Towards systematic Model and Component based development of embedded systems

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Embedded Control System group

Systems engineering for embedded (control) systems

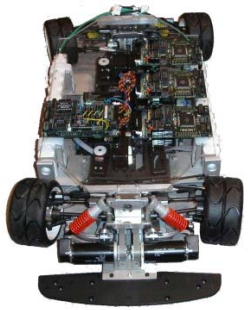
Research themes:

- Architectural design
- Model based development
- Systematic verification and integration

KTH Embedded Systems Centre

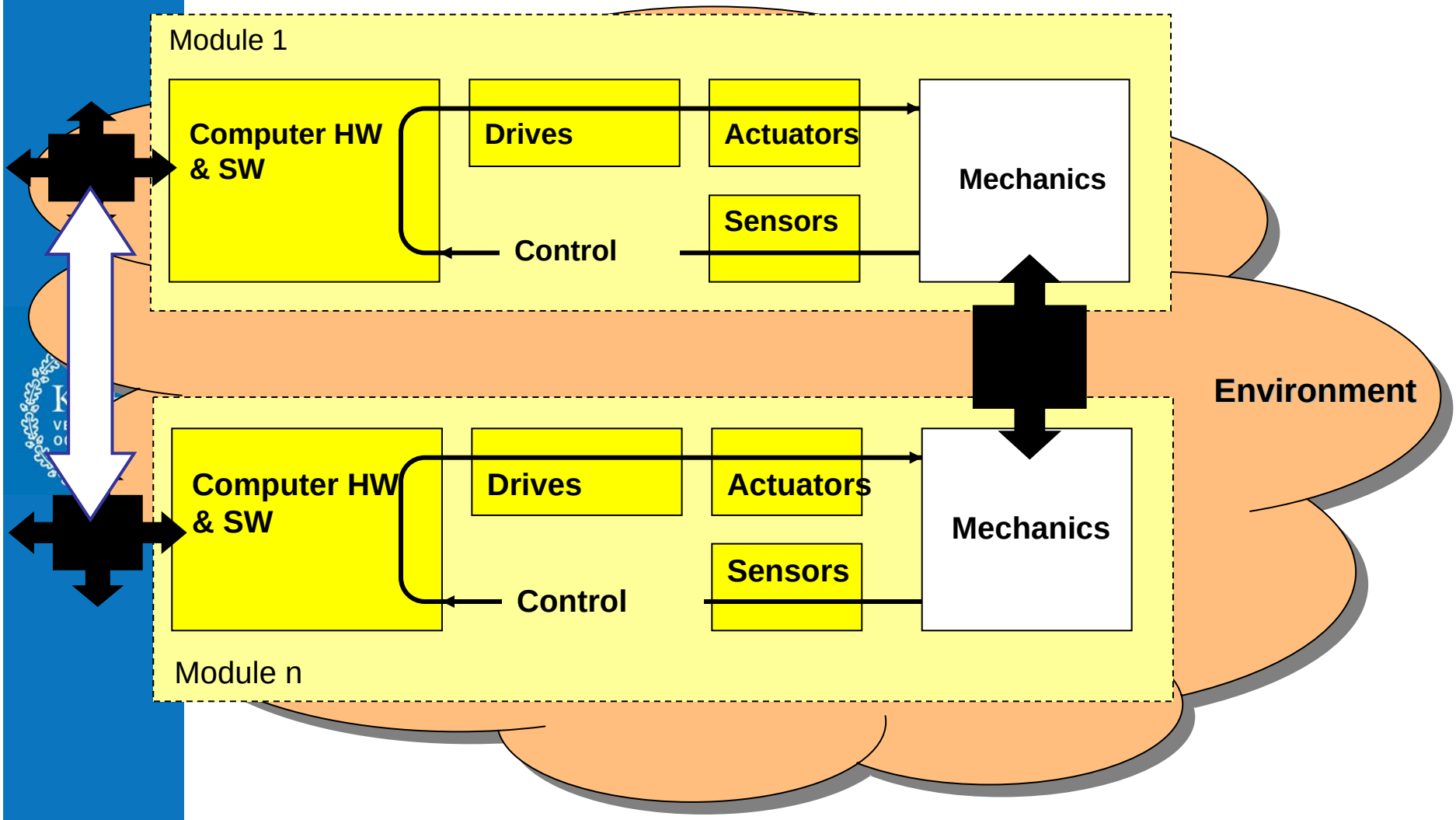
Projects: ARTIST2, ATESST, DYSCAS, Rembrandt, ++

Current emphasis on automotive applications



See www.md.kth.se/RTC for more info

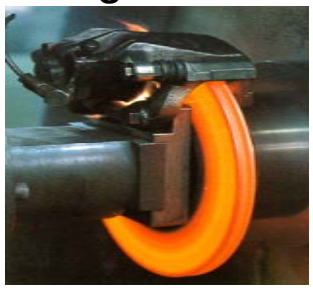
From Mechanics to Mechatronics



Mechanical engineering CBD and MBD

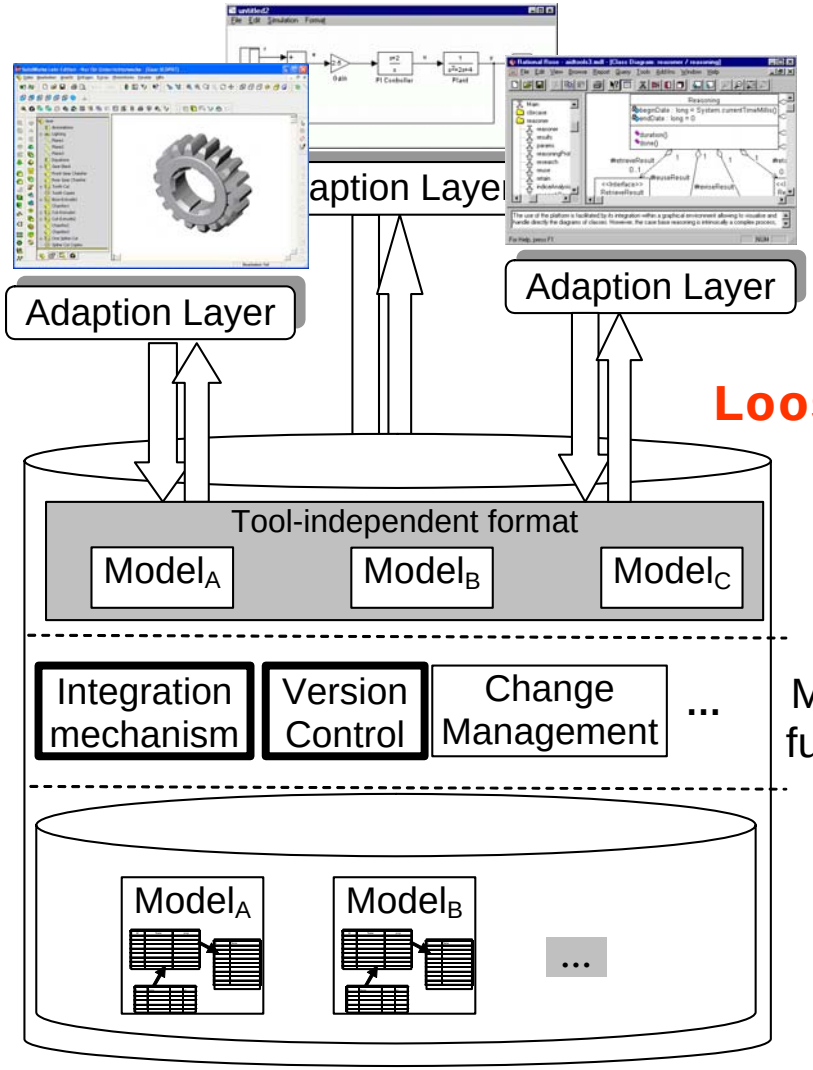
- Well developed methodologies

  However, functional abstractions are not used in practice!
- Component attributes and interfaces
  - Design, look and feel – also interpreted as cognitive interfaces (cognitive) in research
  - Geometry,
  - Physical effects and dependencies – a challenge
- Mature adoption of MBD
  - Technical engineering – CAE
  - Information management – PDM



- Trend
  - Extend systems analysis, introduce functional abstractions / rationale, towards PLM

Model Data Management Platform



Modeling & analysis tools

Loose integration

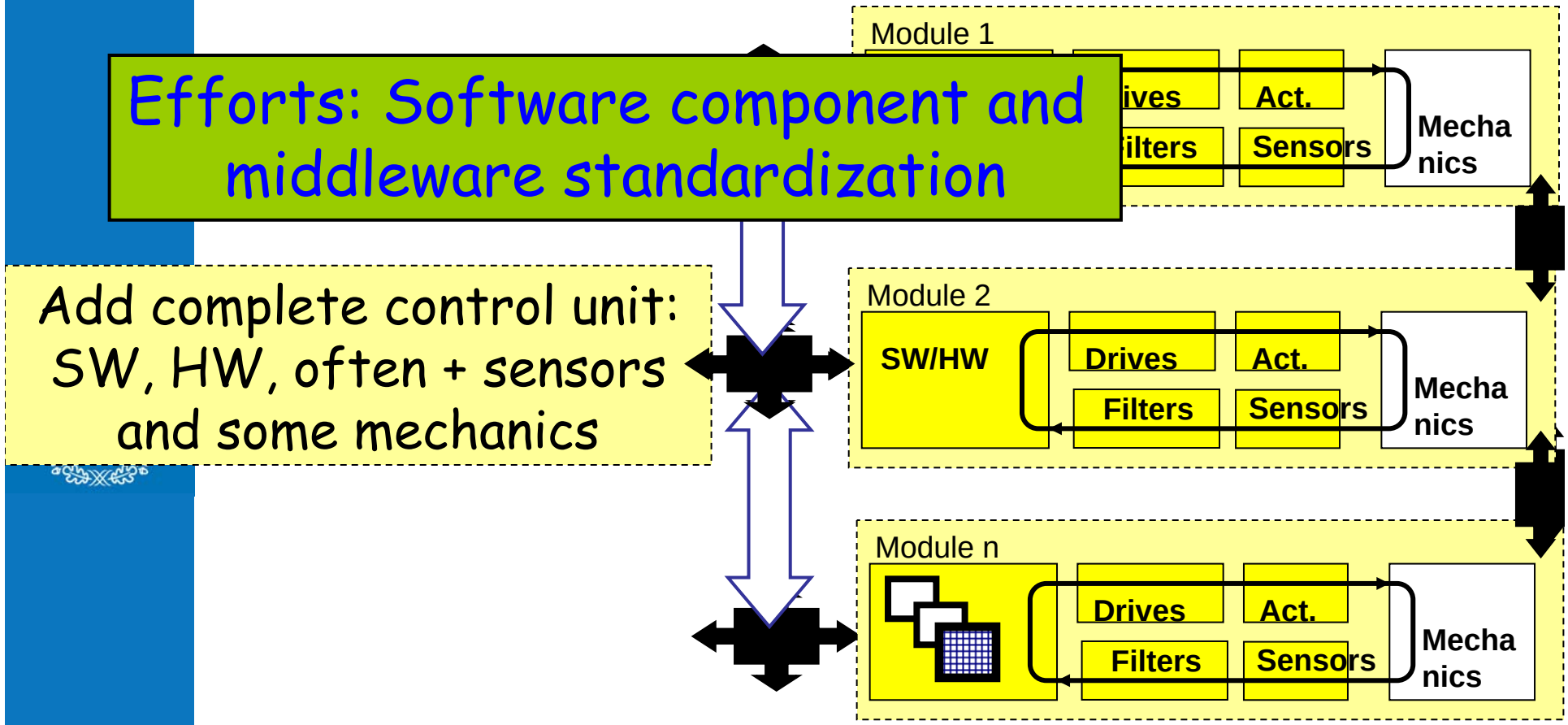
Tool interface

Management functionalities

Data repository

Existing or new data management tools

Mechatronics: Adding new functions



Towards model level integration

”Purely” mechanical vehicle

	Sus/C	Brake	Steer	Wheel	Diff	Trans	Clutch	Eng	Driver
Susp				X					X
Brake				X					X
Steer				X					X
Wheel	X	X	X		X				
Diff				X		X			
Trans					X		X		
Clutch						X		X	
Eng							X		
Driver		X	X				X		

X – Mechanical relations

Fully programmable vehicle!

	Sus/C	Brake	Steer	Wheel	Diff	Trans	Clutch	Eng	Driver
Susp		P	P	X+P	P	P	P	P	X+P
Brake	P		P	*X*+P	P	P	P	P	*X*+P
Steer	P	P		*X*+P	P	P	P	P	*X*+P
Wheel	X	X	*X*+P		*X*				
Diff	P	P	P	*X*+P		*X*+P	P	P	
Trans	P	P	P	P	*X*+P		*X*+P	P	P
Clutch		P	P		P	*X*+P		*X*+P	P
Eng	P	P	P	P	P	P	*X*+P		P
Driver	P	*X*+P	*X*+P		P	P	*X*+P	P	

P - Programmable relations

X - Possible change

Additional complexities

New functions and technologies

- Domain convergences

Product lines, platforms and components shared across products

- Varying component contexts; ”No” optimal architecture

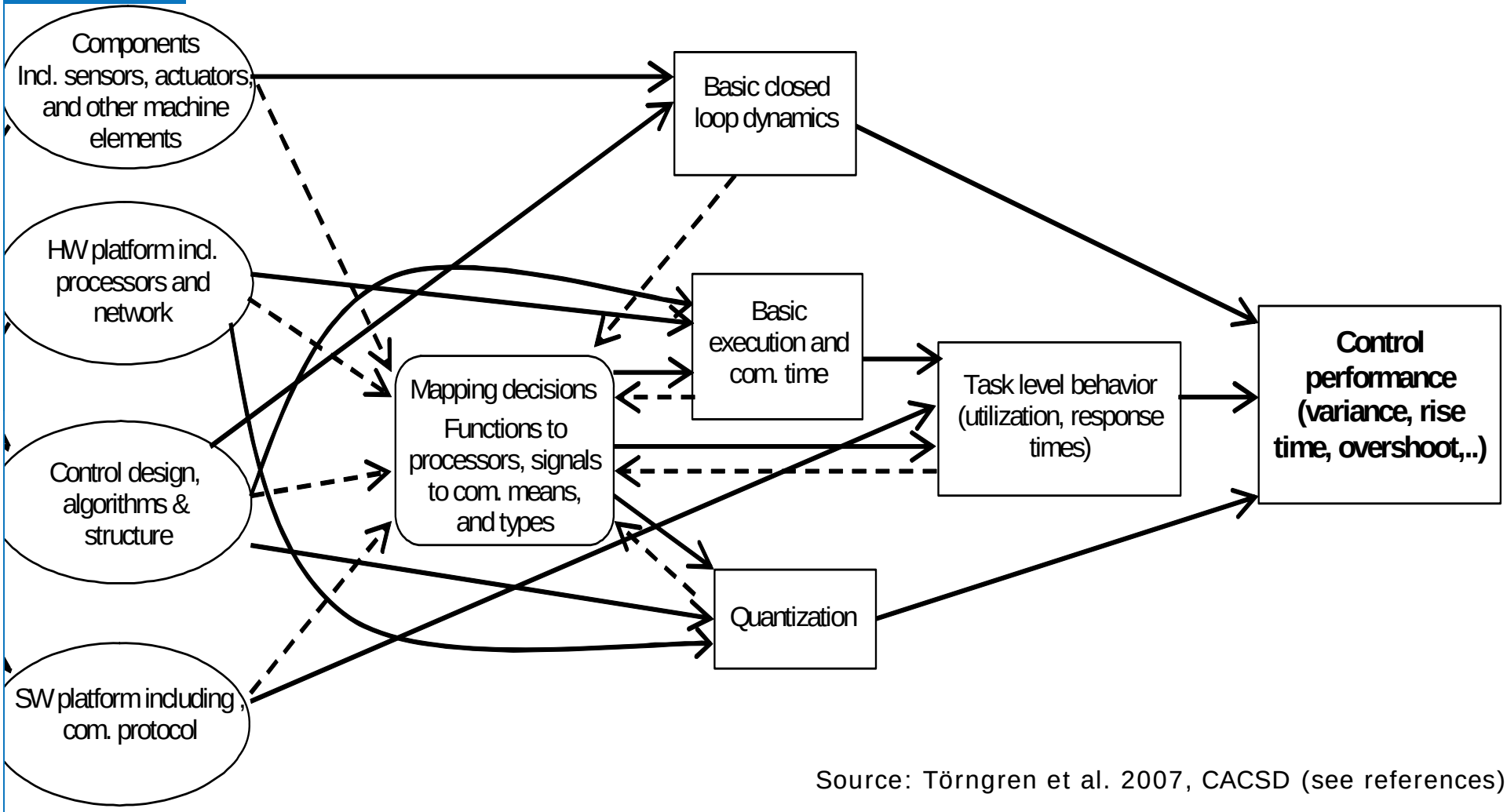
Conflicting requirements, many stake-holders

- Shared design parameters and trade-offs
- Application level vs. Platform level solutions
  - Optimality, compare end to end argument
  - Combined synthesis?

Emerging behavior

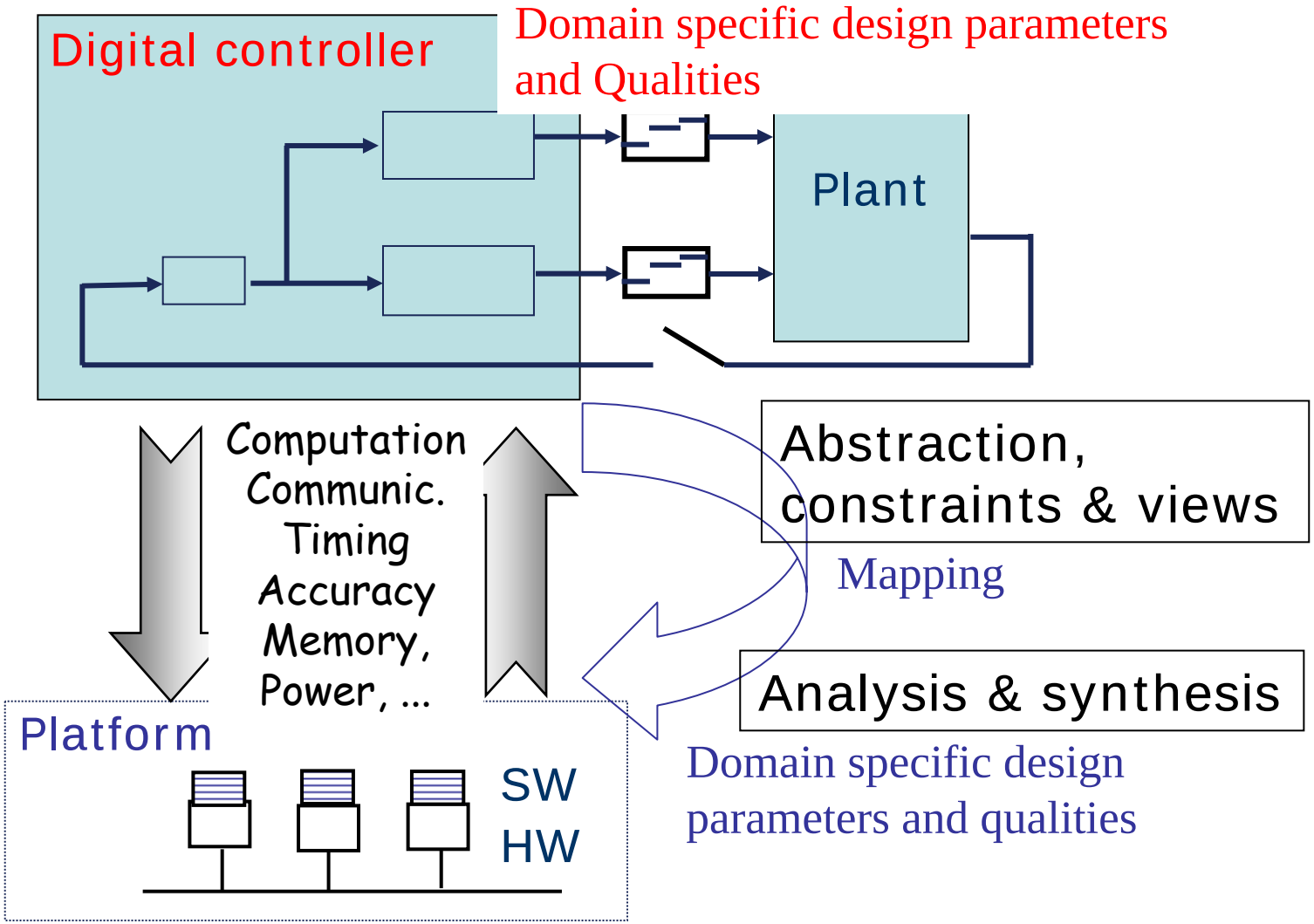
- Implementation depedencies
- Systems integration (uncontrolled behavior)
- External behavior

Dependencies illustrated for control systems

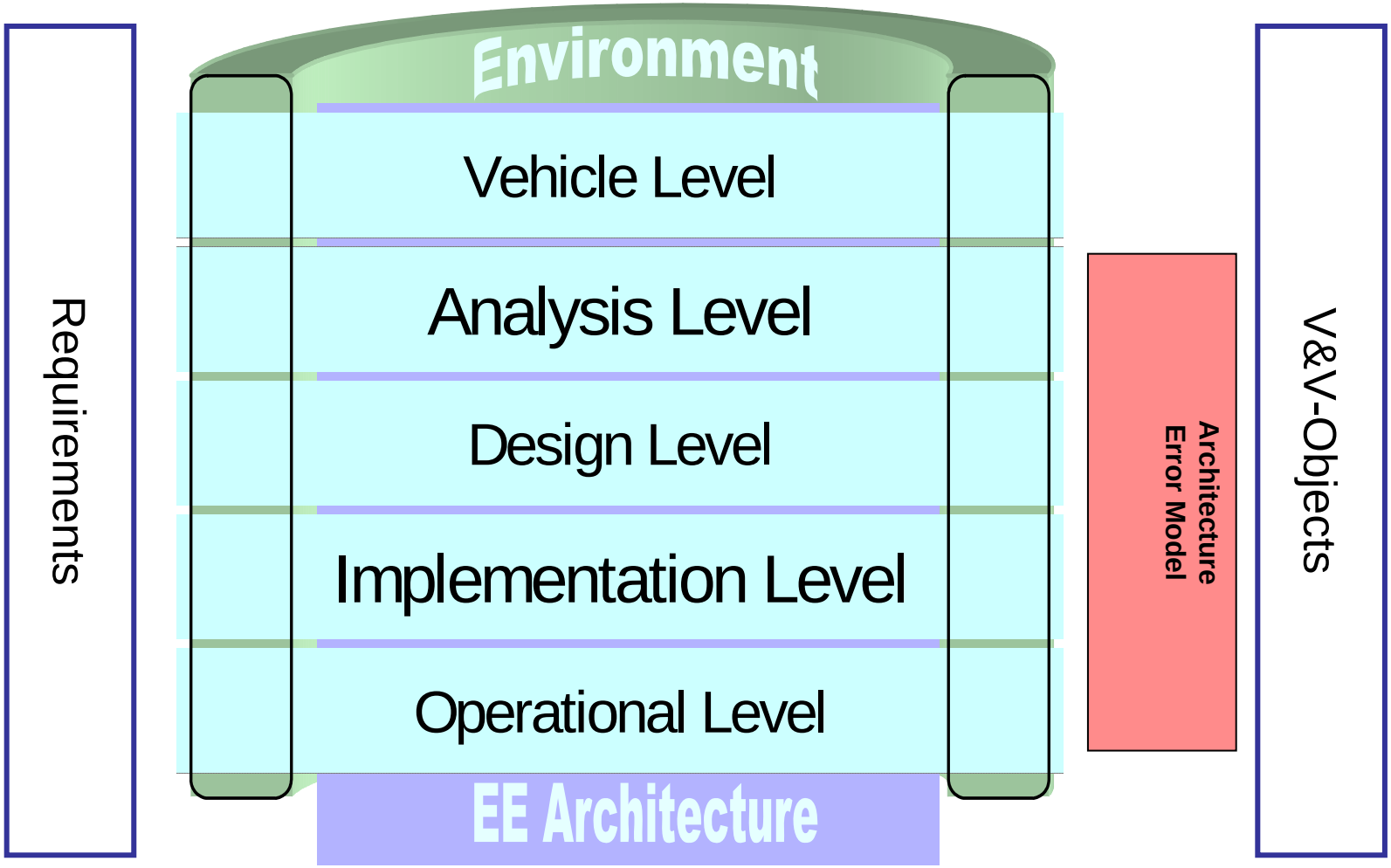


Source: Törngren et al. 2007, CACSD (see references)

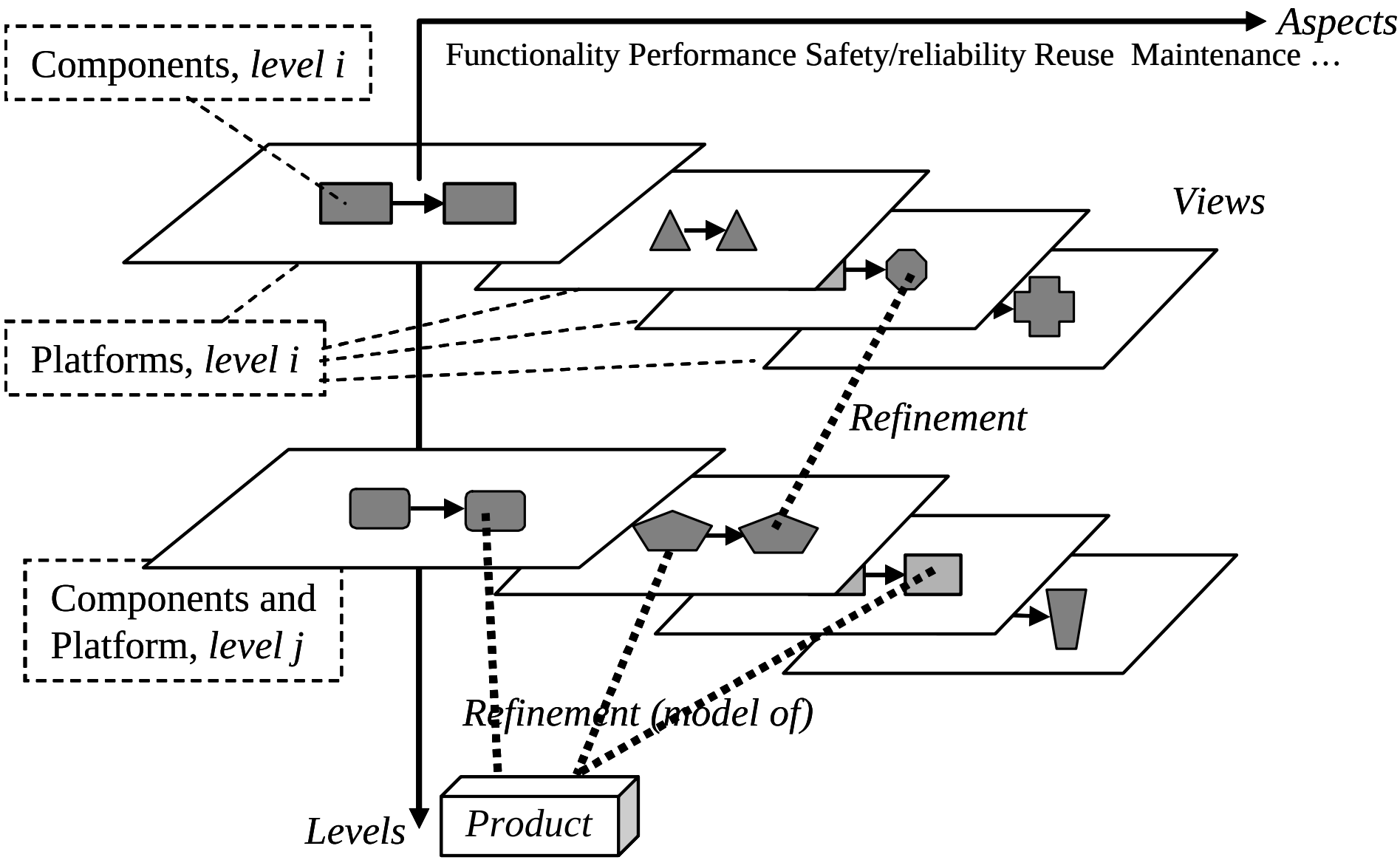
Characterizing control/embedded systems co-design



Embedded systems scope



See Cuenot et al for more info
And ATESST: www.atesst.org



Models for communication, documentation, analysis and synthesis purposes.

See Törngren et al 2005 for details.

Research directions?

Dedicated integration between tools

- E.g. Functions – performance, Functions – platform, Design models – safety, HW architecture – geometry, ...

Repository/information model based solution with integration to domain tools

Integration languages

- SW/HW scope: E.g. AADL and Autosar
- Trend: Broader embedded systems scope: EAST-ADL

Behavioral languages

- Trend: Capture more non-functional aspects, e.g. Metropolis

Evolving situation!

Many research and standardization efforts!

Model & component based development

Component technologies and composition theories

Technologies for model-based development

- Meta-modeling and qualities/aspects frameworks, dependencies, transformations, analysis and synthesis, behavior and structure

Componentization context:

- Strongly related to architectural design and modular products
- Product lines – a structured approach to componentization
- System scenarios providing requirements for component models

Model-based development framework:

- Goals and drivers
- Context: Technology, processes, organizations, business
- Product abstractions, qualities, aspects and parts
- Communication, documentation, analysis, synthesis
- Means: Abstraction, Formalization& structuring, Visualization, Refinement, Prediction, Automation, Methodology
- Keys for Industrial adoption

Many nice (research) challenges!

- Component models for different abstraction levels;
  - Required and provided services
  - Required and provided qualities
  - Fault behavior
  - Functionality, reliability, timing/resource util., maintenance, flexibility
- Application / middleware / platform trade-offs
  - Methodology
  - Synthesis and platform based design
- Reconciliation of model languages
  - Ontologies and View models
- UML – how far can it be formalized and adapted for embedded systems engineering?
  - UML behavior models
  - Safety analysis
  - Continuous-time systems

Complementary information

A complementary presentation, including case studies, was given at the DATE – ARTIST2 workshop

http://www.artist-embedded.org/artist/-ARTIST2-Workshop-at-Date-07-.html

Research projects underlying this presentation include

- ATESST: www.atesst.org
- SAVE, Modcomp, ARTIST2 – see links available here:
  - www.md.kth.se/RTC
  - See also the ARTIST2 Control for Embedded Systems Cluster through the ARTIST2 web-site.

Acknowledgements

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Recent underlying references – see enclosed slides

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Web links to the corresponding books:

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