Models Meeting Automotive Design Challenges

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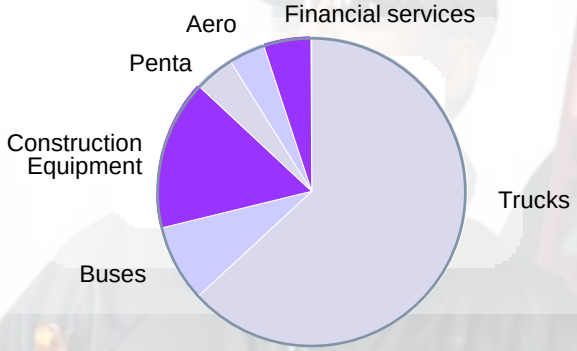
Volvo Group

The Volvo Group is one of the world's leading supplier of commercial transport solutions

Employees ~100 000
Total sales ~25 000 MEUR



MAENAD Project: maenad.eu

Model-based Analysis & Engineering of Novel Architectures for Dependable Electric Vehicles

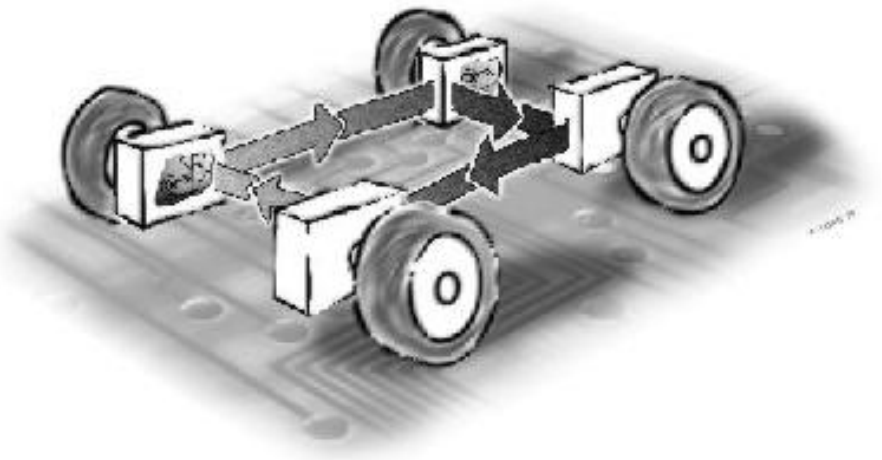
Purpose: Refine EAST-ADL Language, tools and methodology to support Electrical Vehicle development

OEMs:	Volvo Technolgoy, Centro Recherche FIAT	SE, IT
Suppliers:	Continental, Delphi/Mecel, 4S Group	DE, SE, IT
Tools:	MetaCase, Pulse-AR, Systemite	FI, SE, FR
Research:	CEA LIST, KTH, TU Berlin, U Hull	FR, SE, DE, UK

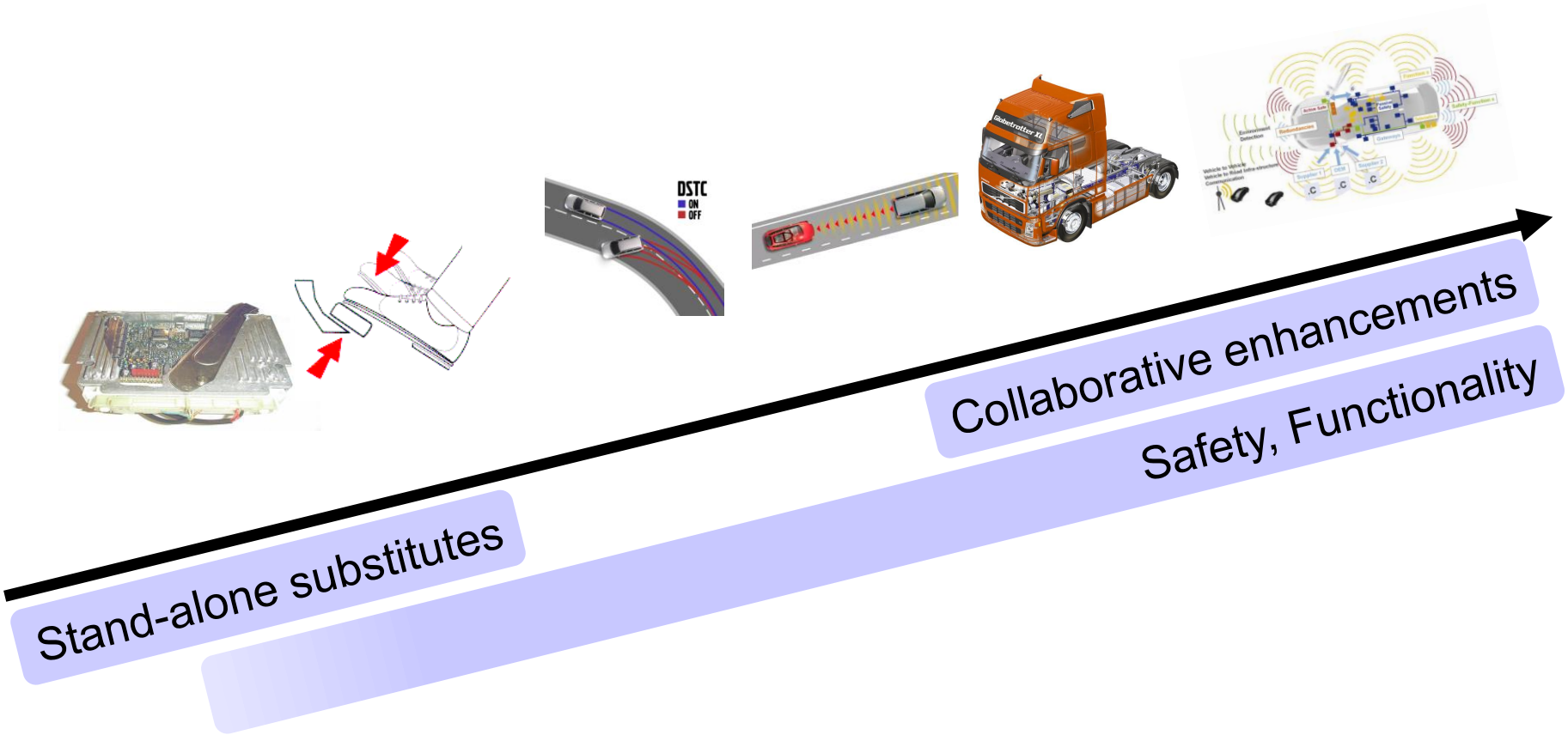
Kind:	FP7 STREP
Budget:	4 MEUR
Duration:	2011-2013
Coordinator:	Henrik Lönn, Volvo Technology

Outline

- Automotive Challenges
- Need for Modelling
- EAST-ADL
- AUTOSAR
- Conclusions



Evolution of Vehicle Electronics

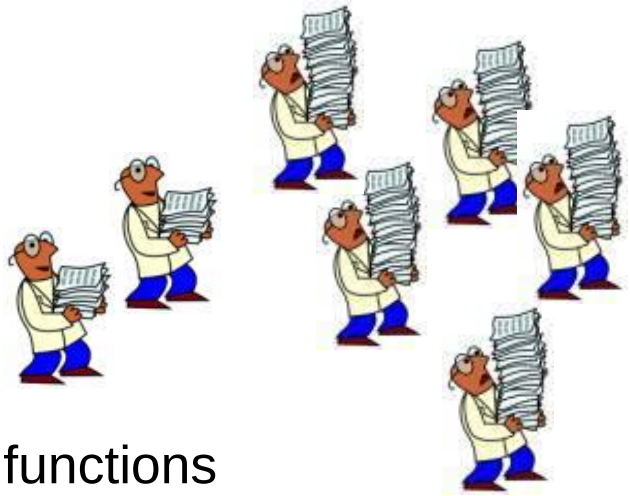


Challenges from two sides

- Product Aspects
  - Functionality increase
  - Complexity increase
  - Electrification
  - Quality and Safety implications
- Development Aspects
  - Supplier-OEM relationship
  - Multiple sites & departments
  - Product families
  - Componentization
  - Separation of application from infrastructure
  - Rules and Rigor (ISO26262, SPICE, CMM, etc.)

Complexity Increase

- Infrastructure-induced complexity
  - Multiple ECUs
  - Multiple network segments/domains
  - Componentization
  - HW-SW Dependencies
- Application-induced complexity
  - Functionality growth
  - Infrastructure interaction
  - Vehicle-to-vehicle interaction
  - Increased coupling between vehicle functions



Need for Flexibility

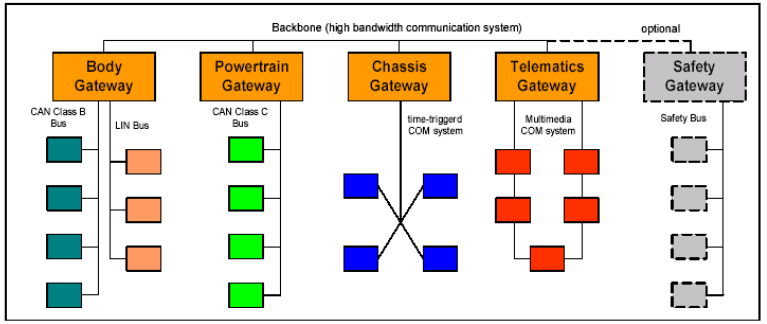
- Late Changes
  - Reduced time to market
  - Changes come late due to changed top level requirements
  - Changes come late due to distributed development
  - Integration is late
- Mechanichal Constraints enforce early decisions
  - ECU locations
  - Wiring Locations
  - Sensors and actuators

Need for Harmonization

- Different Brands from the same architechture
  - World top 10 Car manufacturers ⇔ 58 Brands
- Different Vehicles from the same architechture
  - Volvo Cars: P2 platform – ”4” vehicles
  - Volvo Group: TEAx platform – ”∞” vehicles
- Different Specification Levels from the same architechture
  - Electronics content vary from Basic to Luxus, from China to Europe, etc.

Need for Harmonization, Cont'd

- Multiple Domains one architechture
  - Body
  - Telematics
  - Chassis
  - Powertrain
  - …

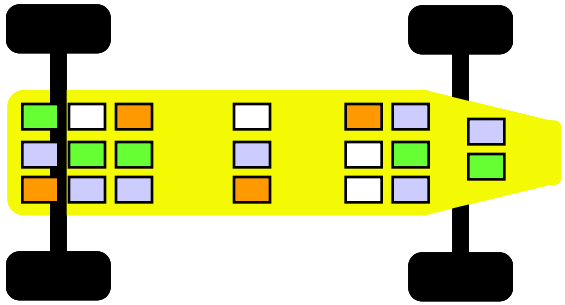


- Multiple Departments one architechture
  - >1 department for each domain, Function development vs. Software vs. Hardware, Testing, Integration, Prototyping, Product Planning, …
- Multiple Companies one architechture
  - Alliances, mergers, supplier-OEM
- Multiple Locations one architechture
  - Global industry

Need for Federated Architechture

(Modularization of HW)

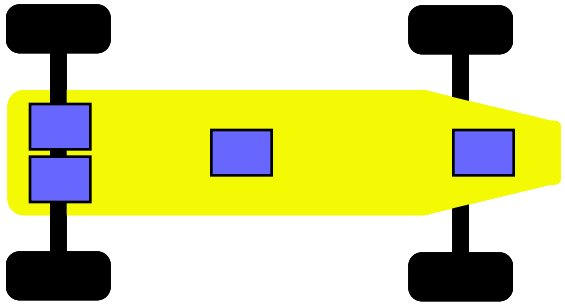
- Testing
  - Divide-and-conquer
- Pre-assembly
  - Fewer dependencies between components
- Procurement
  - Self-contained units
  - Fewer integration issues
- Development
  - Self-contained units
  - Fewer integration issues
- Safety
  - Fault containment
  - Fault independence



Need for Integrated Architechture

- ECU count
  - Each ECU has a large initial cost
- Flexibility

  (Over time and over vehicle variants)
  - Functionality is less hardware dependent
- Wiring
  - Wiring can be optimized
- Quality & Safety
  - Hardware and Connectors are error prone
  - Advanced development methods enforced



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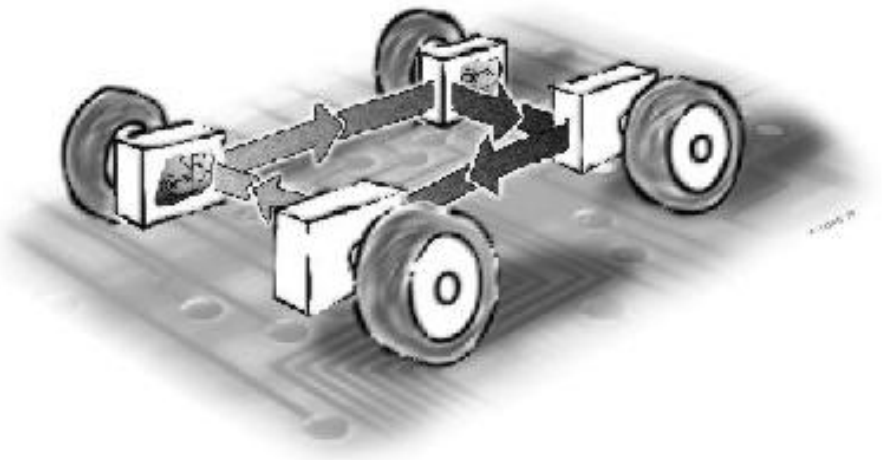
- Need for Modelling
- EAST-ADL
- AUTOSAR
- Conclusions

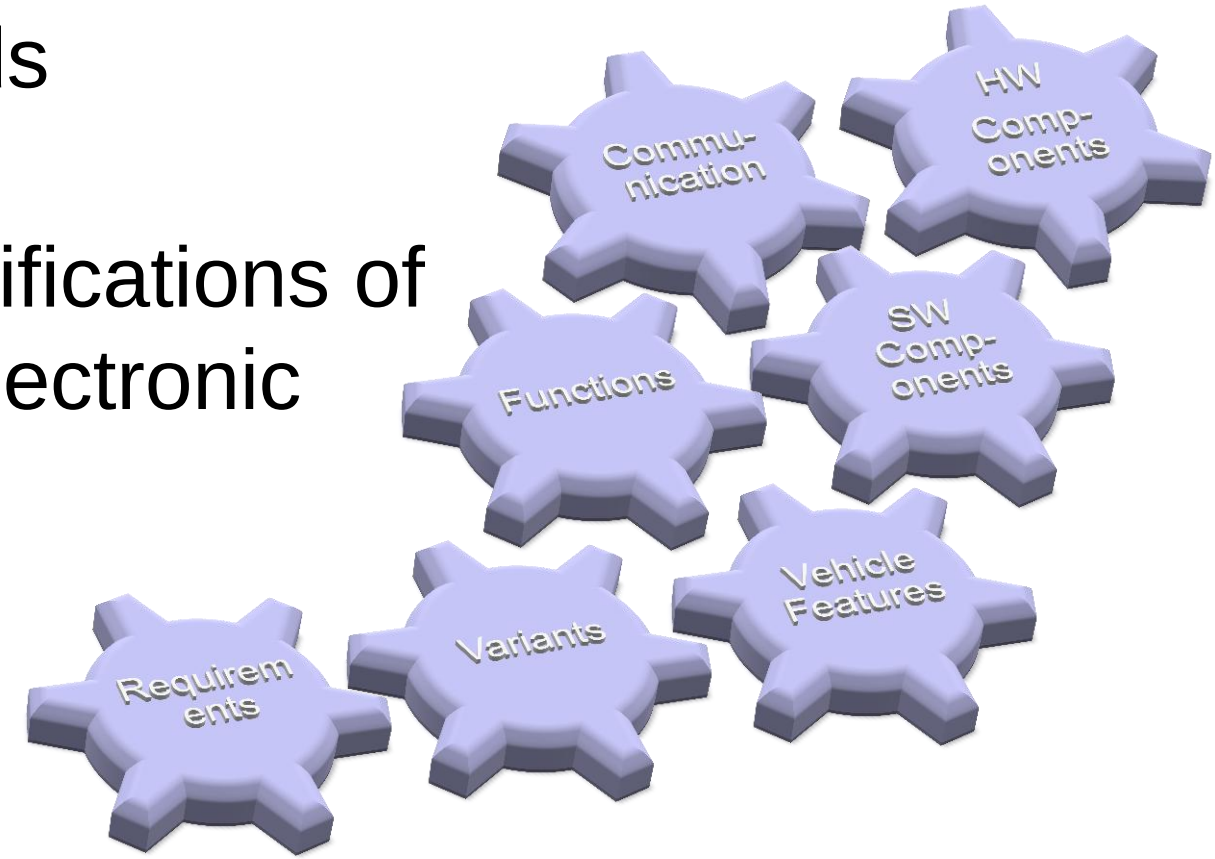


System Specifications - State of Practice

- Formats and specification styles are informal
- Formats and specification styles are textual
- Formats and specification styles are company specific
- Formats and specification styles vary over time
- Different tools and approaches depending on Domain

Modelling Needs

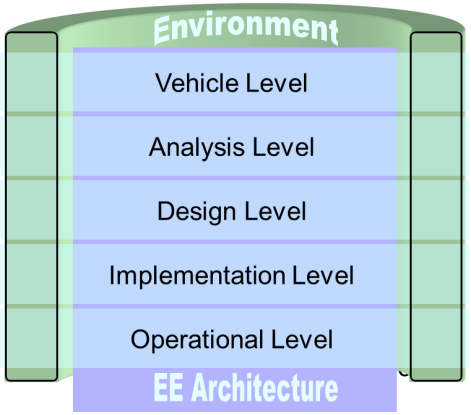
- Capture Specifications of Automotive Electronic Systems



Architecture Description Language
An information model that captures engineering information in a standardized way

Potential of an Architecture Description Language

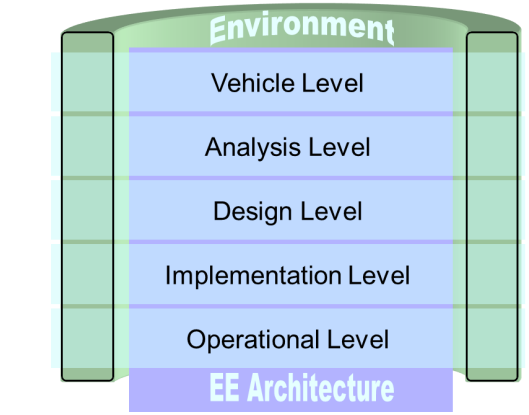
- Multiple aspects/abstraction levels
  - Separation of Concerns
  - Early System Integration
- Requirements Engineering
  - Tracing between Requirements
  - Allocation of Requirements to System Elements
  - V&V Information Support
- Basis for Variability Modelling
  - Product Families
  - Variability propagation
- Integrated Information Handling
  - Multi-user opportunity
  - Effective Documentation management
  - Traceability
  - Tool Integration
- Validation and Synthesis
  - Simulation
  - Analysis
  - Synthesis



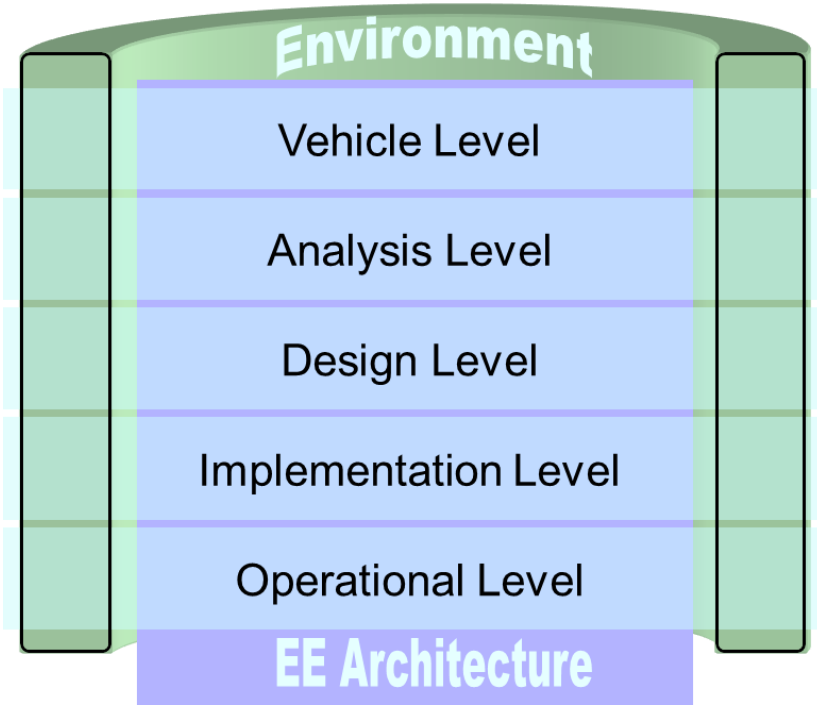
EAST-ADL Elements

- EAST-ADL Metamodel
- UML2 Profile
- XSD Schema
- EAST-ADL Methodology
- Tooling
  - EATOP Eclipse Platform
  - Papyrus UML
  - Proprietary

(MentorGraphics VSA, Arcticus Rubus, MetaCase ME+, Systemite SystemWeaver)



EAST-ADL Overview

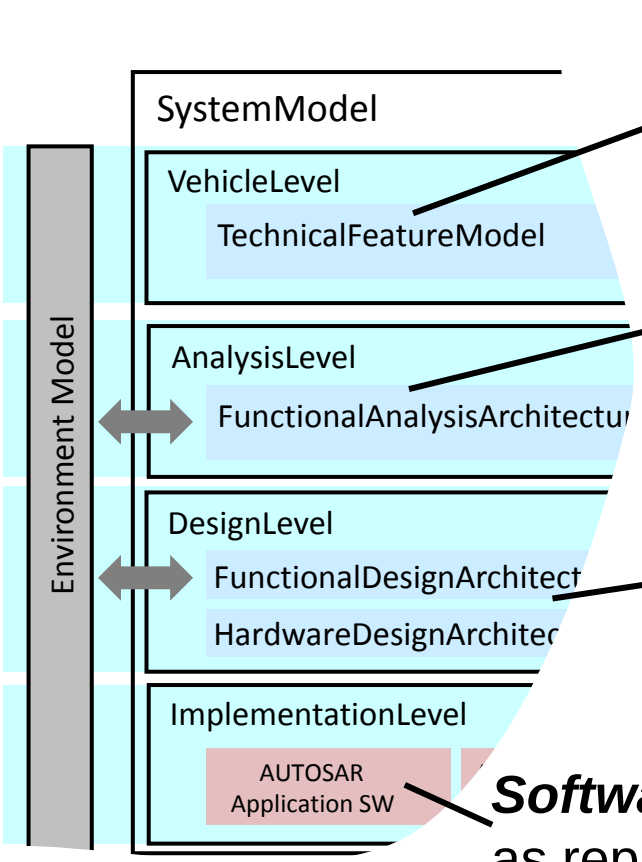


EAST-ADL defines an *Engineering information structure*

- Feature content
- Functional content
- Software architecture

- Requirements
- Variability
- Safety information
- V&V Information
- Behavior
- Timing
- …

EAST-ADL+AUTOSAR Representation

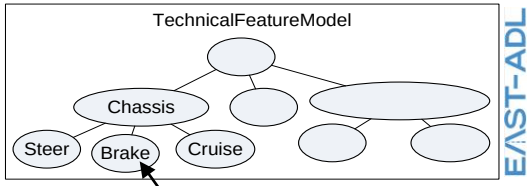


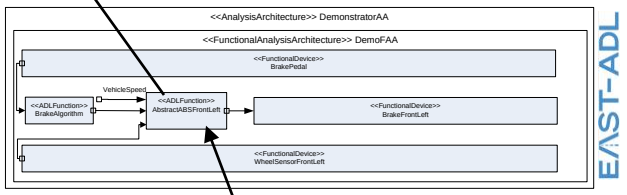
Features of the vehicle

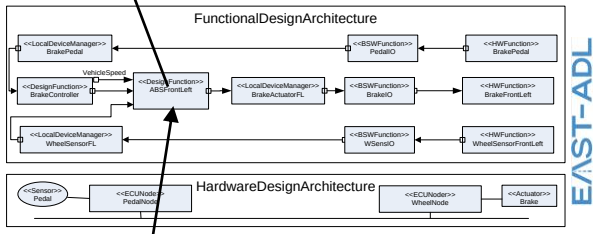
Abstract functions

Hardware topology, ***concrete functions***, ***allocation*** to nodes

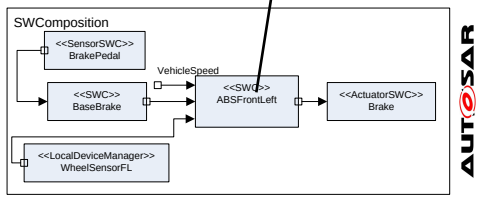
Software Architecture as represented by AUTOSAR



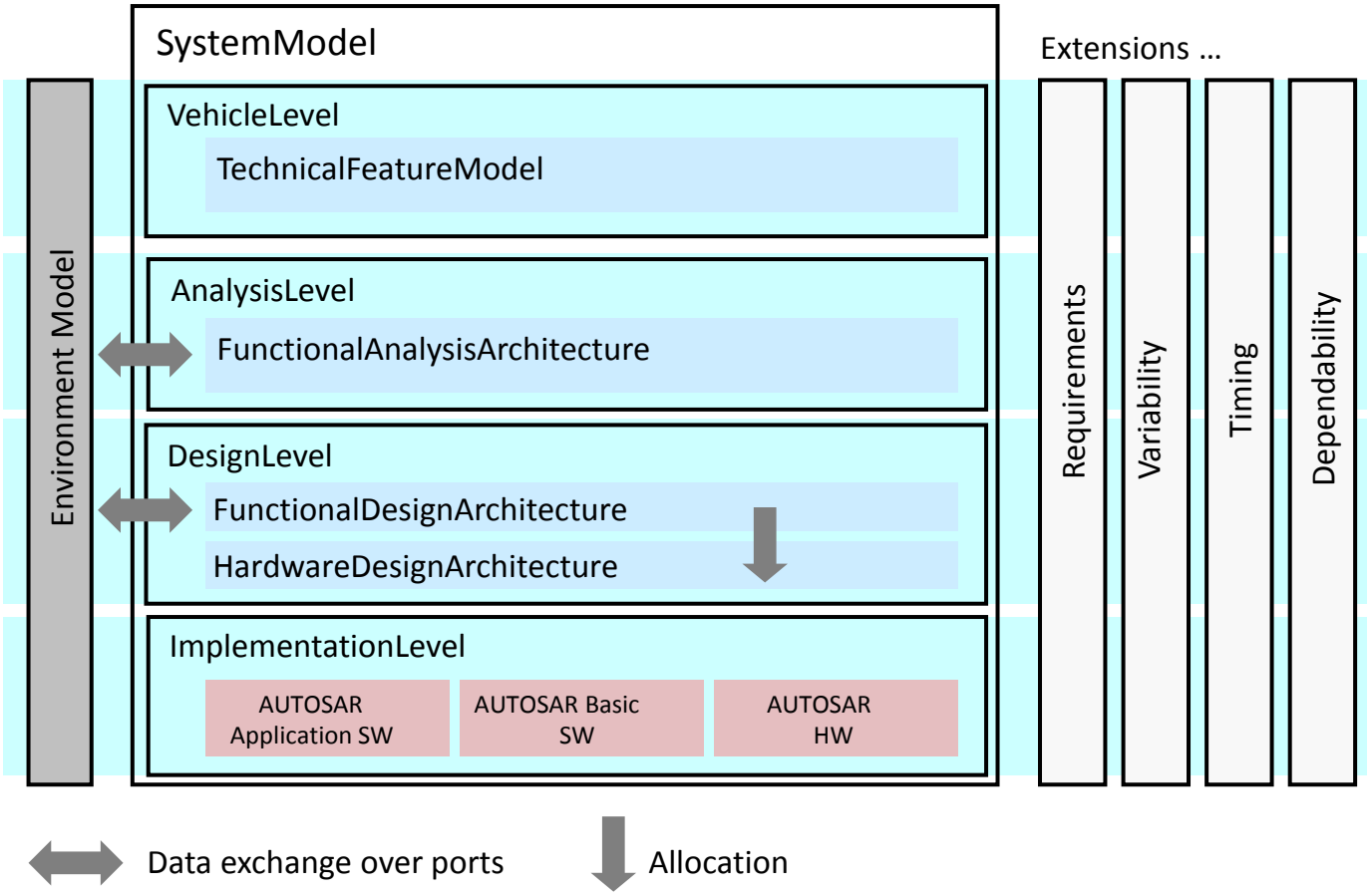




<<Realize>>



EAST-ADL Extensions



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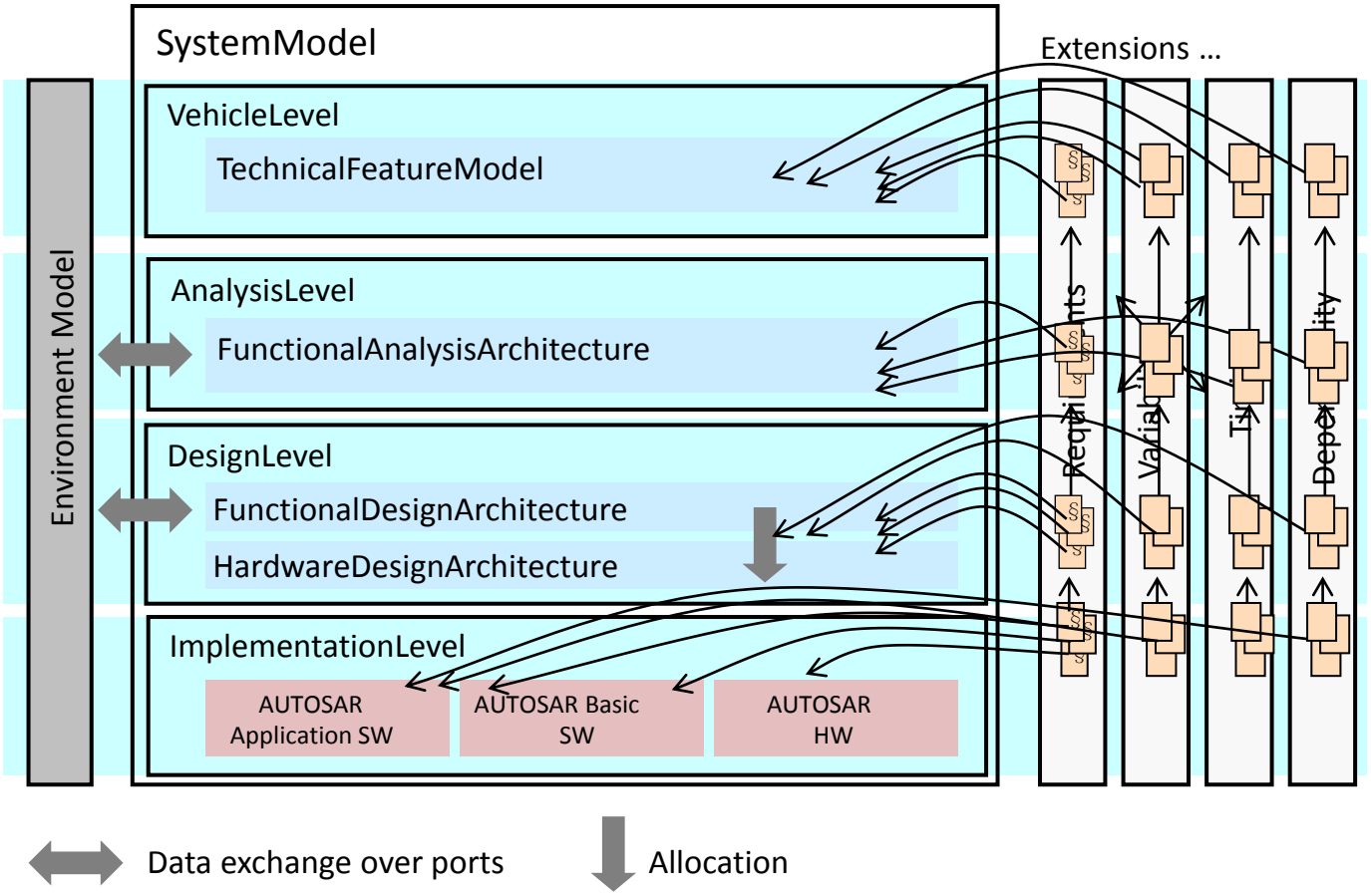
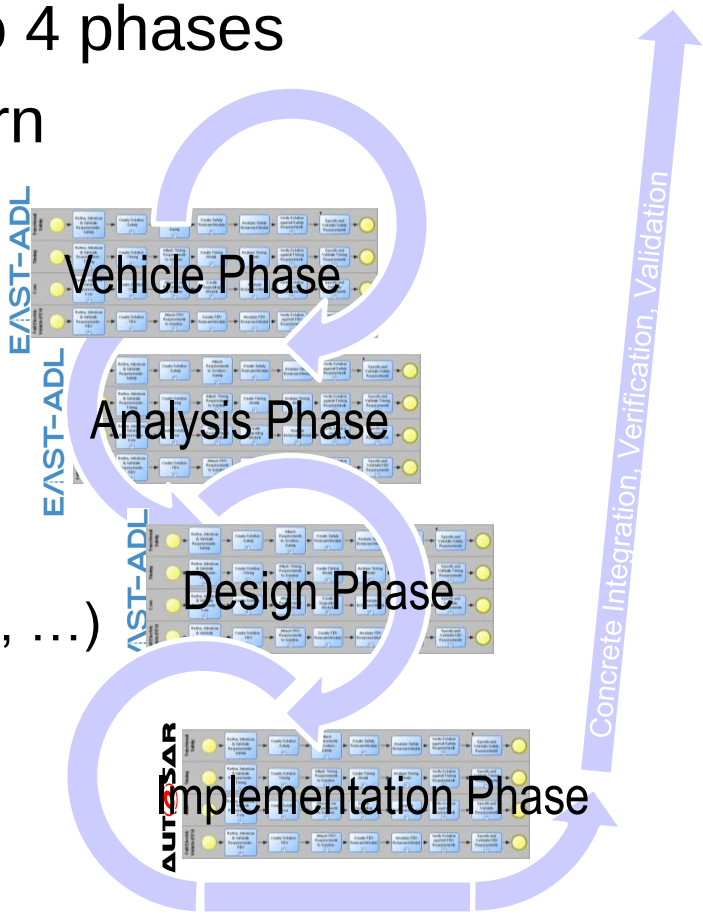


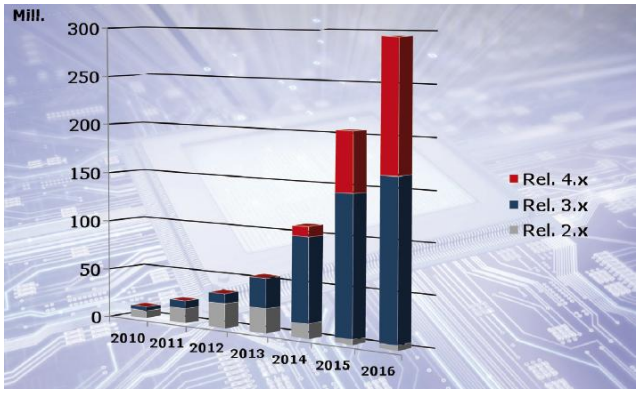
EAST-ADL Methodology

- Methodology organized according to 4 phases
- Each phase follows a Generic Pattern
  1. Introduce and Refine Requirements
  2. Create Initial Solution
  3. Attach Requirements to Solution
  4. Refine Solution
  5. Analyze Solution
  6. Verify Solution
  7. Specify and Validate Requirements
- Different aspects have individual "Swimlanes" (Safety, timing, variability, …)
- Methodology Model
  - SPEM (EPF tool)
  - BPMN (ADONIS tool)



AUTOSAR - Technical Goals

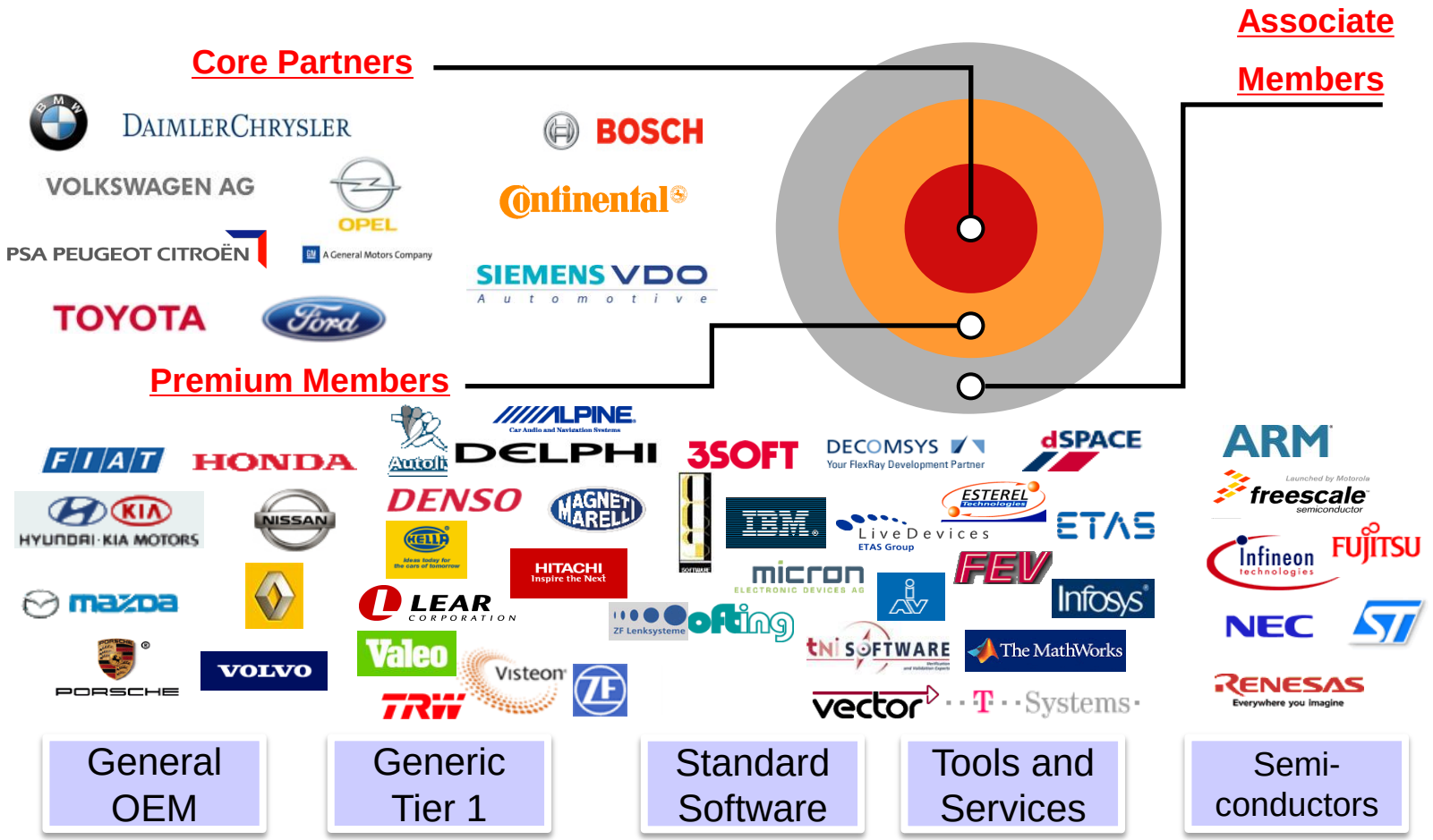
- Increased Flexibility
  - Modularity
  - Scalability
  - Transferability
  - Re-usability
- Standardized platform
  - Off-the-shelf purchase & integration of comm, OS, diagnosis, drivers, etc.
  - Off-the-shelf hardware
- Standardized Interfaces
  - Off-the-shelf purchase & integration of common vehicle functions



300 million AUTOSAR ECU:s in 2016

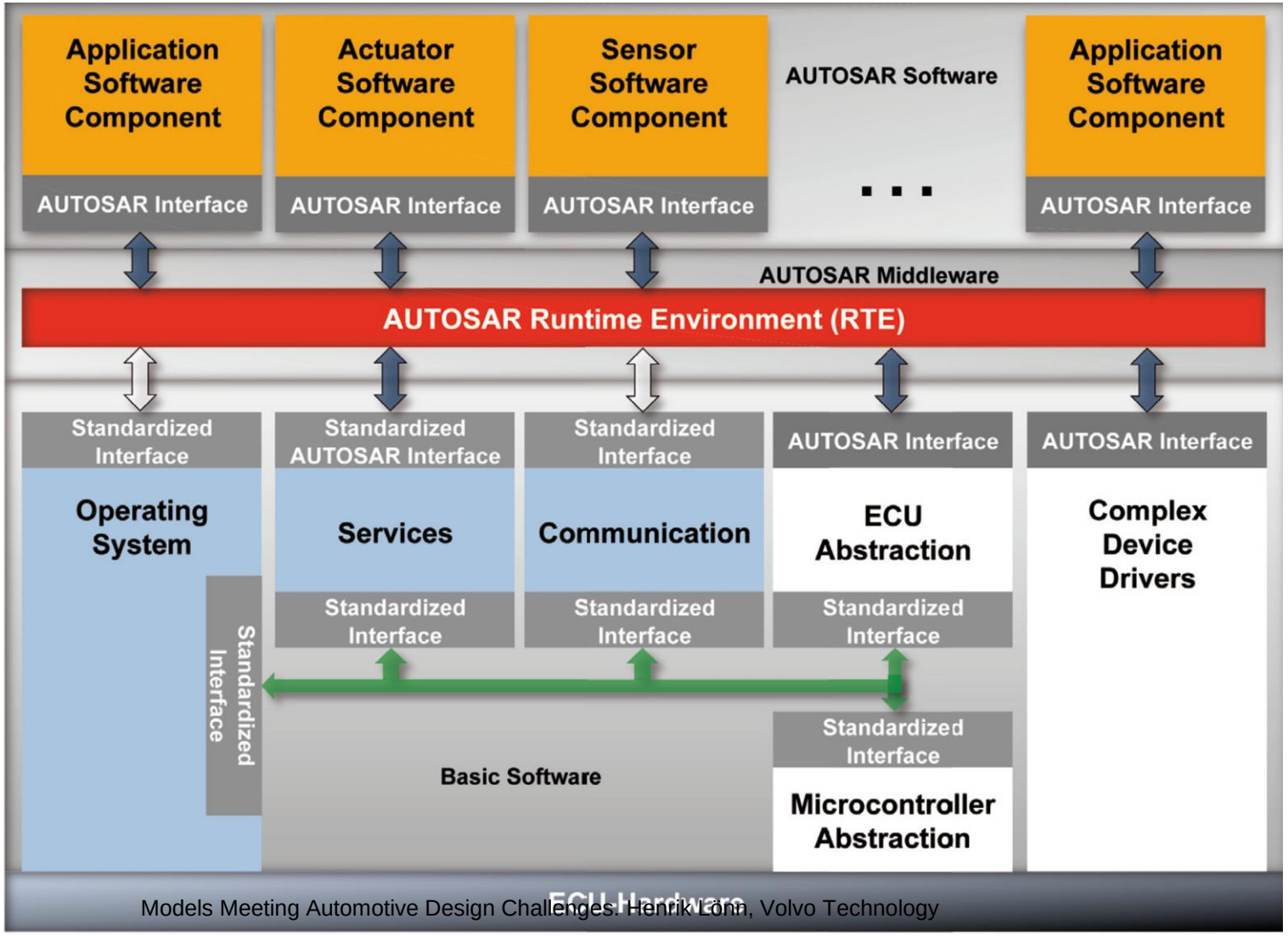
(~60 million cars made 2011 worldwide)

AUTOSAR - Consortium



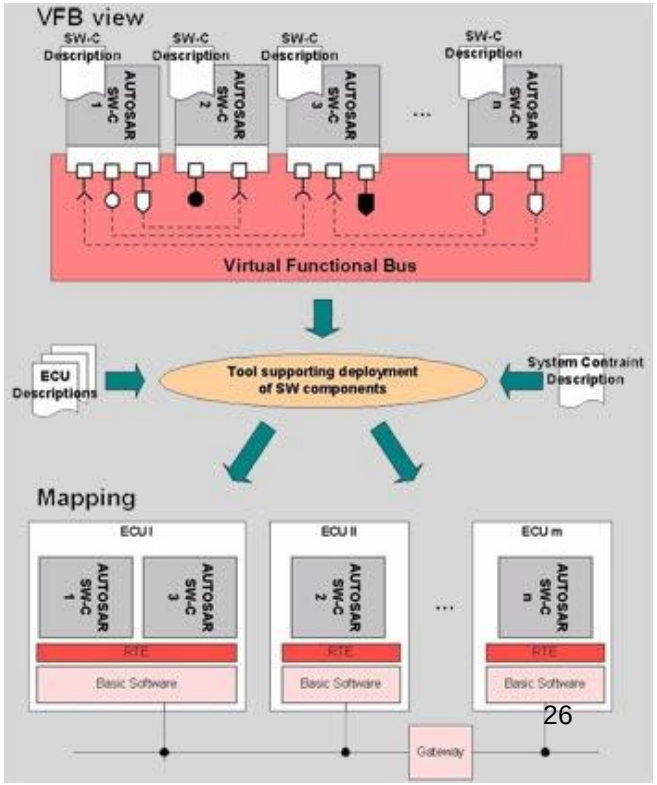
>150 members Dec 2011

AUTOSAR ECU SW Architecture



AUTOSAR - Elements

- Modelling
  - Capture SW Components SW Component Template
  - Capture ECU resources: ECU Resource Description
  - Capture allocation and communication: System Description
- Methodology
  - Autogenerate ECU configuration
  - Autogenerate platform SW configuration
  - Autogenerate glue code (RTE)
- Application Interfaces
  - Standard interface definitions for well-established functions in all domains (Body, powertrain, chassis, …)
- Architecture
  - Standard platform SW
  - Standard interfaces



EAST-ADL vs AUTOSAR

EAST-ADL

For Features, Functional Architecture and Topology

AUTOSAR

For Software Architecture and Execution Platform

EAST-ADL vs AUTOSAR

- Different Abstraction Levels:
  - EAST-ADL complements AUTOSAR with “early phase” information
- Different Engineering Information Scope:
  - EAST-ADL complements AUTOSAR with more concepts
    - Requirements Engineering
    - Variant Management
    - Behaviour (nominal/error)
    - Timing
    - Safety

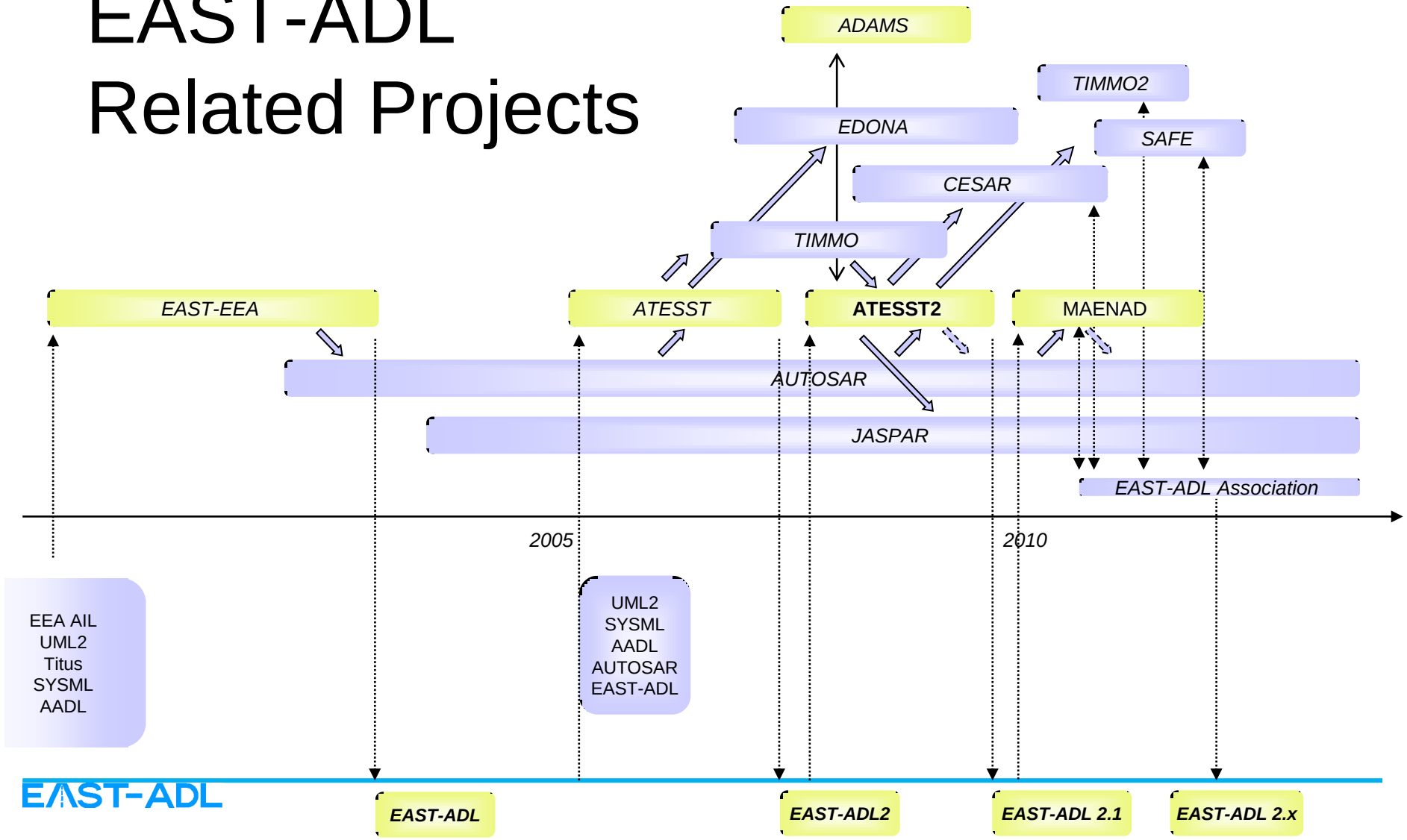
Scope in AUTOSAR depending on version

- Same Meta-Metamodel
  - Enterprise Architect model used for both
  - Same file exchange ARXML-EAXML
  - Same tool infrastructure possible ARTOP-EATOP

Re-Inventing the Wheel?

- Why not UML?
  - The EAST-ADL profile allows usage of UML
- Why not SysML?
  - EAST-ADL is based on applicable SysML concepts
- Why not Autosar?
  - EAST-ADL Complements Autosar
- Why not proven proprietary tools?
  - EAST-ADL integrates external tools and provides an information structure for the engineering data regardless of tool
- Why not proven open scientific/academic approaches?
  - EAST-ADL integrates relevant approaches

EAST-ADL Related Projects

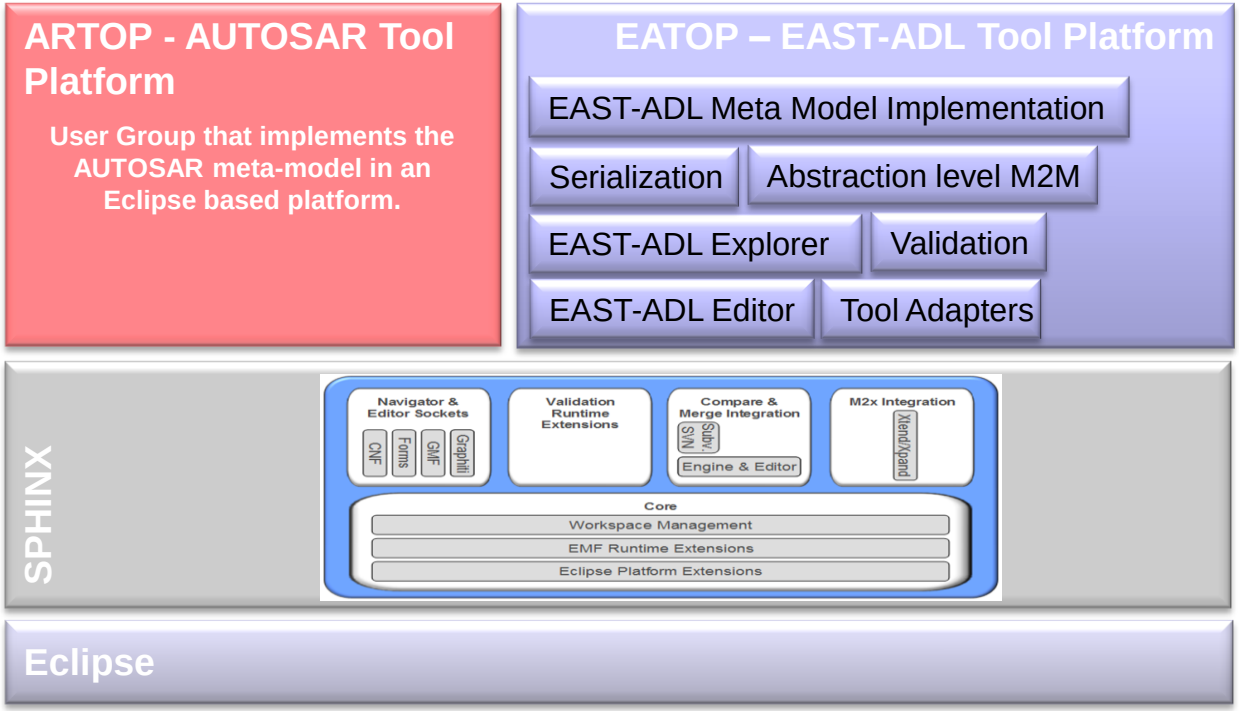


EAST-ADL Association

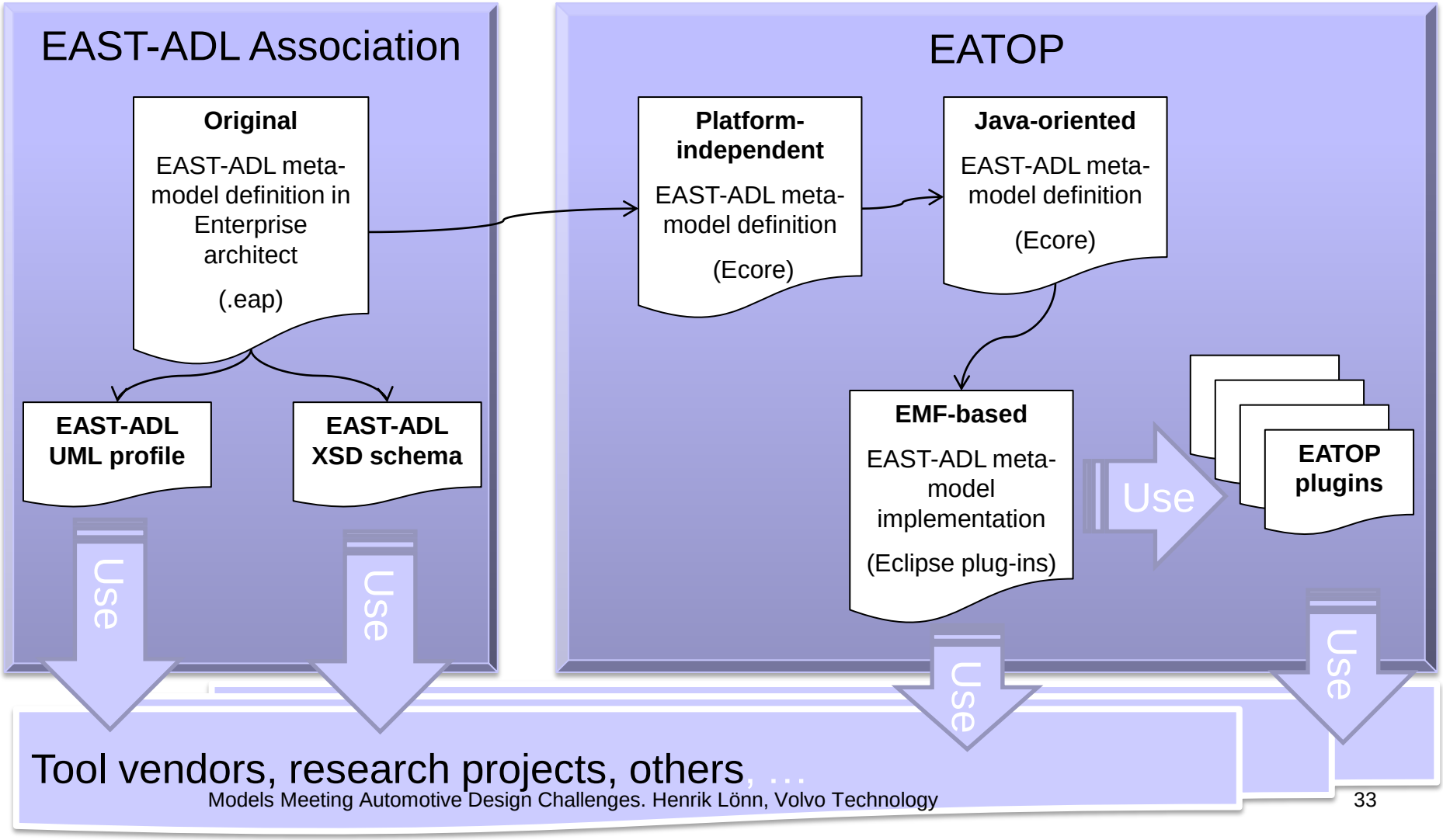
- Non-profit, non-governmental organization
- Assist and promote the development and application of the EAST-ADL.
- The EAST-ADL Association will stipulate the content of new versions of the EAST-ADL language.
- The EAST-ADL Association has no fees or funds, and each member carry any costs for contributing.
- Membership is open to individuals and organizations
- 50 members: OEMs, Suppliers, Tool Vendors, Institutes, Academia

EATOP – EAST-ADL Tool Platform

- Eclipse project initiated
  - Eclipse Automotive Industry Working Group
- Conceptually aligned with ARTOP
- Fully open
  You are Invited!



EATOP – EAST-ADL Tool Platform



EAST-ADL Contributors 2000-20xx

AUDI AG
BMW AG
Carmeq GmbH
CRF
Daimler AG
ETAS GmbH
Mecel AB
Mentor Graphics
OPEL GmbH
PSA
Renault
Robert Bosch GmbH
Siemens, Continental
Valeo
Vector
Volvo Car Corporation
Volvo Technology AB
ZF
CEA-LIST
INRIA
LORIA
Paderborn Univerisity-C-LAB
Technical University of Darmstadt
Technische Universität Berlin
The Royal Institute of Technology
The University of Hull
…

You Are Invited

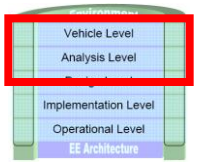
- Conceptual Work on EAST-ADL Language
- Methodology Refinement for specific aspect
- Tool Development

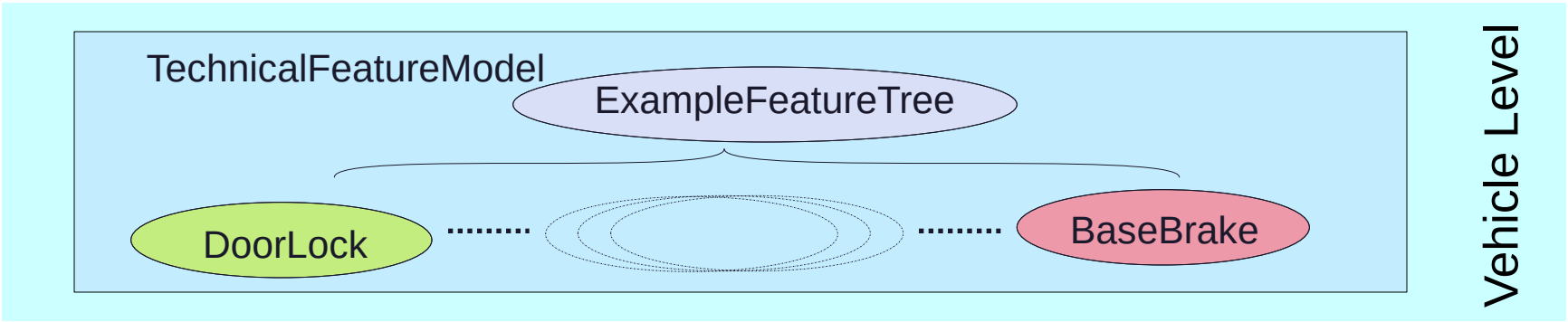
  Simulators, viewers, tool integration, synthesis, analysis, optimization, requirements engineering, …
  - EATOP
  - Papyrus UML
  - Proprietary (EAXML file format)

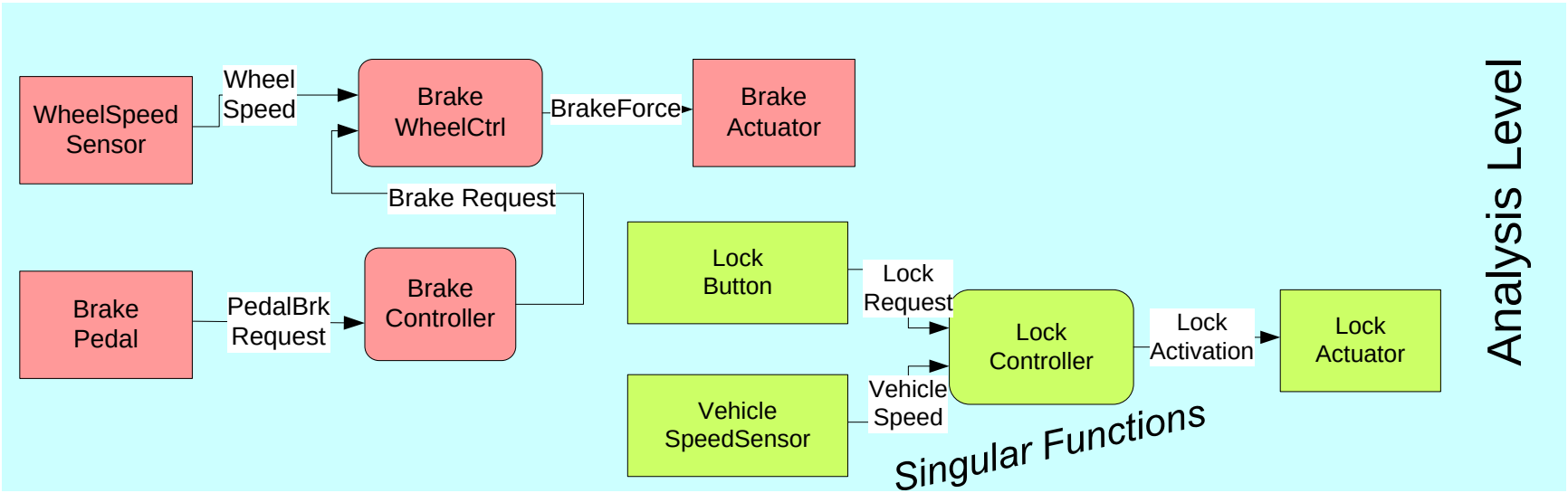
EAST-ADL Topics

- Structure
- Variability
- Requirements
- Behavior
- Plant Modelling
- Analysis
- Optimization
- Timing
- Safety
- Dependability
- Tools
- Methodology

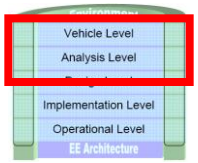
EAST-ADL Abstraction Levels







EAST-ADL Abstraction Levels



Vehicle Level

TechnicalFeatureModel

ExampleFeatureTree

DoorLock

BaseBrake

ABS

BrakeLight

Realization relations

Analysis Level

FunctionalAnalysisArchitecture

Lock Button

LockRequest

Vehicle SpeedCalc

Vehicle Speed

Lock Controller

Lock Activation

Lock Actuator

WheelSpeed Sensor

WheelSpeed

Brake WheelCtrl

BrakeForce

Brake Actuator

Brake Pedal

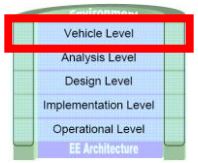
PedalBrk Request

Brake Controller

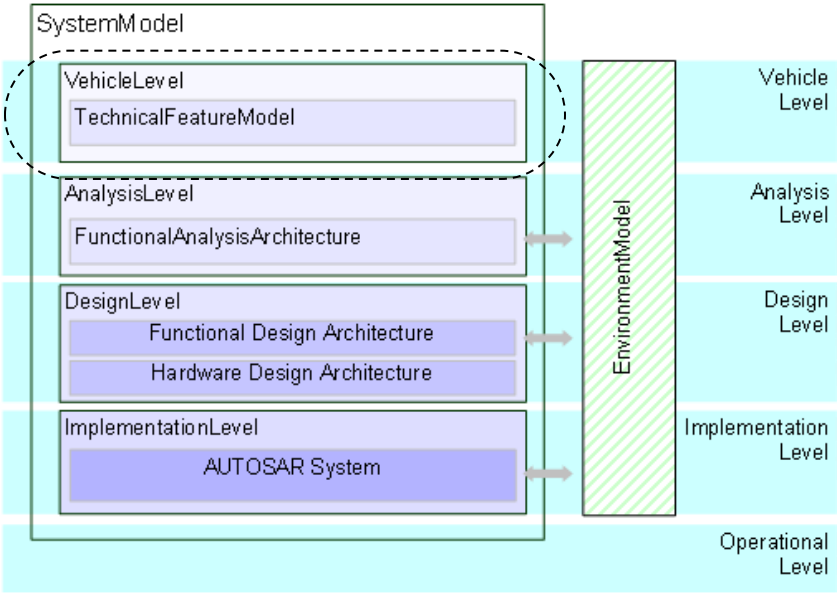
Brake Request

Integrated Functions

Vehicle Level

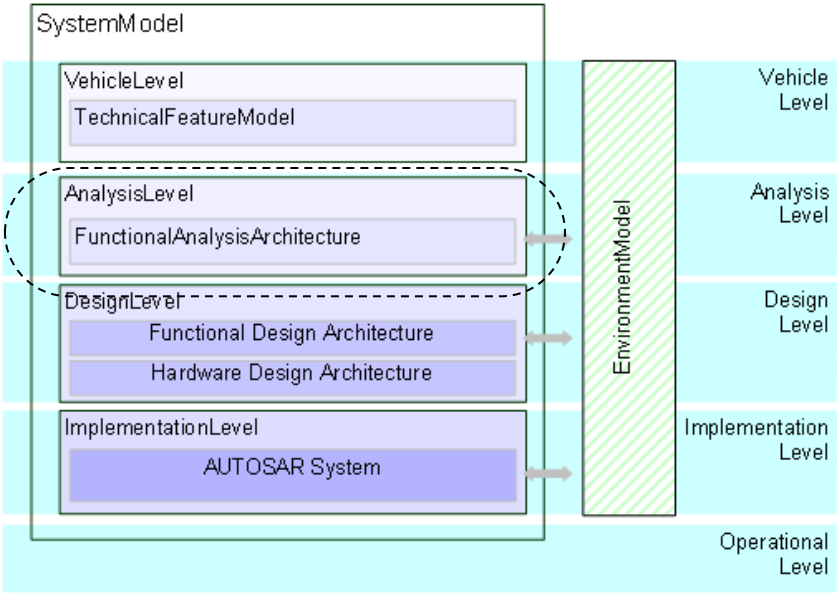


- Characterization of Vehicle by a means of Features
  - *Stakeholder* requested functional or non-functional characteristics
  - Describes "what",
    but shall not fix the "how"
  - Specified by requirements and use cases
  - Configuration points to create a vehicle variant
  - ProductFeatureModels for Configuration of TechnicalFeatureModel

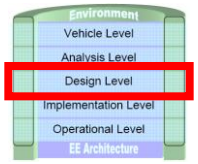


Analysis Level

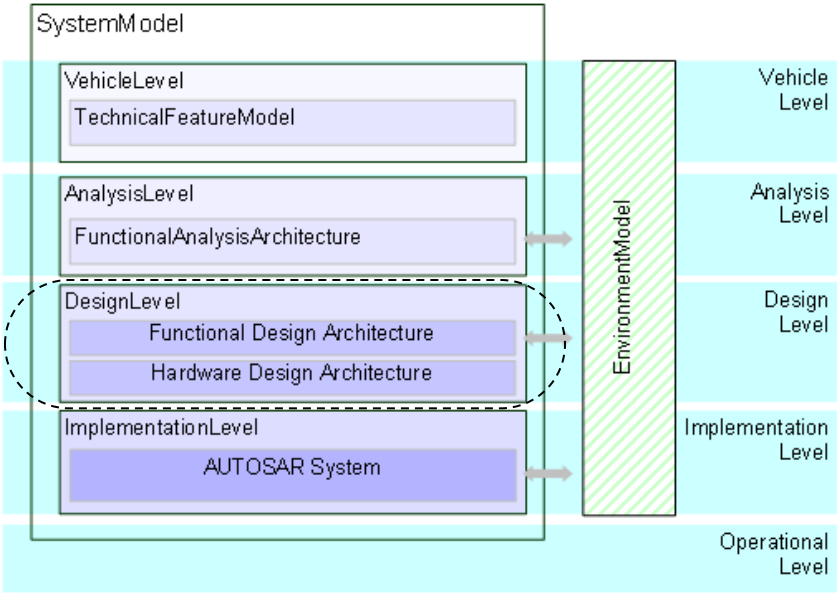
- Abstract Functional description of the EE system
  - Realizes functionality based on the features and requirements
  - Abstract functional definition avoiding implementation details
  - Defines the system boundary
  - Environment model define context
  - Basis for abstract safety analysis



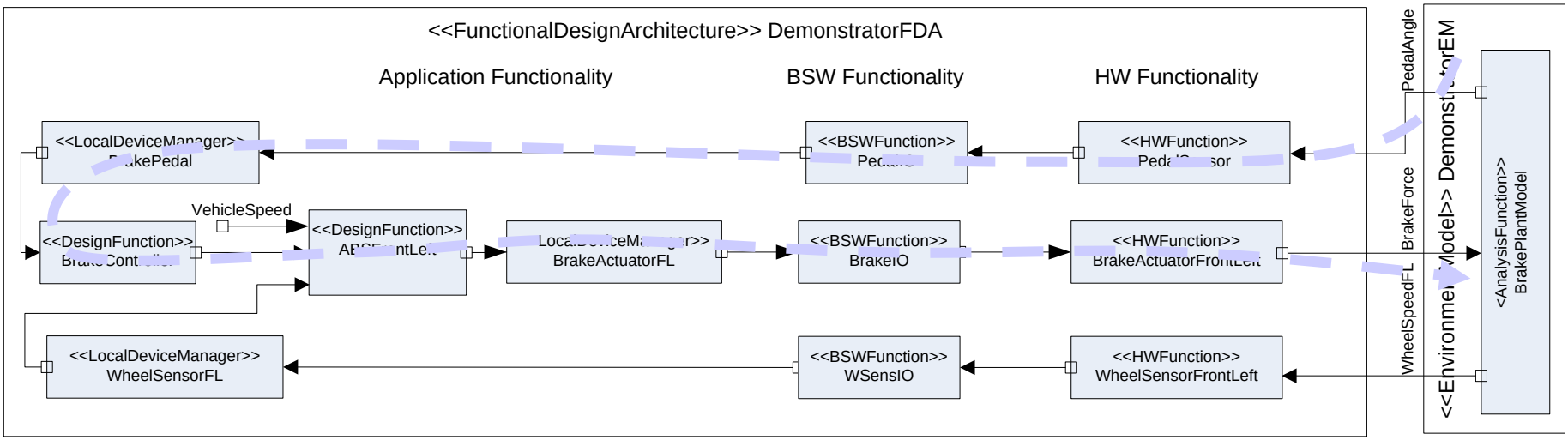
Design Level



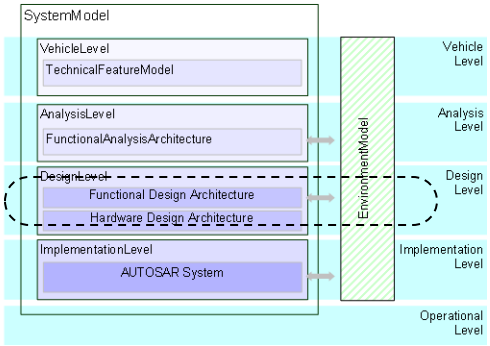
- Concrete functional definition
  - Functional definition of application software
  - Functional abstraction of hardware and middleware
  - Hardware architecture
  - Function-to-hardware allocation
  - *No SW Architecture*



Function interaction – end-to-end

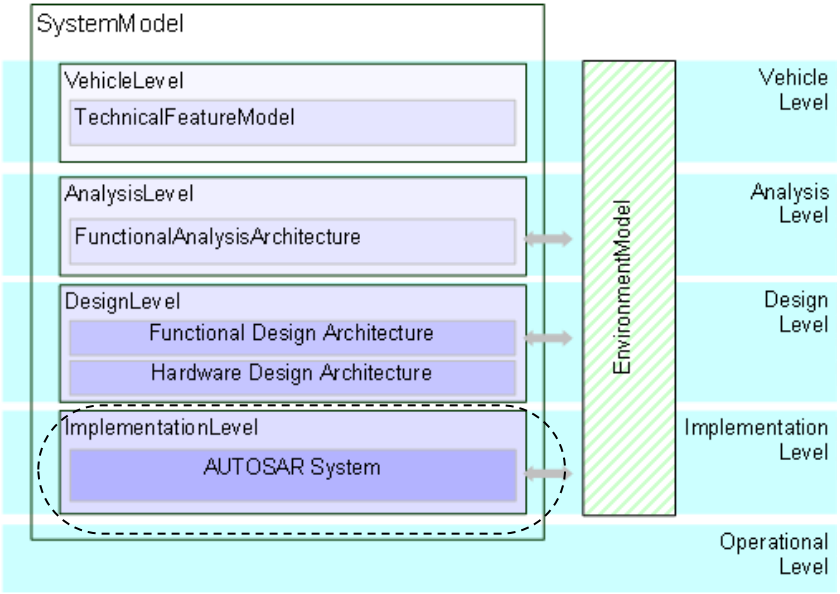


Model structure supports interaction with the environment and end-to-end functional definitions



Implementation Level

- Software-based implementation of the system
  - AUTOSAR Software components represent application functionality
  - AUTOSAR Basic software represents platform
  - ECU specifications and topology represent hardware
  - Model is captured in AUTOSAR
    - Software component template
    - ECU resource template
    - System Template



Conclusion

- EAST-ADL is a language for Automotive EE engineering information
  - Shared ontology/terminology across companies and domains
  - EAXML exchange format to secure tool interoperability
  - Allows joint efforts on methodology, modelling and tools
- Supports several aspecs (timing, variability, behavior, V&V, etc. through extensions)
- EAST-ADL is aligned with AUTOSAR modelling elements and modelling infrastrucure
- EATOP platform can foster tool prototyping
- EAST-ADL Association is a structure to coordinate and harmonize language progress
- *The Open and Extensible/Integrateable character of EAST-ADL makes it particularly suitable for industry-relevant research*

THANK YOU FOR YOUR ATTENTION!

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