Requirements Engineering for Control Systems

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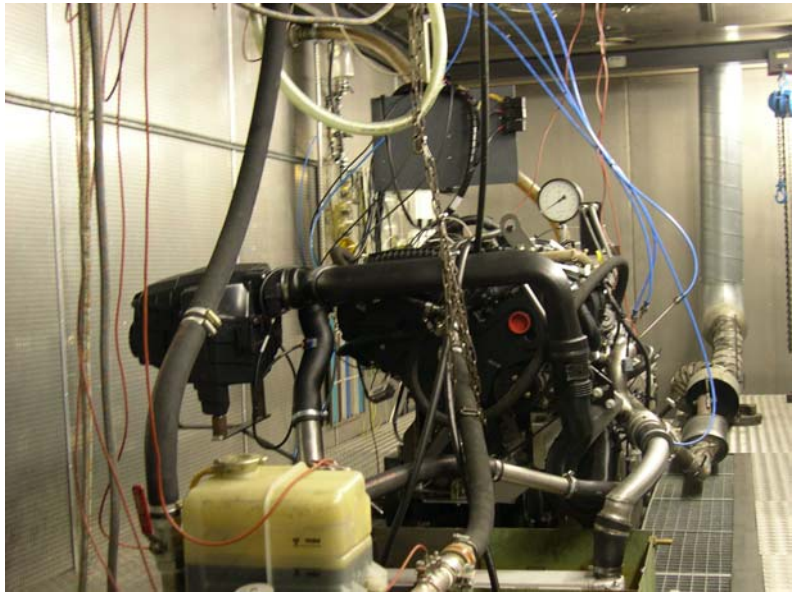
ZAMOMO Project

- „Integration of model-based software and model-based control systems engineering“
- Innovations in cars nowadays mainly driven by software, but control system engineering and software engineering currently not interacting
  ⇒ methodological supplement is hindered
- Application domain: combustion engine controller



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ZAMOMO Project

- „Integration of model-based software and m
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Characteristics

- Interdisciplinary
- Importance of hardware, in particular sensors and actuators
- Flexible, innovative, customer-oriented small- & medium enterprises
  - RE as part of offer development (timing, costs, reuse decisions,…)
  - Project-driven work, frequent innovations

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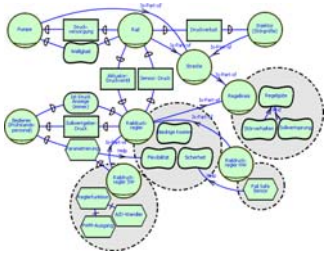
*i** based RE

control systems requirements

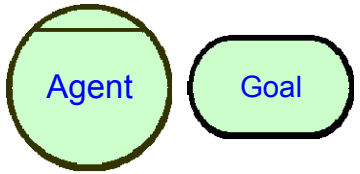
software requirements

common problem understanding with customer

*i**

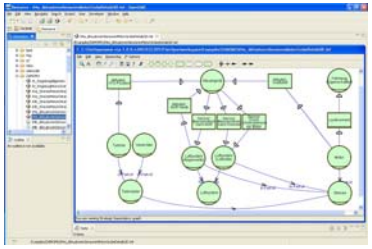


common comprehensible representation

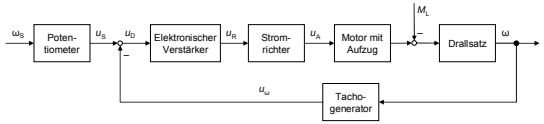


model-based requirements capture

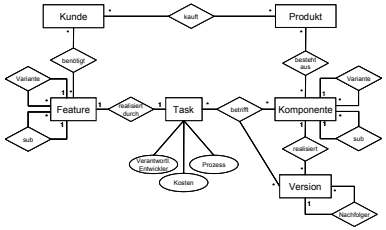
tool and analysis support



transition to (mathematical) design



traceability, configuration management



*i** based RE

control systems requirements

software requirements

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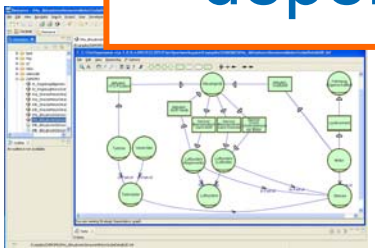
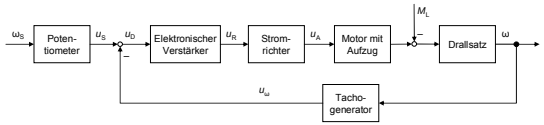
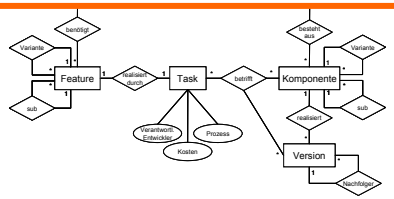
*i** based capture of control requirements

- Model-based
- Functional and non-functional aspects
- Combined, inter-disciplinary investigation
- Capture any (kind of) stakeholder
- Sensors and actuators as resource dependencies

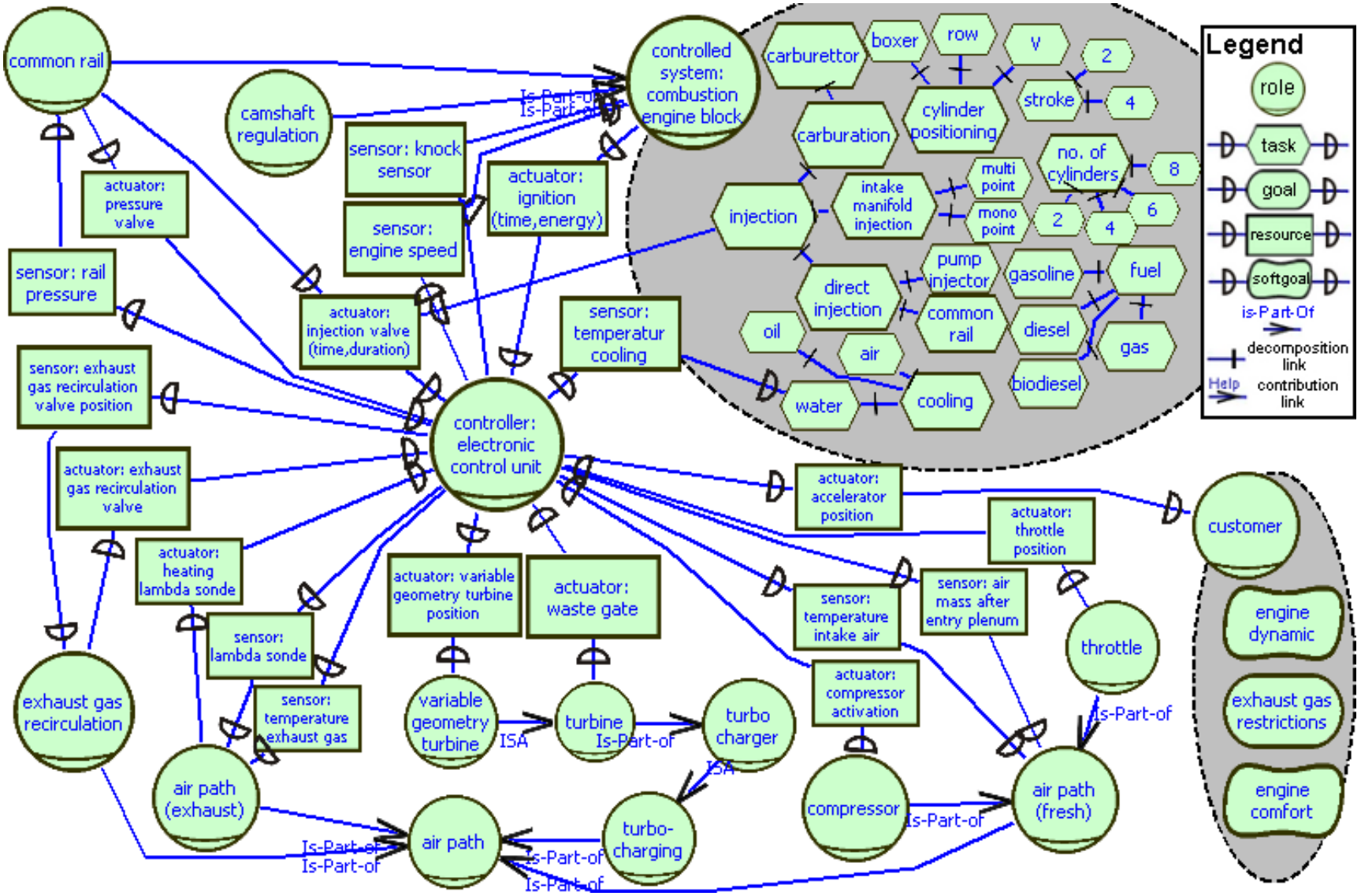


(mathematical) design

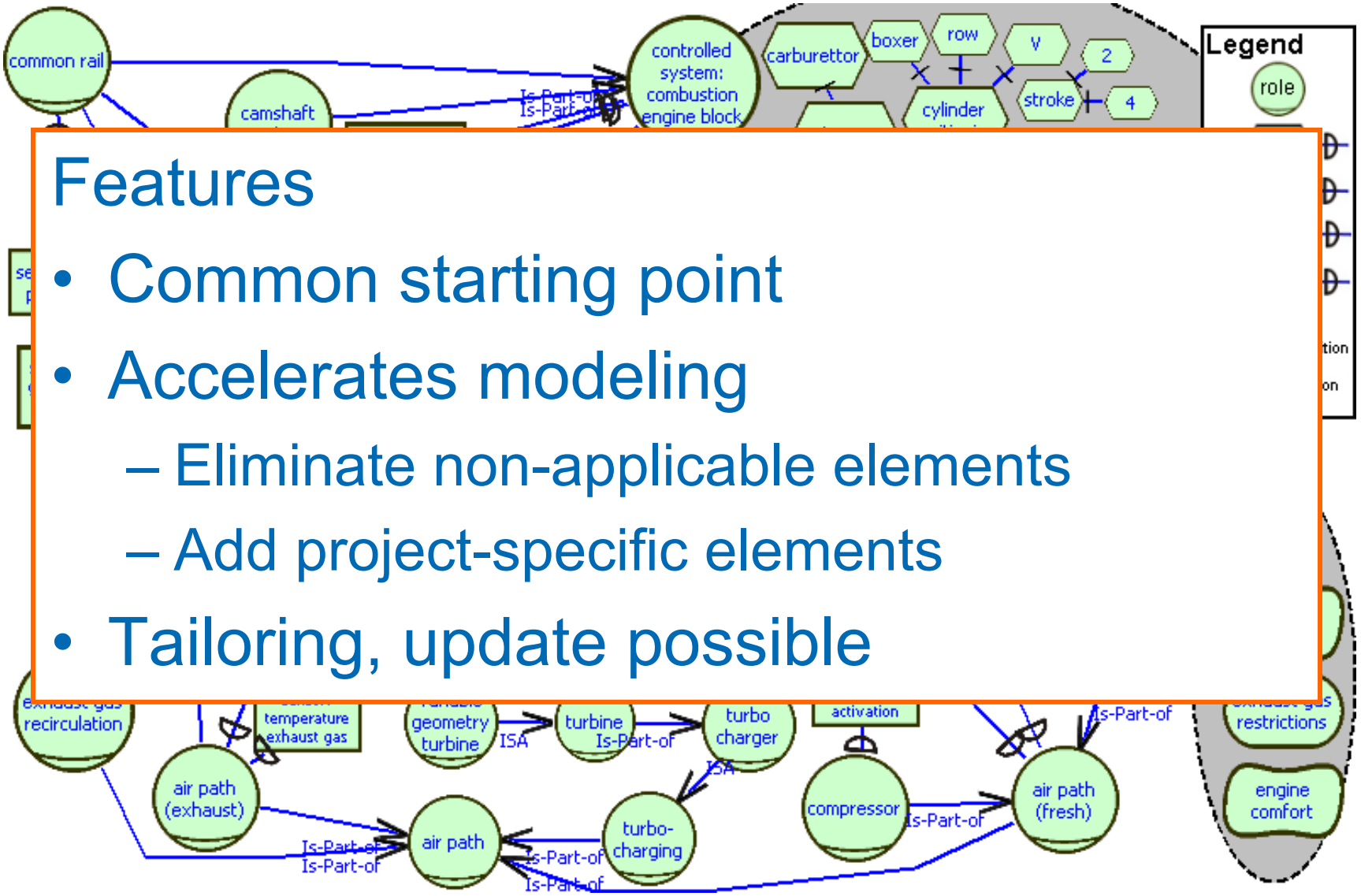




Domain Model-based RE



Domain Model-based RE



Features

- Common starting point
- Accelerates modeling
  - Eliminate non-applicable elements
  - Add project-specific elements
- Tailoring, update possible

Challenges during Offer Development

Offer development

- Model requirements from SMEs point of view
- Senior engineer manually selects similar projects, inspects, and includes reusable artifacts
- Prepare cost calculation

Two dangers

- Reusable artifacts not found (too many projects, too less time) $\Rightarrow$ offer too expensive
- Artifacts actually not reusable $\Rightarrow$ project loss

Challenges during Offer Development

Offer development

- Model requirements from SMEs point of view
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- [illegible]

Tw[illegible]

- Reusable artifacts not found (too many projects, too less time) ⇒ offer too expensive
- Artifacts actually not reusable ⇒ project loss

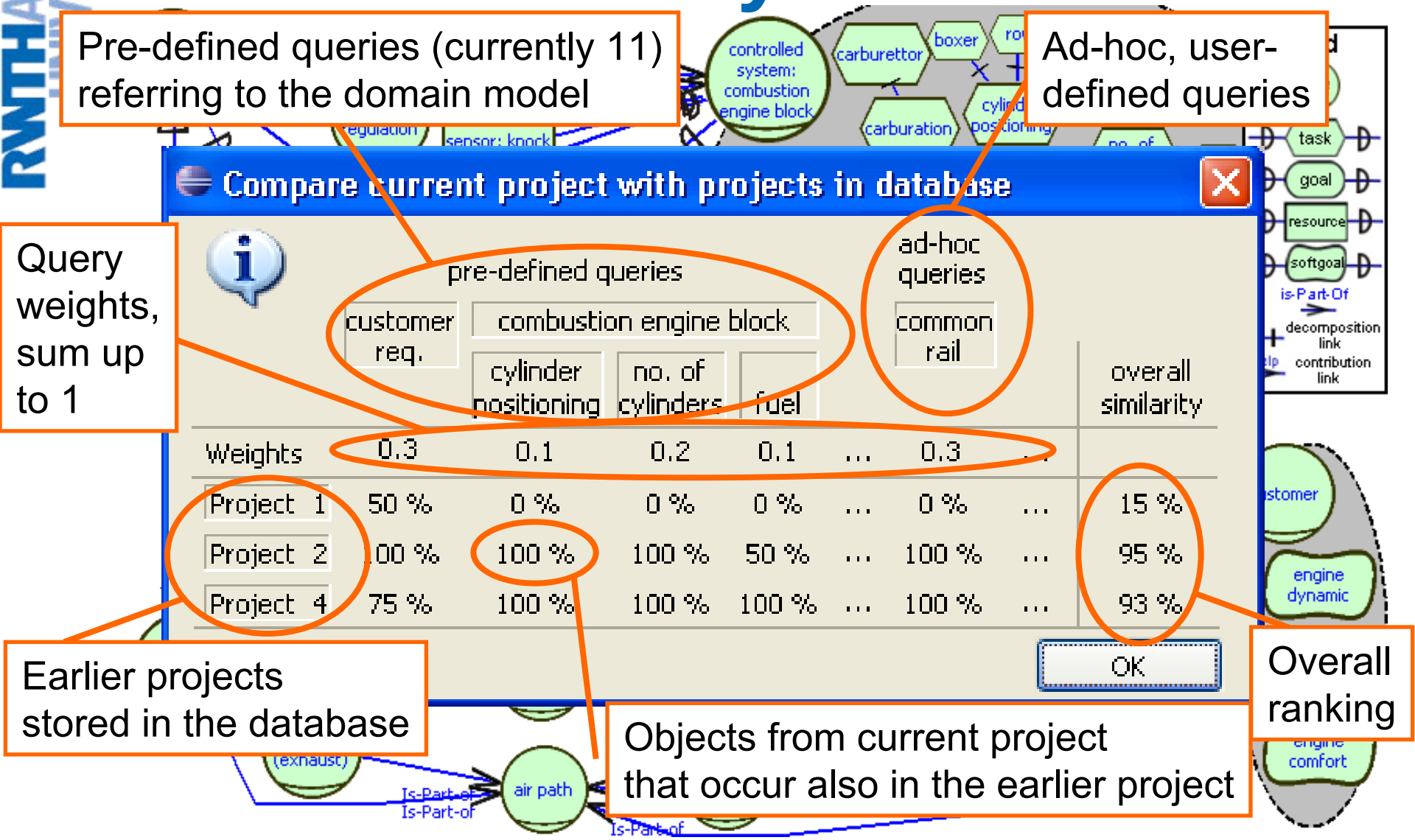
Support engineer in identifying similar projects

- Similar = requirements match
- Reduce and focus number of relevant projects to be inspected in-depth

Similarity Search

Pre-defined queries (currently 11) referring to the domain model

Ad-hoc, user-defined queries



Query weights, sum up to 1

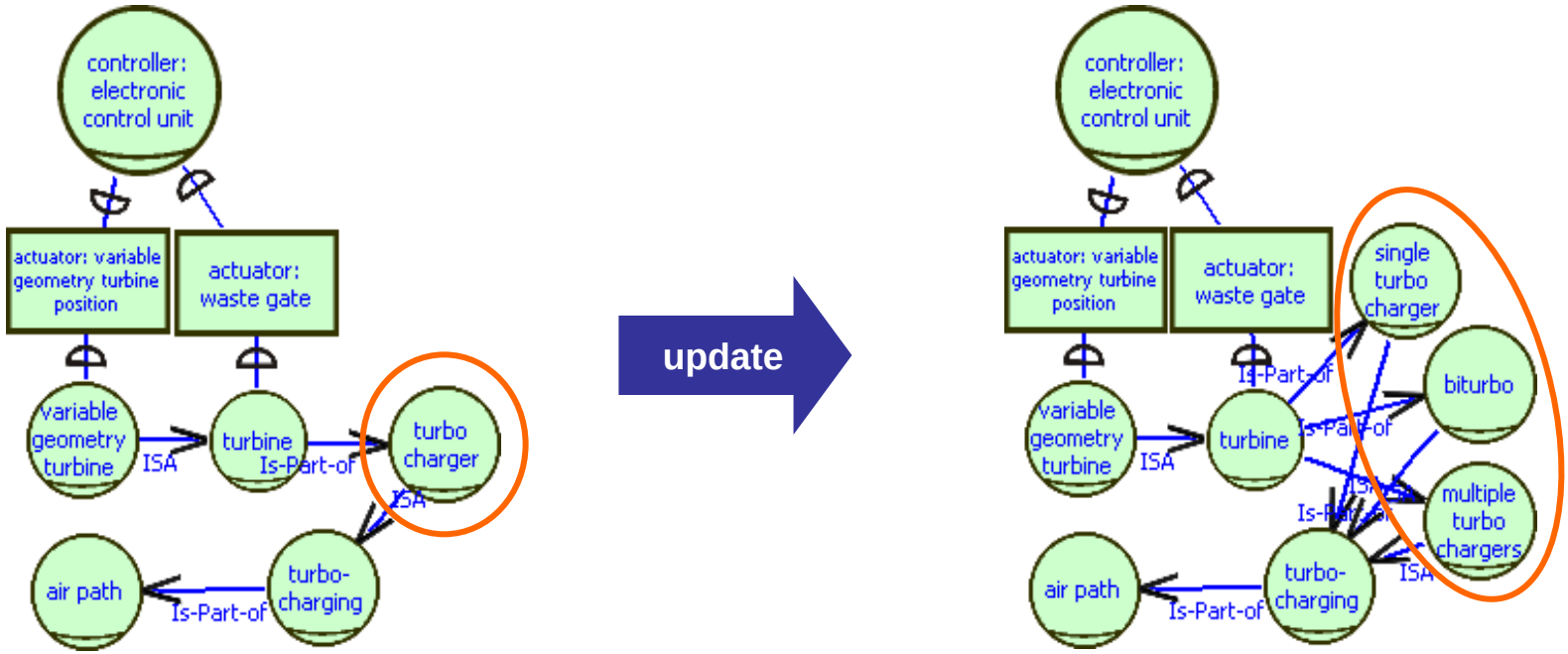
Earlier projects stored in the database

Objects from current project that occur also in the earlier project

Overall ranking

Domain Model Evolution

- Adjust domain model to reasonable size and to reflect new innovations



- Problems for model comparison ⇒ push domain model changes to finalized projects

Domain Model Evolution (2)

- Suggestions for reductions, extensions from usage in previous projects
- Computation of extension in 5 steps
  - Identify project-specific extensions
  - Compute similarity between them (shared anchor objects in domain model)
  - Group similar extensions
  - Inspection and implementation by engineer
  - Store results

Domain Model Evolution (2)

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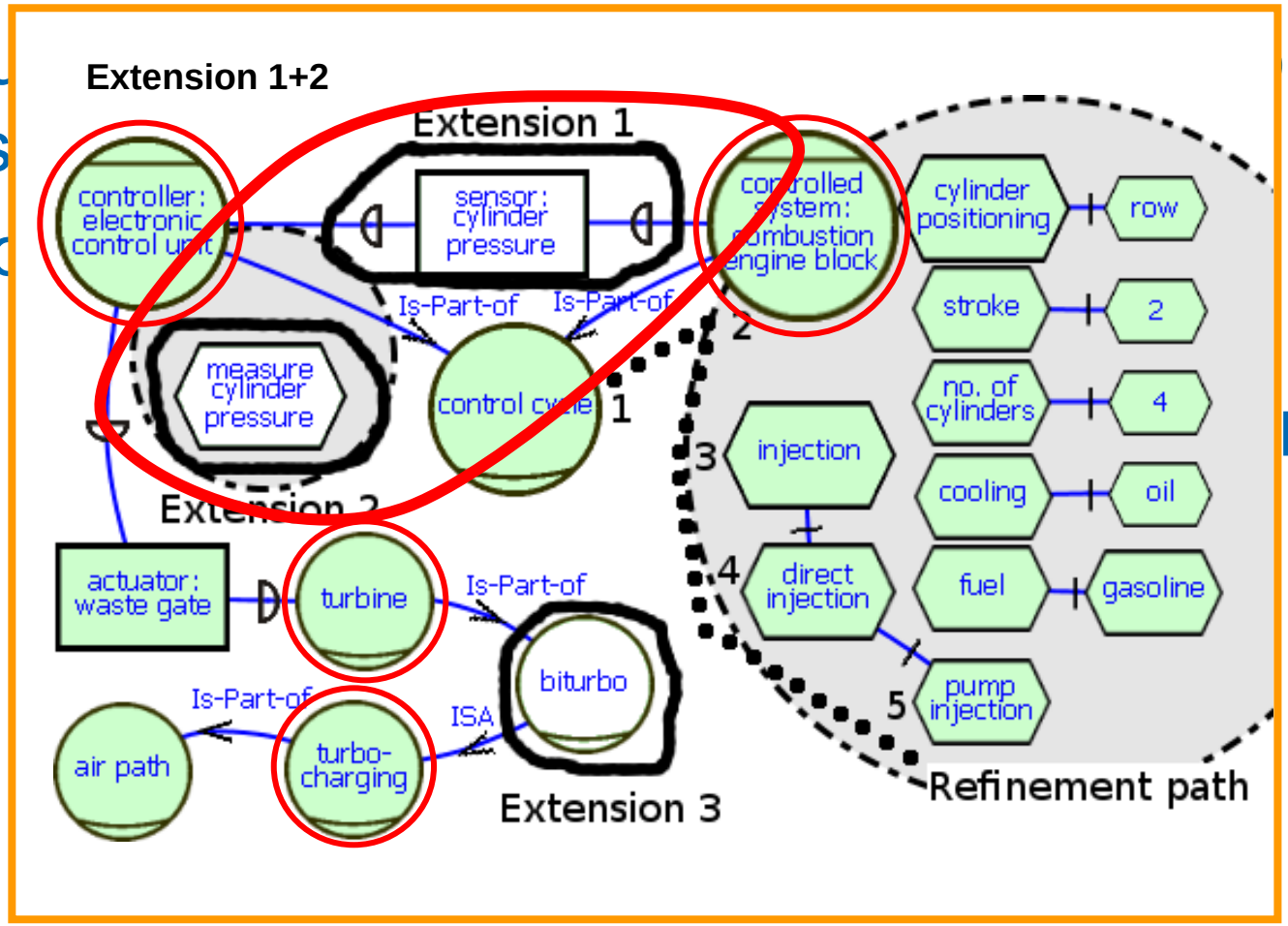
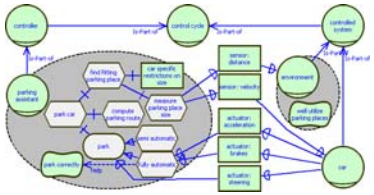
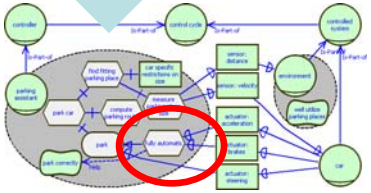


Transformation to Simulink



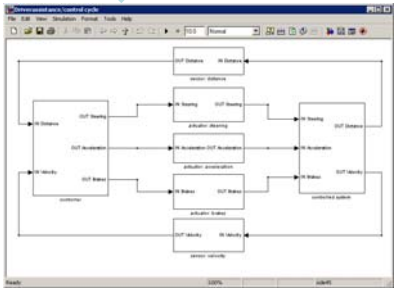
Requirements model (PIM)

1. Take design decisions



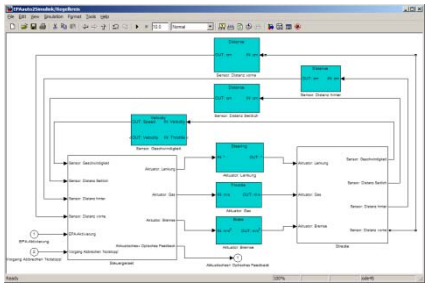
Refined model (PIM)

2. Derive Matlab/Simulink skeleton



Matlab/Simulink model (PSM – Matlab) (PIM – RCP)

3. Incorporate hardware details



Specific libraries considered (PSM – RCP)

Manual

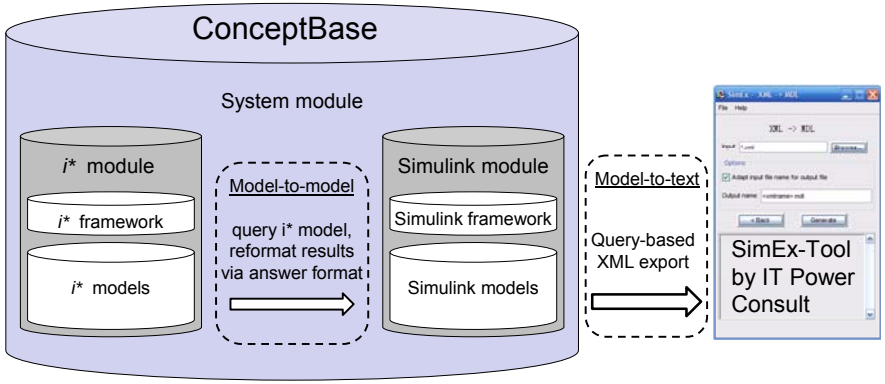
Support for checking readiness

Automated

Interactive

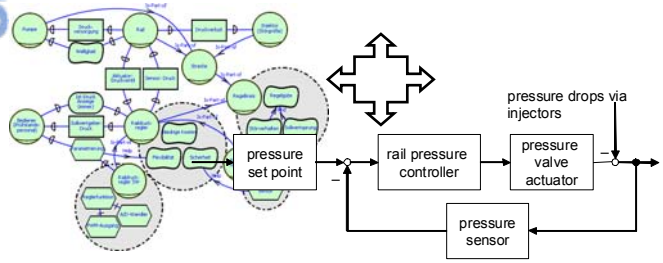
Add RCP platform specific libraries

Implementation Details

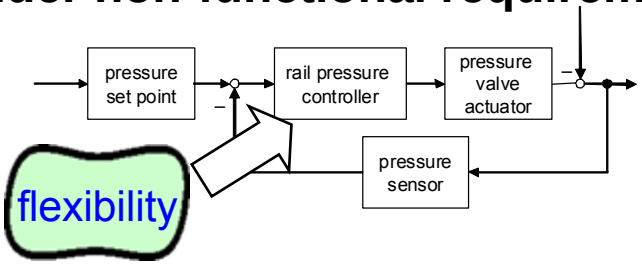


Summary

interdisciplinary methodology



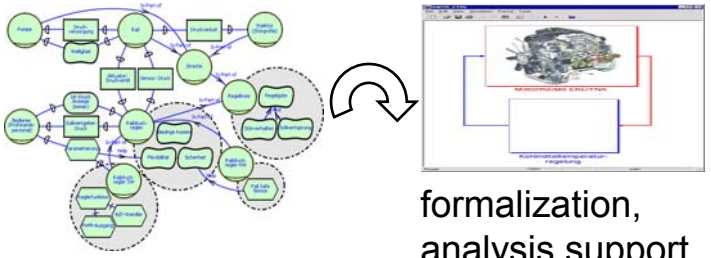
consider non-functional requirements



equal treatment of

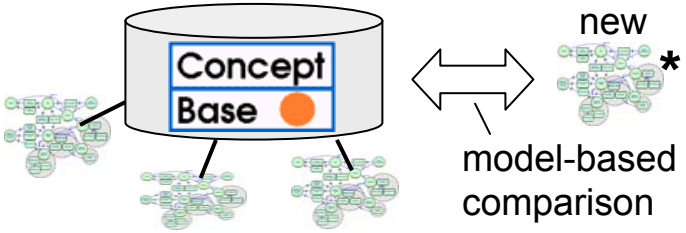
comprehensively optimal solutions

continuously model-based



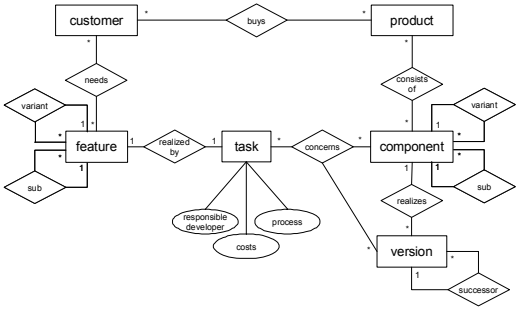
formalization,
analysis support

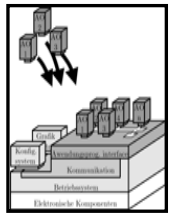
domain- & project-oriented reuse



model-based
comparison

traceability, configuration management





Future Work

- Enhance domain model evolution support, e.g. by additional heuristics
- Simulation at RE level
  - against abstract model of controlled system?
  - against detailed Matlab/Simulink model?
- Investigate sociality of *i** actors in control system setting
- Apply domain model based approach to other fields

- *i** Wiki – **http://istar.rwth-aachen.de**
  - Quick guide
  - Tool comparison
  - Growing community
  - *i** workshops
  - *i** news, e.g. on iStarML, upcoming events, project ideas, …

ZAMOMO – Publications

[RE 2009] H. W. Nissen, D. Schmitz, M. Jarke, T. Rose, P. Drews, F. J. Hesseler, M. Reke: *Evolution in Domain Model-Based Requirements Engineering for Control Systems Development*, Atlanta, 2009, IEEE

[MaRK@RE 2009] H. W. Nissen, D. Schmitz, M. Jarke, T. Rose: *How to Keep Domain Requirements Models Reasonably Sized*, Atlanta, 2009, IEEE

[ECMDA 2009] D. Schmitz, M. Zhang, T. Rose, M. Jarke, A. Polzer, J. Palczynski, S. Kowalewski, M. Reke: *Mapping Requirement Models to Mathematical Models in Control System Development*, Enschede, 2009, LNCS 5562, Springer

[Euromicro 2009] D. Schmitz, W. Deng, T. Rose, M. Jarke, H. Nonn, K. Sanguanpiyapan: *Configuration Management for Realtime Simulation Software*, SPPI Track, Patras, 2009, IEEE

[RE 2008] D. Schmitz, H. W. Nissen, M. Jarke, T. Rose, P. Drews, F. J. Hesseler, M. Reke: *Requirements Engineering for Control Systems Development in Small and Medium-Sized Enterprises*, Barcelona, 2008, IEEE

[MaRK@RE 2008] D. Schmitz, H. W. Nissen, M. Jarke, T. Rose: *Telos: Representing Knowledge about Control Systems?*, Barcelona, 2008, IEEE

[SE 2008] D. Schmitz, P. Drews, F. J. Hesseler, M. Jarke, S. Kowalewski, J. Palczynski, A. Polzer, M. Reke, T. Rose: *Modellbasierte Anforderungserfassung für softwarebasierte Regelungen*, Munich, Feb. 2008