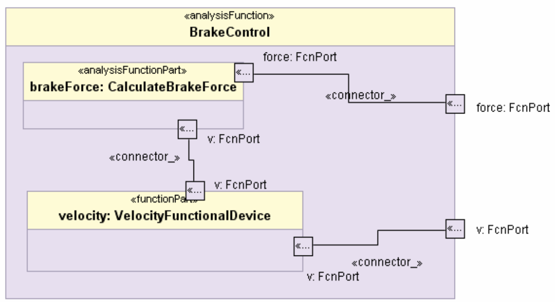
Used in several steps

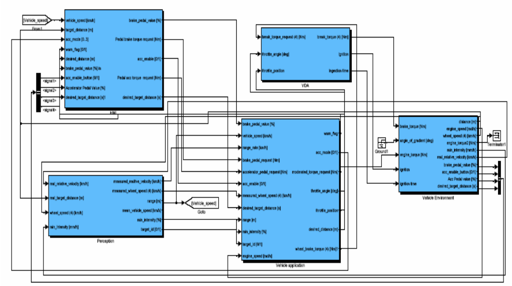
1. Simulink
2. EAST ADL / UML Tool (MagicDraw)
3. EAST ADL / ATESST Tool
4. Tool experiments (Code generation, variability, requirements)

Contains Engine control, ACC, CMbB (based on PReVENT application), Speed regulation, Environment Model





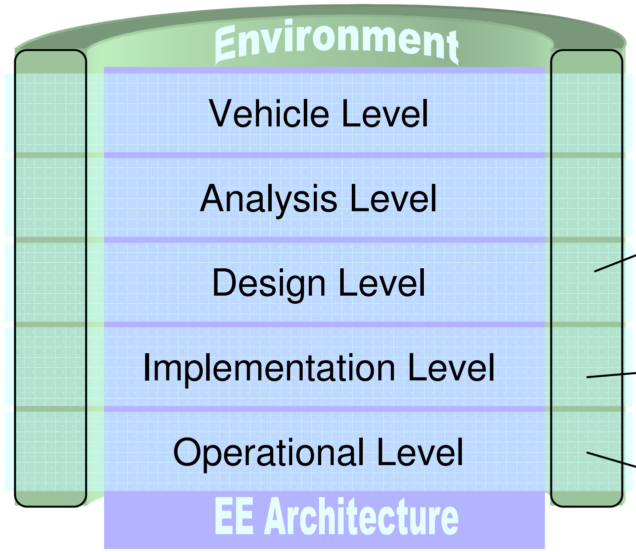




Part II
Overview of EAST-ADL2

Levels of Abstraction in EAST-ADL2

An *Information Model*
That captures engineering information in a standardized way

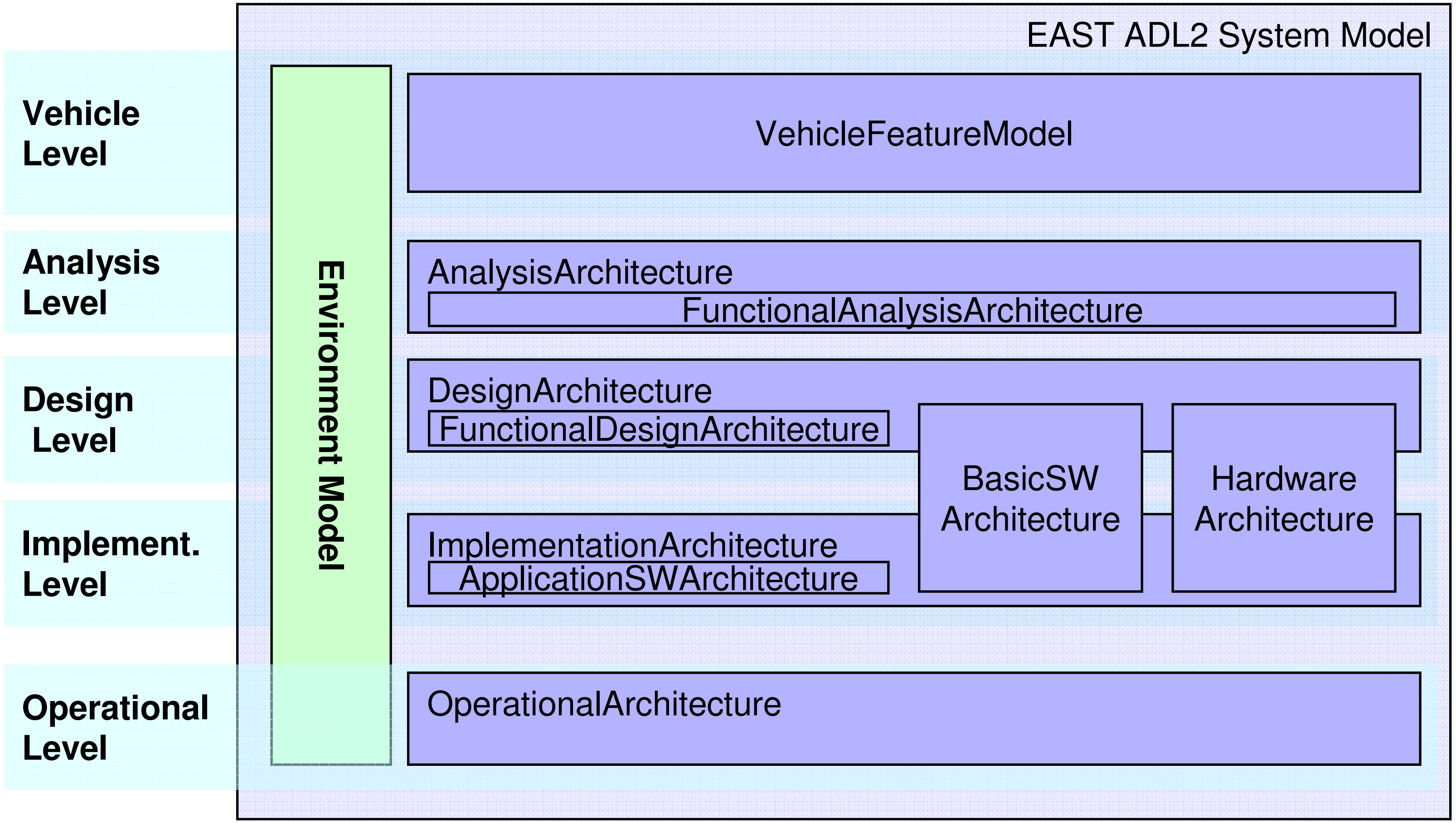


functional definition of software ; independent of hardware topology

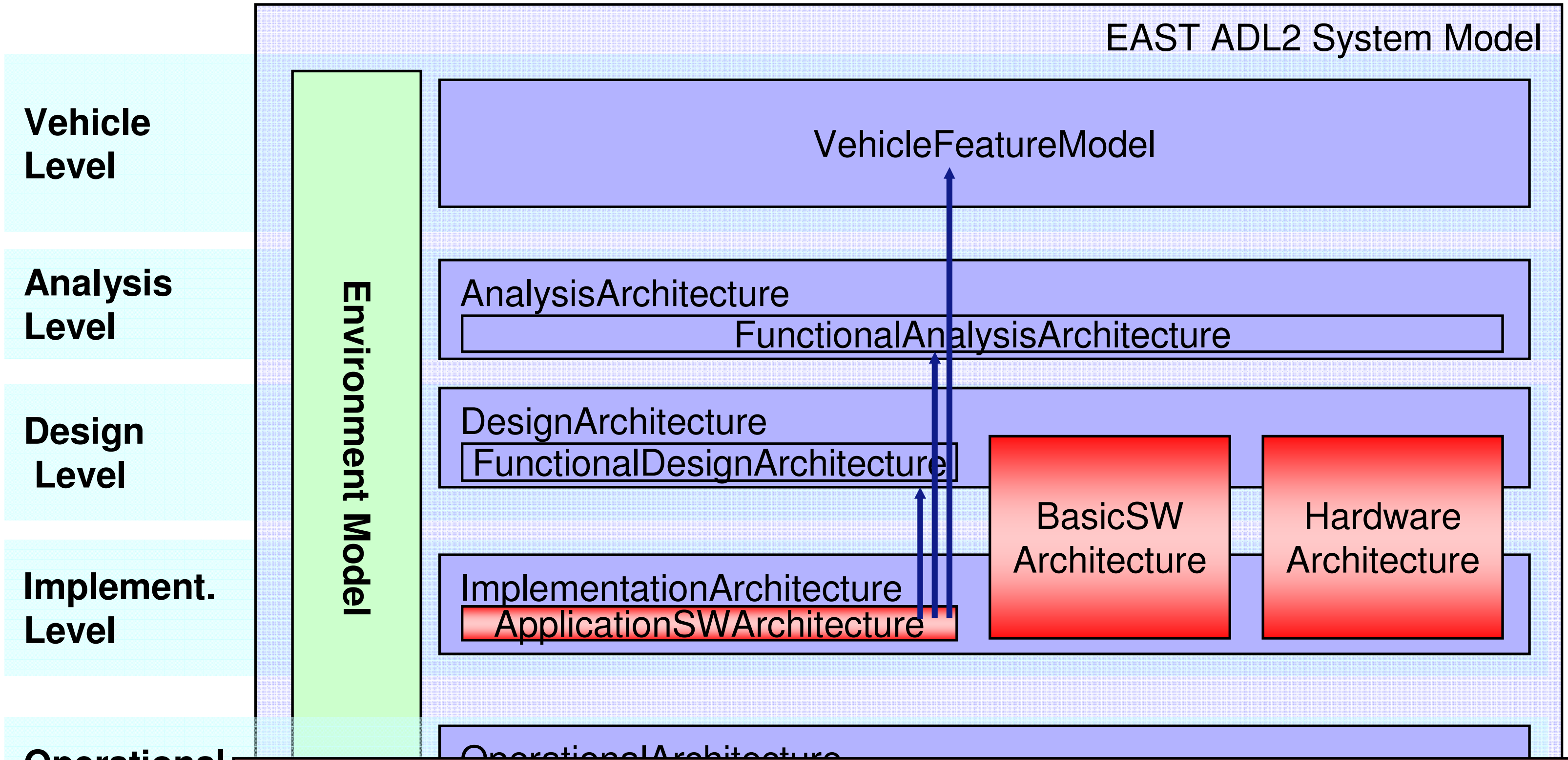
reusable platform-independent code and system configuration for hardware deployment

final binary software deployment

EAST ADL2 Structure



AUTOSAR Integration



- AUTOSAR entities populate architectures on Implementation Level
- Requirements, variability constructs, traceability relations link to AUTOSAR entities
- Behavioral semantics adapted to map to AUTOSAR behavioral concept

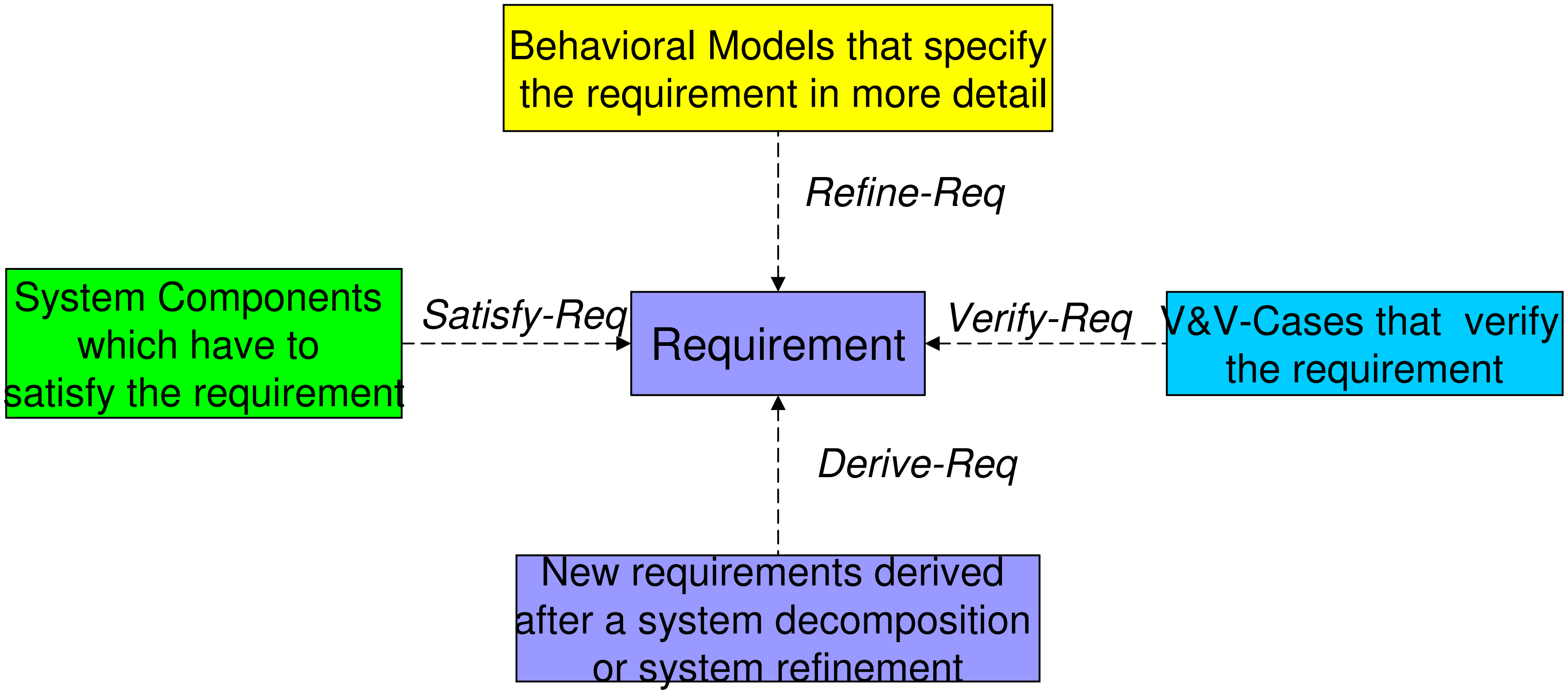
SysML Harmonization

- EAST ADLFunction on analysis and design level inherits from SysML block
- Port and datatype concepts from SysML used
- Requirements constructs from SysML used
- Parametric diagrams from SysML potential candidate for certain plant models

Behavior Modeling

- External and Native Behavior are investigated
  - External via URL and defined execution semantics
  - Native behavior preliminarily from UML & SysML
- Compatible with state of practice tools Simulink, ASCET...
  - Relation with URL
  - Code generated from this part of the external model is the implementation code and referenced in model
- Harmonization with AUTOSAR via relation to runable entities
- Ongoing investigation how environment models should be described in EAST-ADL2.0

Requirements



Supporting Requirements Tracing and Linking to system components trough EAST-ADL view point (from VFM to Implementation)

Others Requirements Modeling

- Hazards or hazardous events

  defined modeled in the environment model

- Safety requirement attributes

  Relation to hazards event

  Include safety integrity level (SIL), operation state, fault time span, emergency operation times, safety state, and functional redundancy.

- Timing requirement attributes

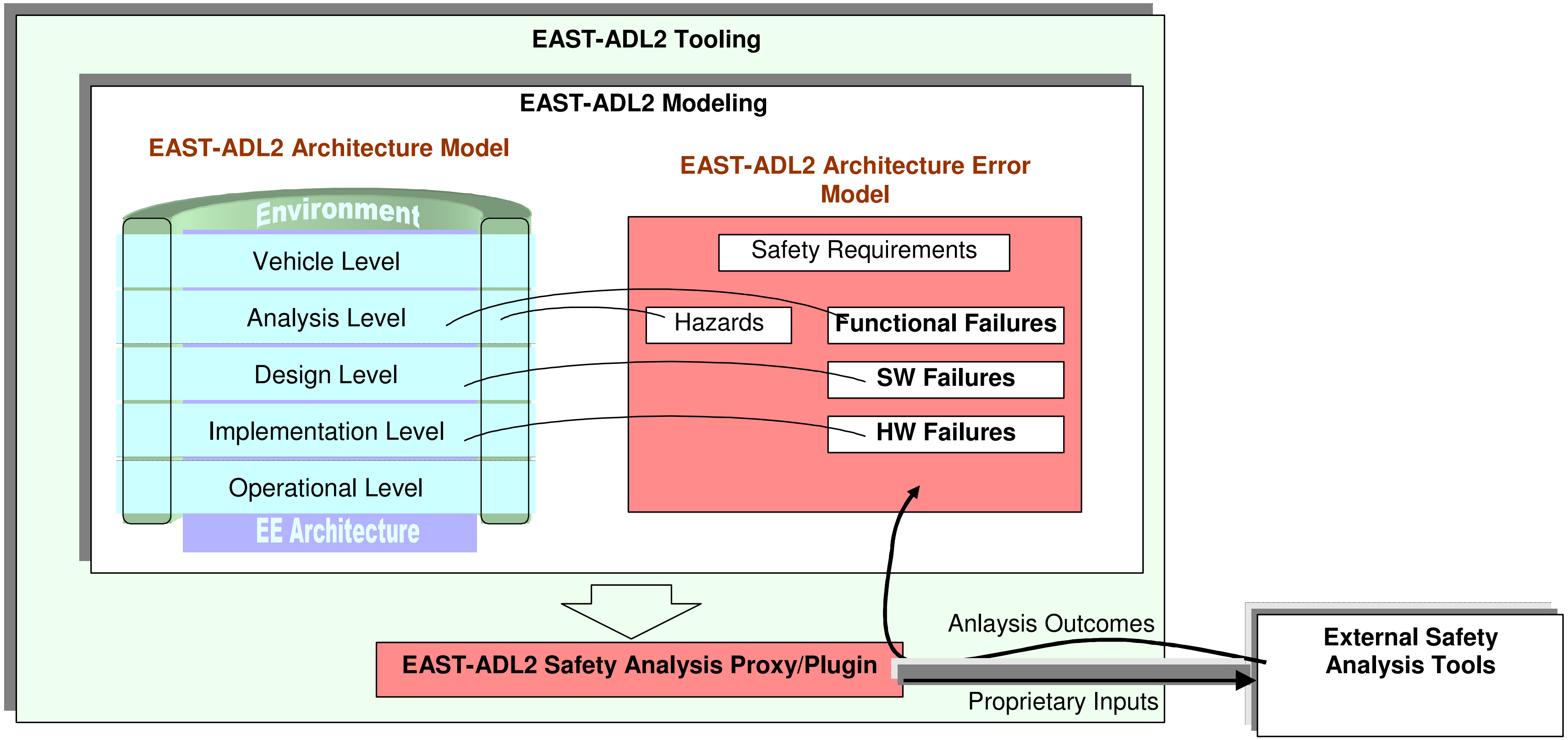
  Minimum, maximum, Jitter for concept such delays, synchronisation point and interval

- V&V Case modeling

  combination of a V&V-case, its environment and its target object is described as a V&V context

Error Modeling

Extending EAST-ADL with **error modeling** for enabling the integration of architecture **design and safety analysis** in an efficient way.



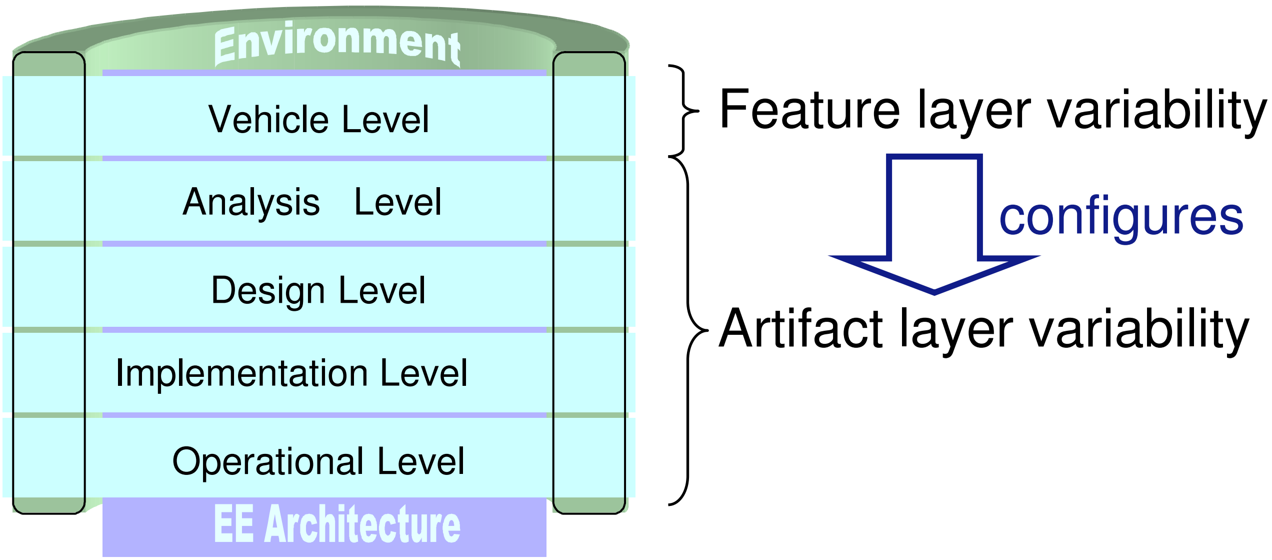
Part III
Variability Management

1. Overview
2. Basic Concepts
3. Advanced Concepts

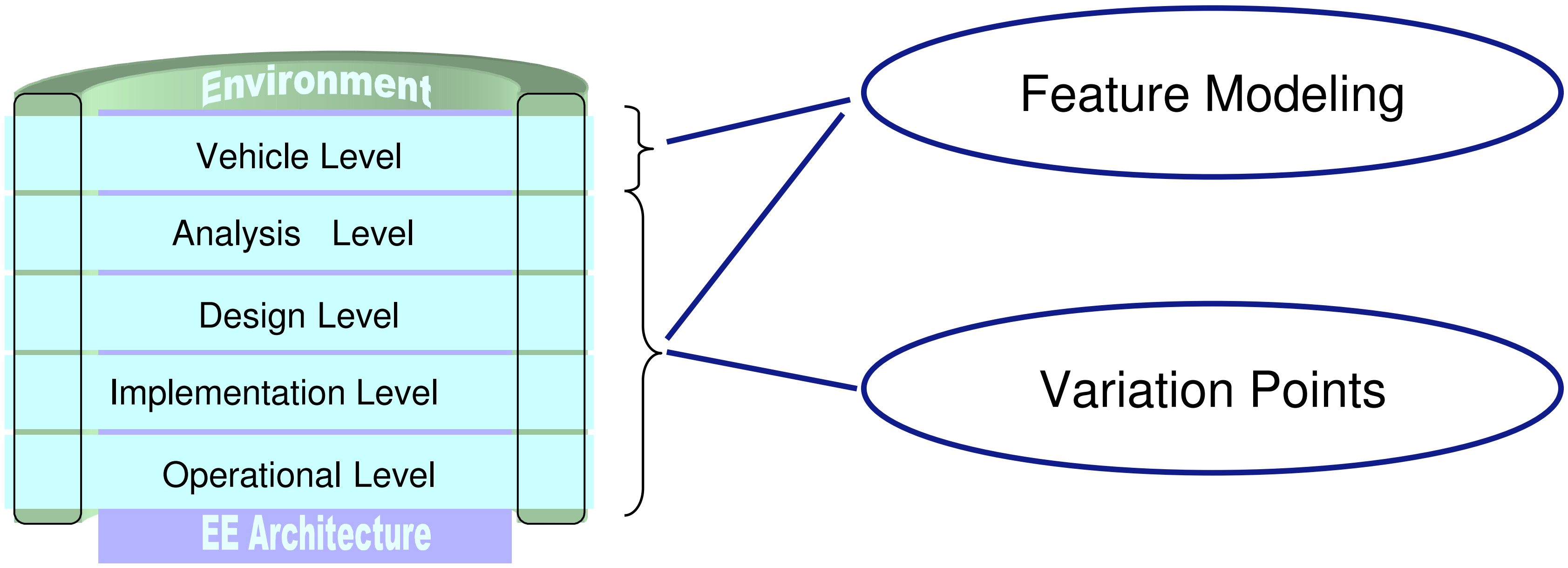
Variability – Overview

Variability is modeled essentially on two different abstraction layers:

1. Feature layer variability (being the primary source for variant/product configuration)
2. Artifact layer variability (comprising all artifact elements, e.g. requirements, FAA, FDA…)

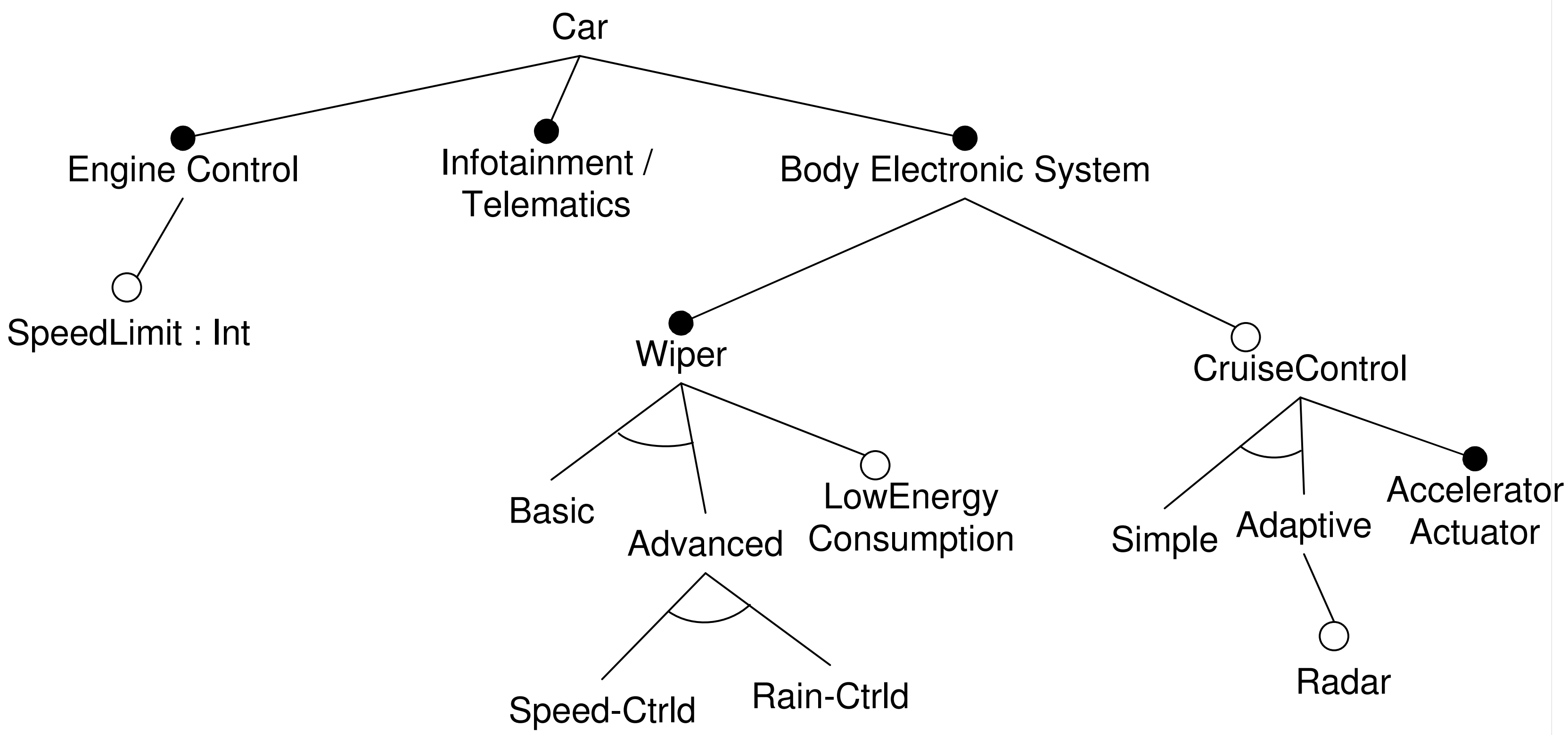


Basic Concepts



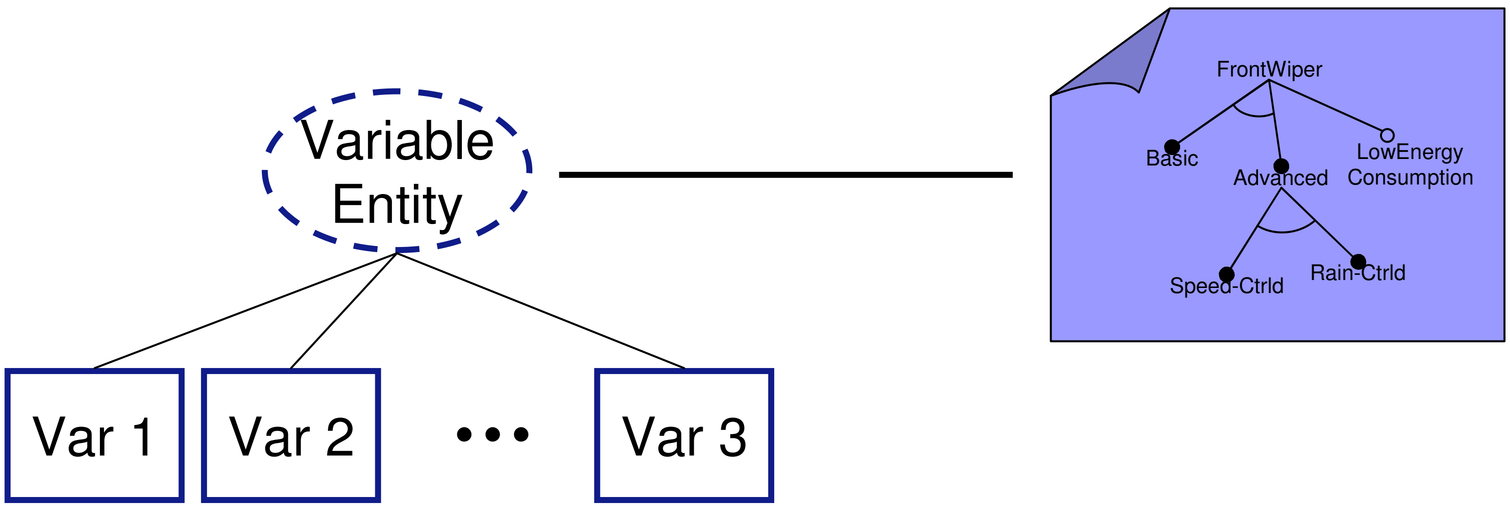
Basic Concepts – Feature Modeling

- as introduced by Kang et al. in 1990

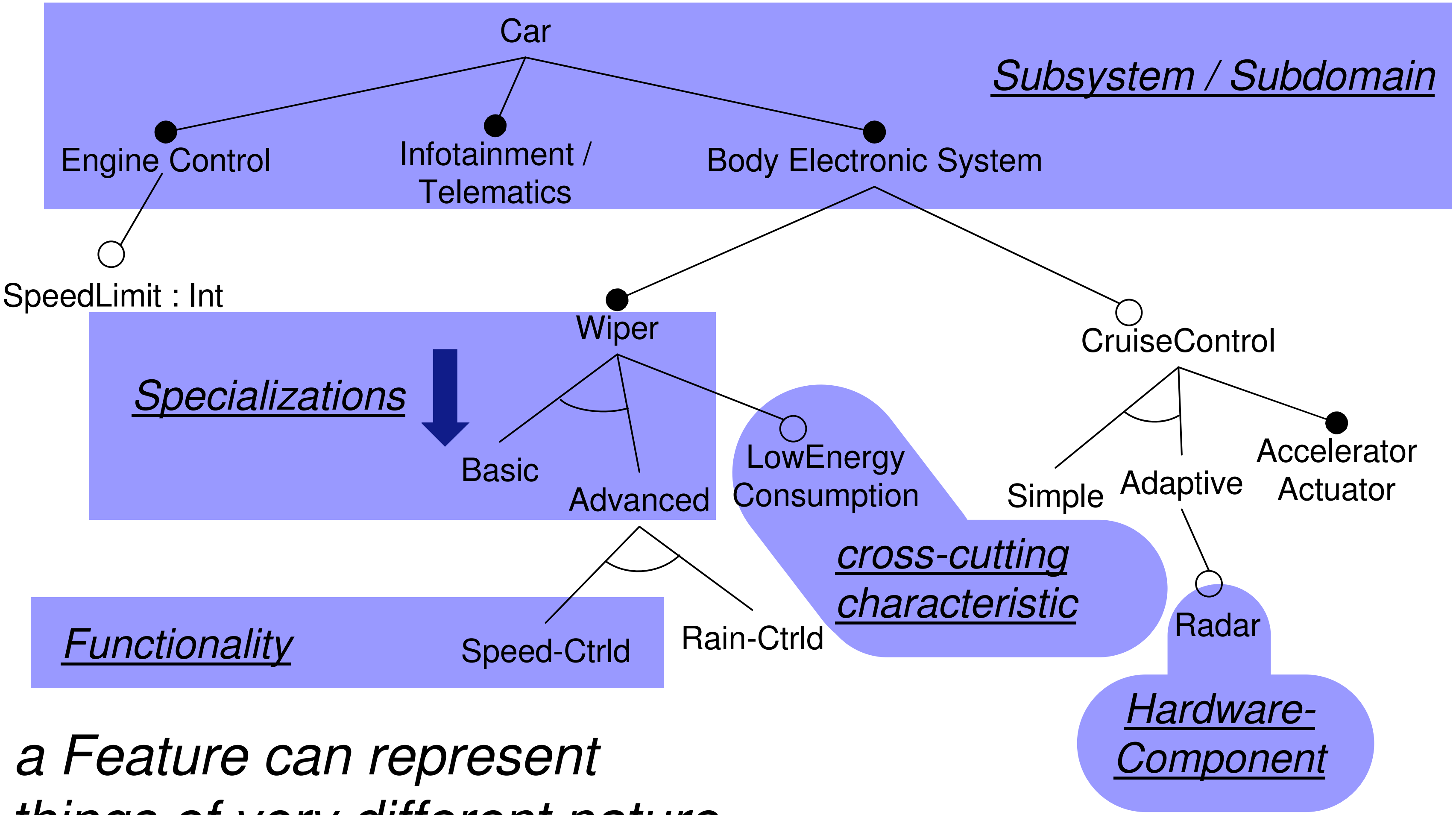


What is a Feature ?

A Feature is a characteristic or trait that the variants of a variable entity may or may not have.



What is a Feature ?



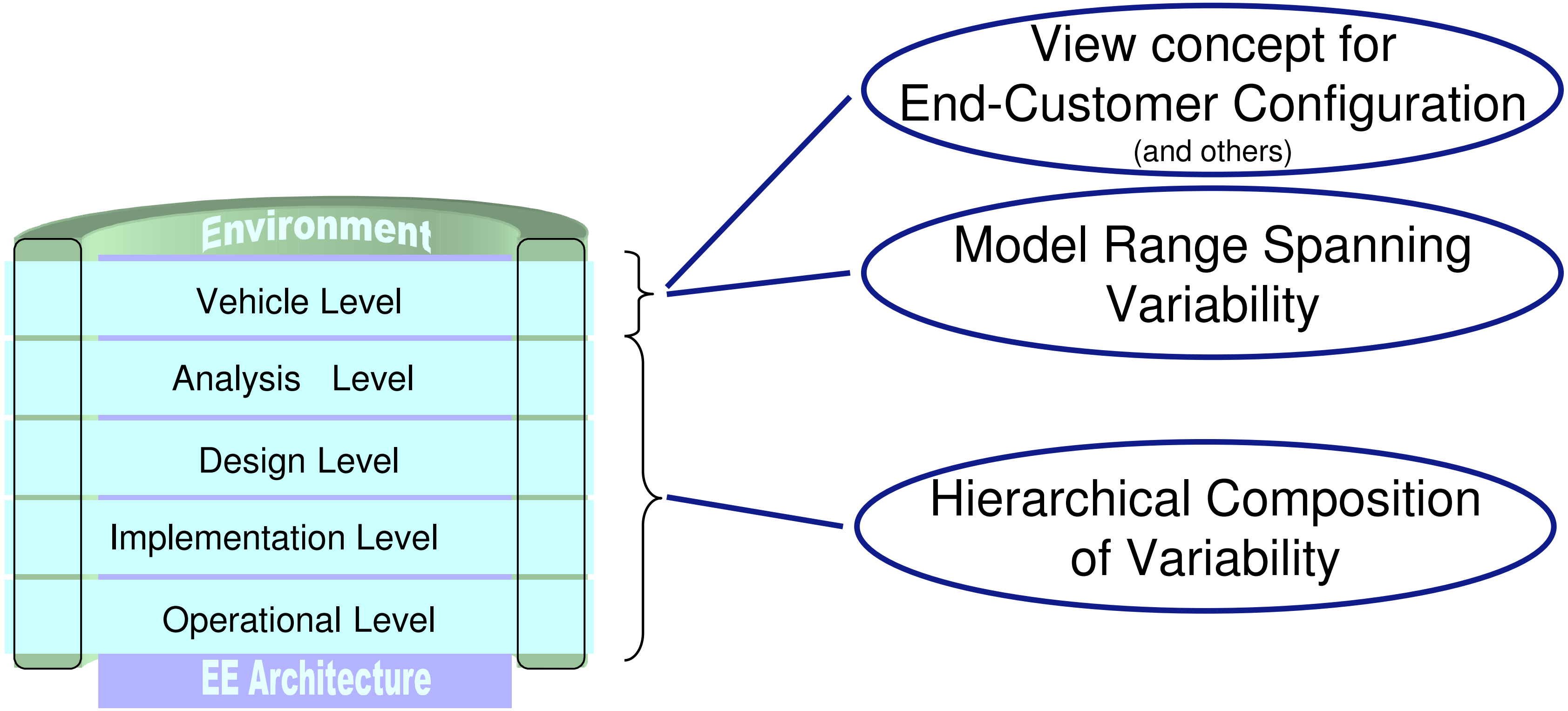
→ *a Feature can represent things of very different nature*

Basic Concepts – Variation Points

Variability is modeled for the artifacts based on the notion of variation points and variation groups:

- all ADLEntities can be variable
- variable ADLEntities are marked a variation point (and then serve as a placeholder)
- the variation point is linked to the entities that represent the available variants
- variation groups can describe various constraints between arbitrary variable entities

Advanced Concepts



End-Customer Configuration

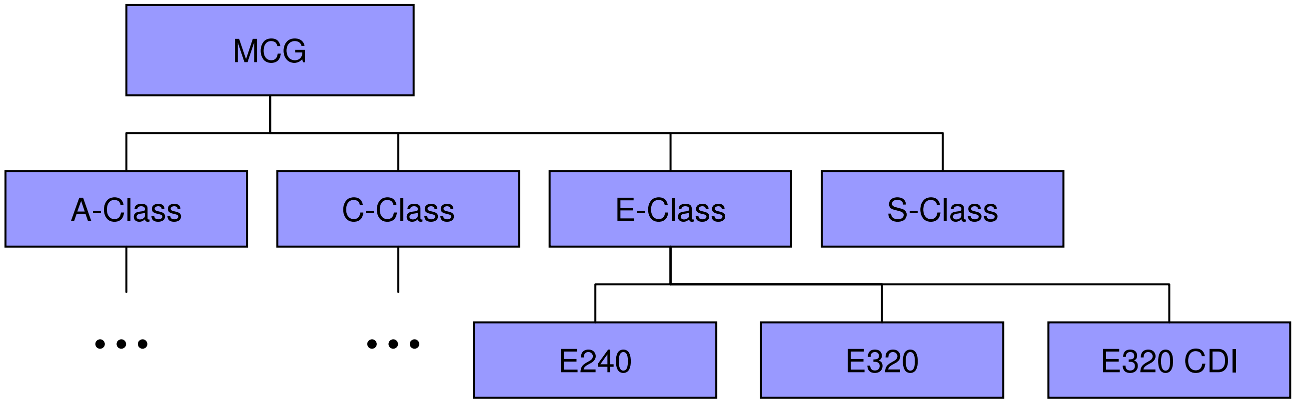
- vehicle level contains the core feature model
  - showing variability of the complete system
  - high complexity
  - technical viewpoint
    (terminology, customer-invisible variability, diverse life-cycle)
  - not appropriate for end-customer configuration

- vehicle level supports to define end-customer configuration
  - provides „view“ on core feature model
  - allows for orthogonal „packaging“ of variability
  - supports orthogonal configuration considerations
  - can be used for separation of other concerns

Model Range Spanning Variability

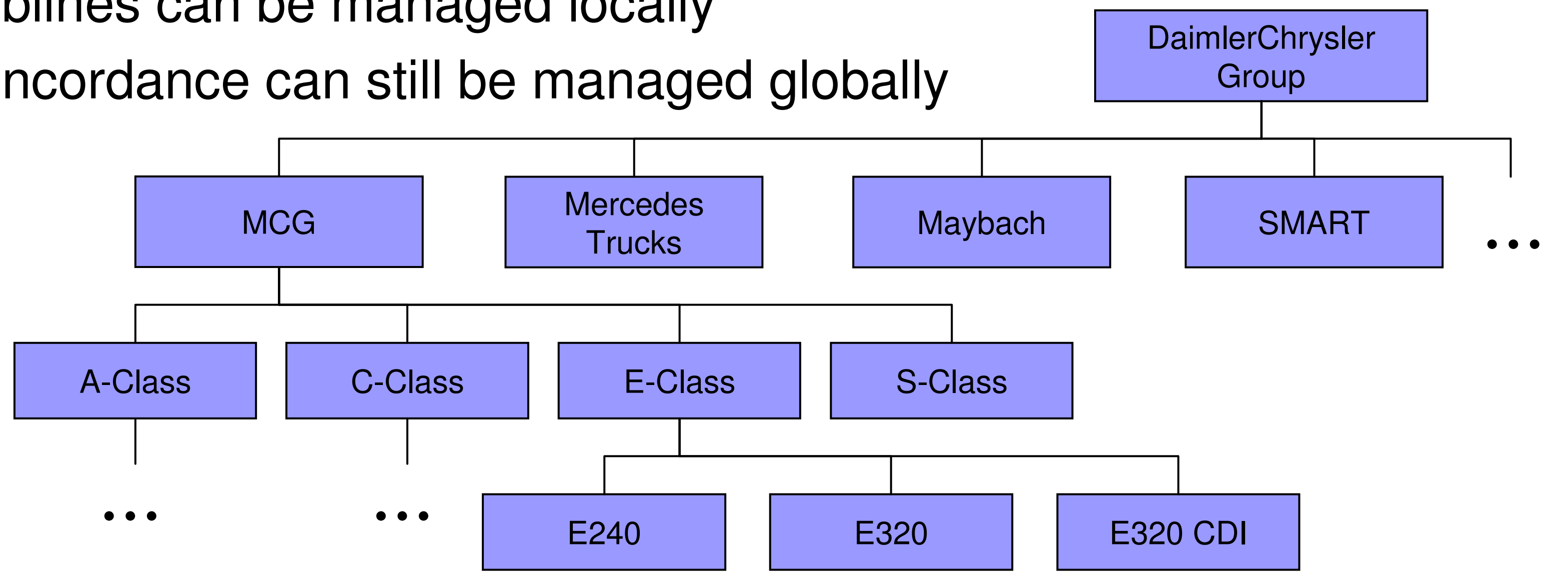
two kinds of variabilty:

- model range specific variability
- model range spanning variability

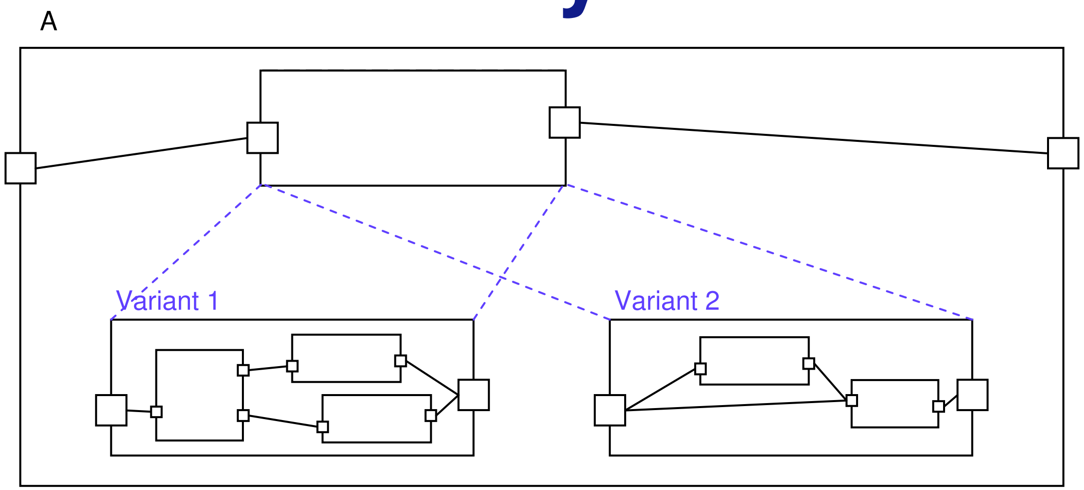


Model Range Spanning Variability

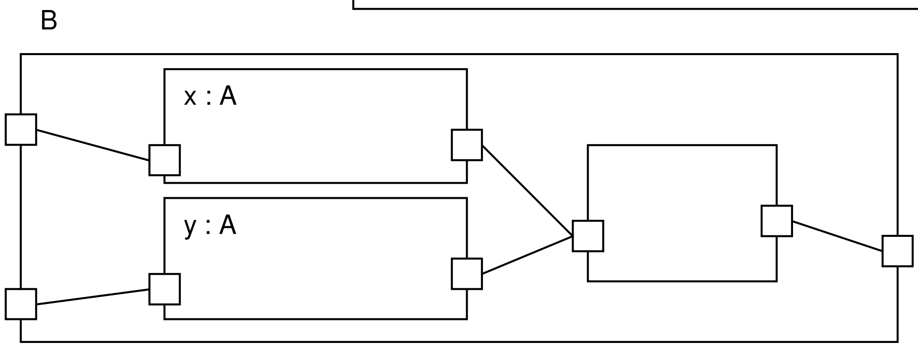
- traditional solution: either one large software product line or several independent ones
- multi-level concept: compromise between the two
  - sublines can be managed locally
  - concordance can still be managed globally



Composite Variability – Motivation



A has variability inside.



When A is used twice in B, then it must be configured separately for each occurence.

→ Thus, definition of A is not a suitable context for configuration !!

Composite Variability

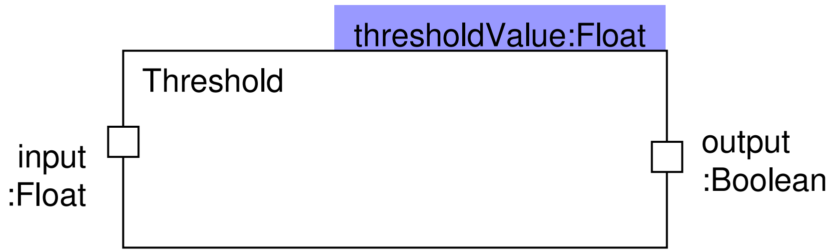
- variability is managed in a hierarchical manner
- key elements:
  - Step 1: ADLFunctions get a „public" feature model
  - Step 2: internal structure of composite ADLFunctions can be variable
    (by way of variation points)
  - Step 2: for each composite ADLFunction a mapping is defined
    from its public feature model to …
    (a) the public feature models of its contained ADLFunctions and
    (b) the variants of the contained variation points

(in other words: it is defined how the configuration of the contained ADLFunctions' feature models can be derived from a given configuration of the public feature model of the container ADLFunction)

Step 1: ADLFunctions get „public“ FM

- as part of their public interface
- for elementary ADLFunctions, the configuration of the public feature model will be made available for reference within the behavioral description of the ADLFunction
  - details depend on type of behavioral description
  - e.g. for C-Source-Code, parameters can be realized as pre-processor macros

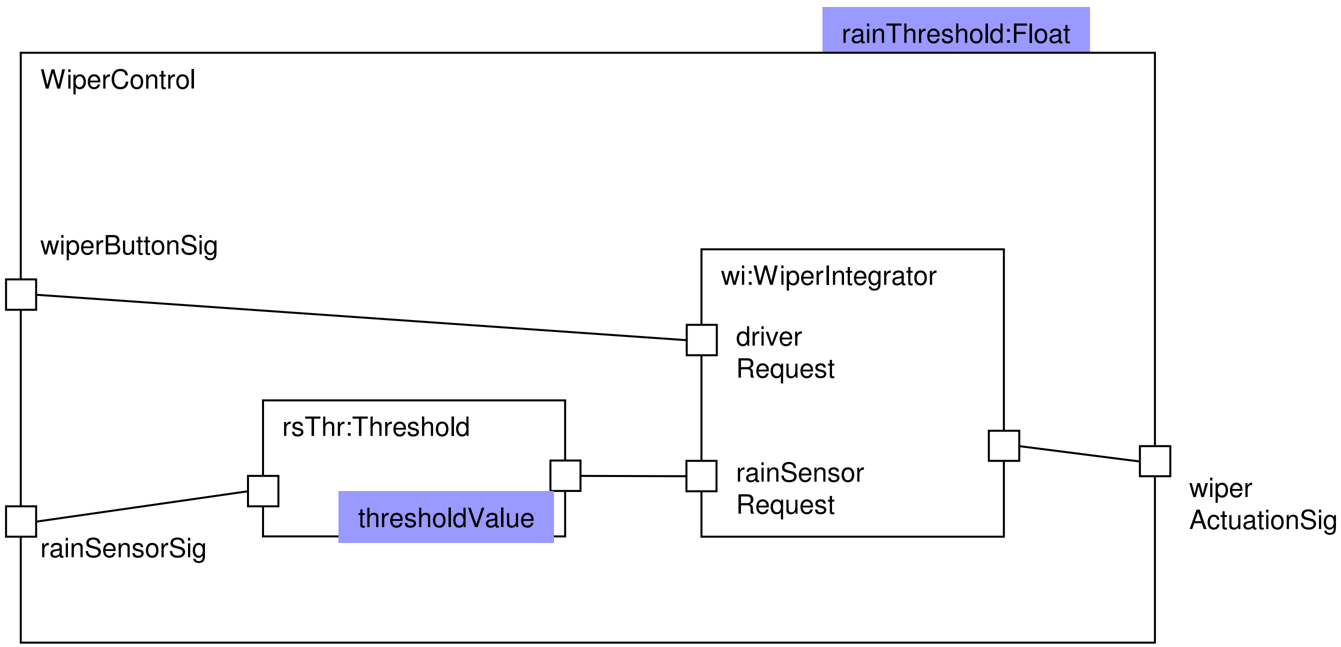
EXAMPLE: ElemSWComp that realizes a „Threshold“



if input >= thresholdValue
then output = True
else output = False.

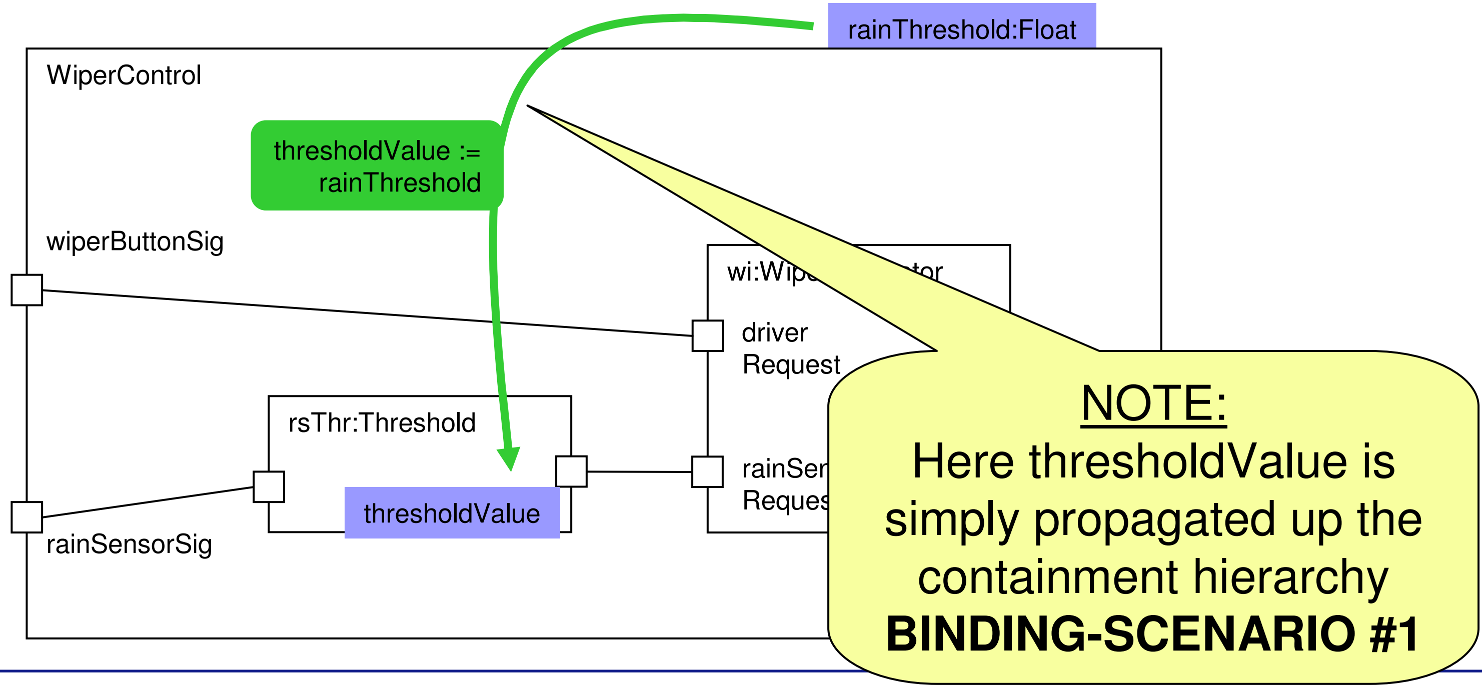
Step 1: cont'd

EXAMPLE: CompSWFunc that controls a wiper depending on driver input and rain sensor

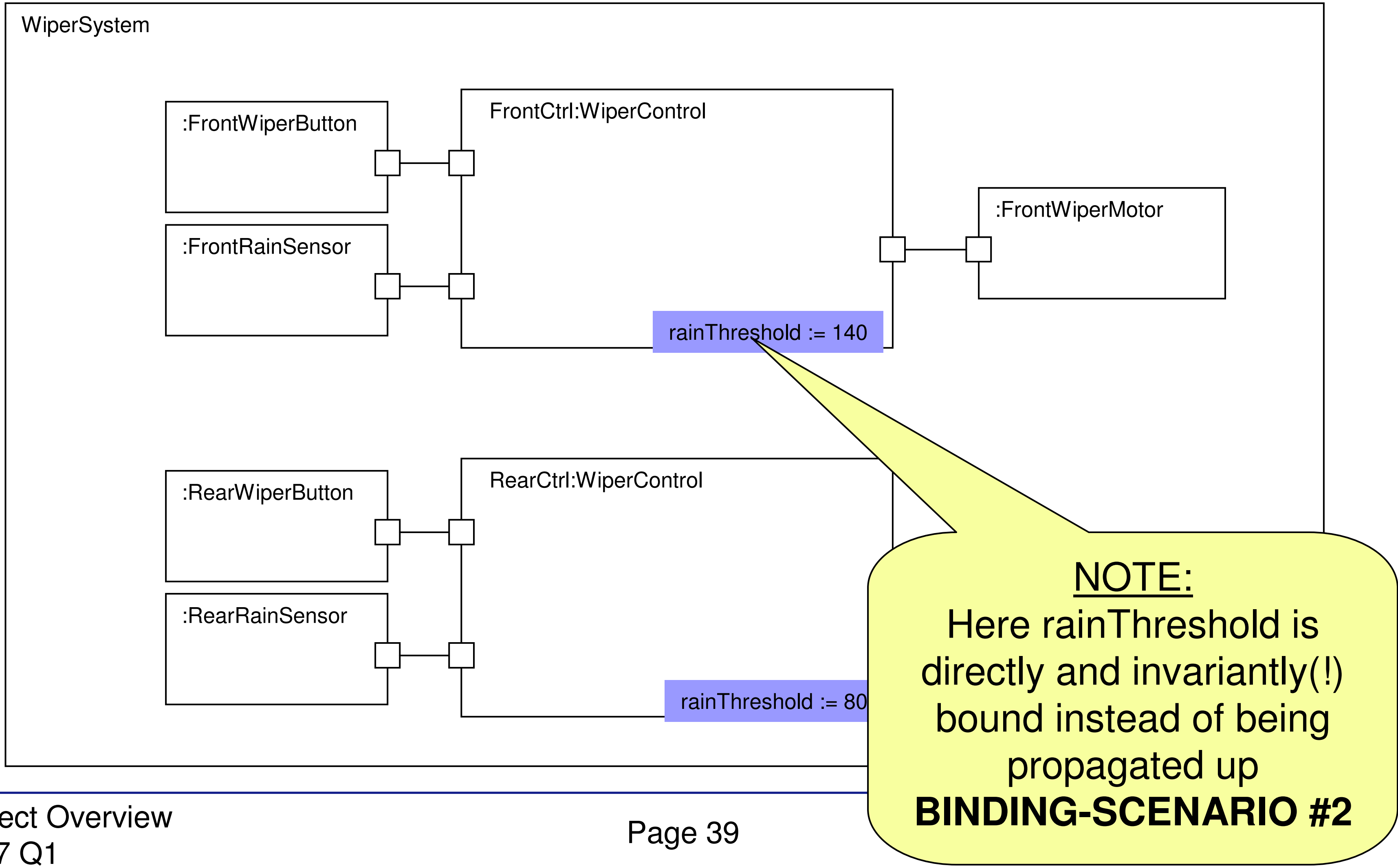


Step 3: Mapping

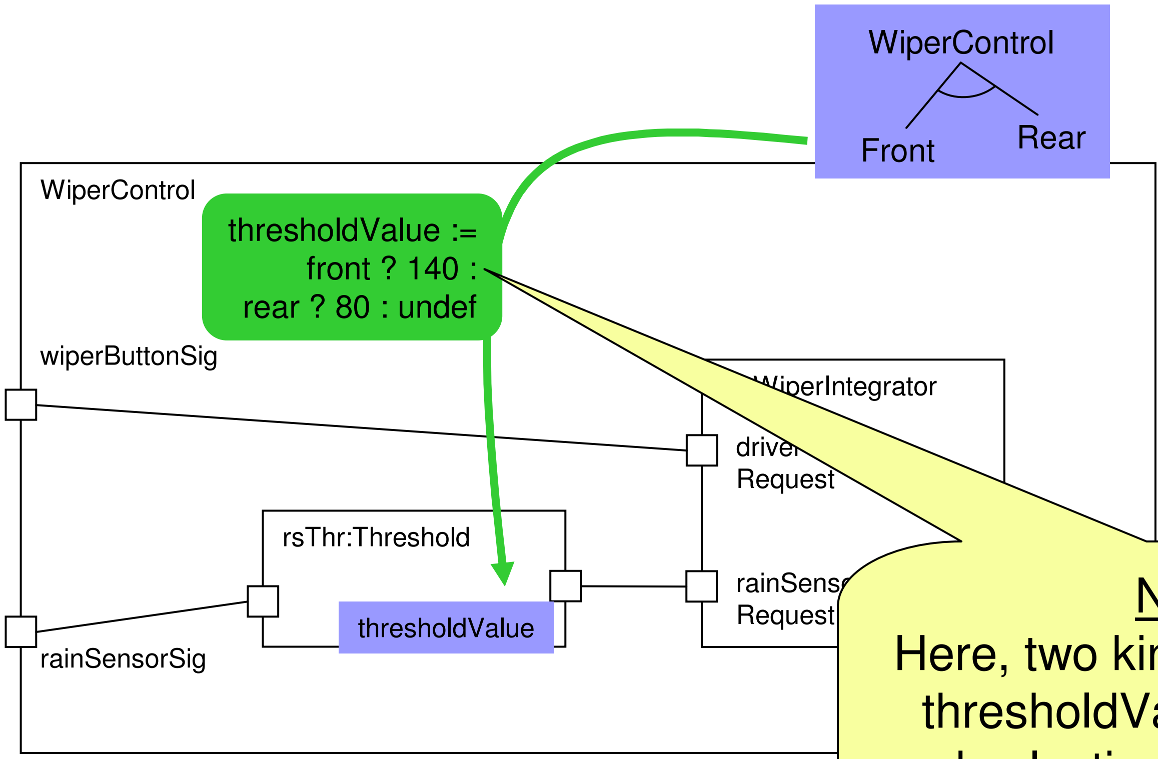
- mapping from the public feature model of a composite ADLFunction to
  (a) the public feature models of its contained ADLFunctions and
  (b) the variants of the contained variation points
- in this case: only (a) used



Applying WiperControl

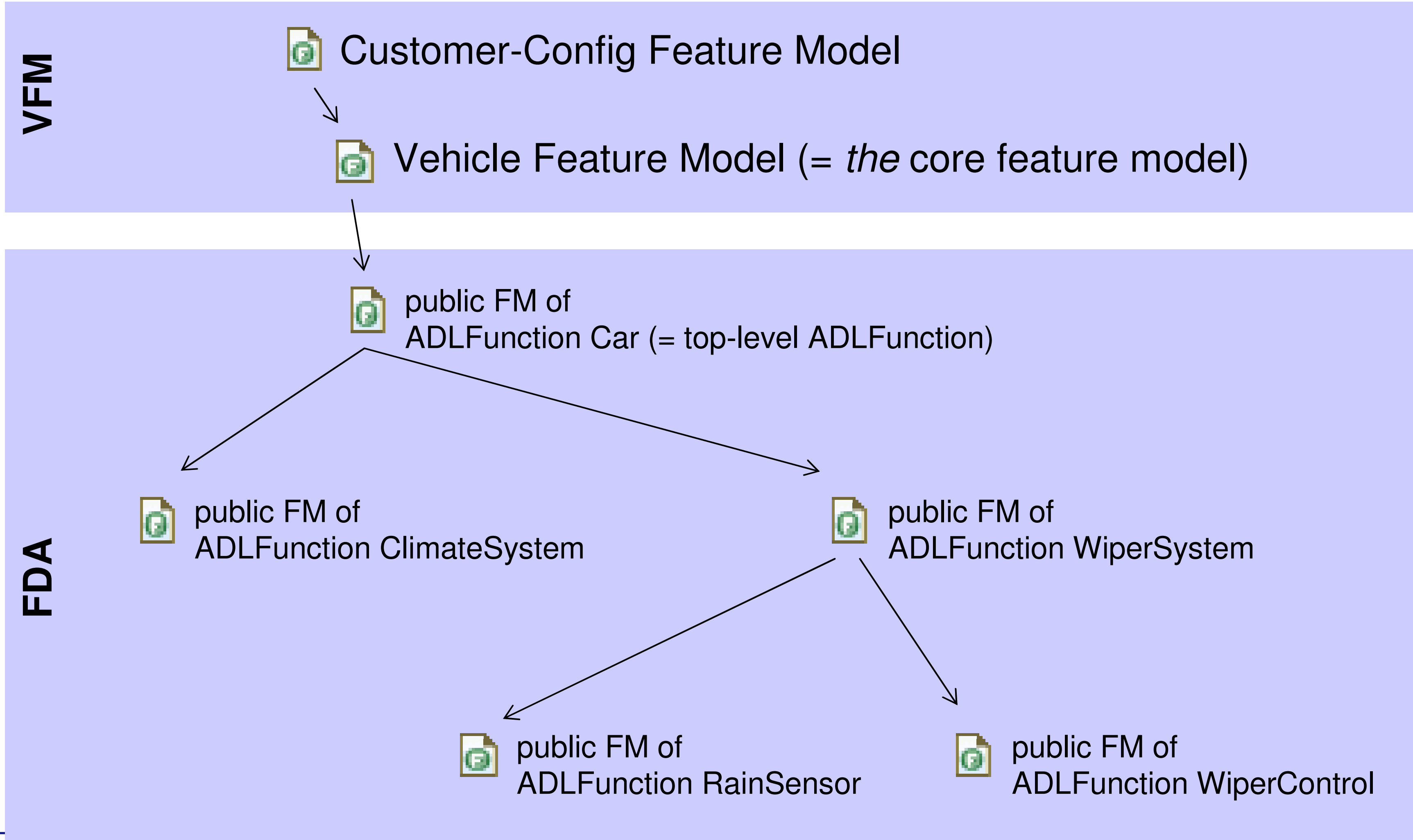


Alternative



<u>NOTE:</u>
Here, two kinds of bindings of thresholdValue are defined and selection between the two is propagated up
BINDING-SCENARIO #3

Feature Models in ATESST



Summary

ATESST Project defines EAST-ADL2

- refinement of EAST-ADL
- integration of Autosar and other recent standards
- contribution of concepts to existing efforts (OMG, Autosar, Proprietary)
- includes
  - Software & Hardware Components, Communication
  - Environment modelling
  - Requirements and V&V
  - Variant handling and product families
- variant handling based on feature modeling
- supports end-customer configuration, model range spanning variability, hierarchical composition of variable entities