Engineering support for the design-operation continuum

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Efficient design and operation

- continuously evolving which softens the traditional separation between the engineering/design phases and the operational stages
- high degree of heterogeneity and partial autonomy requires new, fully integrated approaches for their design, validation, and operation
- highly flexible and thus subject to frequent, dynamic reconfiguration, which must be supported by design support tools
- failures, abnormal states, unexpected/emerging behaviours are the norm
- socio-technical systems: machines and humans interact closely

Characteristic	**Old-Classic**	**New-SoS**
Scope of System	Fixed (known)	Not known
Specification	Fixed	Changing
Control	Central	Distributed
Evolution	Version controlled	Uncoordinated
Testing	Test phases	Continuous
Technology	Given and fixed	Uncertain
System development	Process model	????

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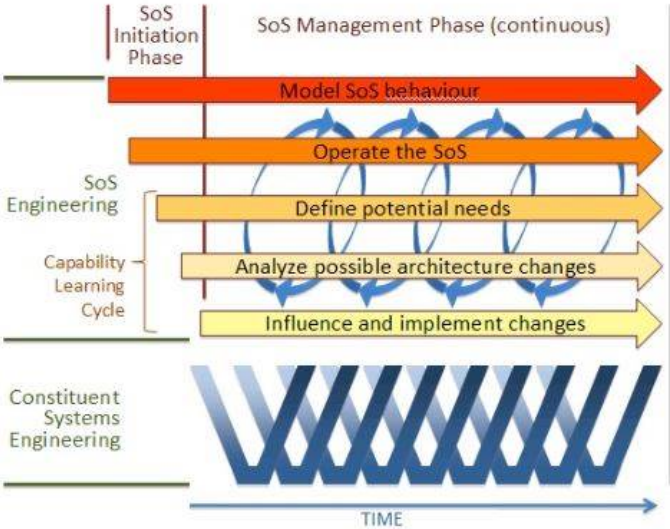
Research topics

1. Integrated engineering of CPSoS over their full life-cycle

2. Modelling, simulation, and optimization of CPSoS

3. Establishing system-wide and key properties of CPSoS

1. Integrated engineering of CPSoS over their full life-cycle

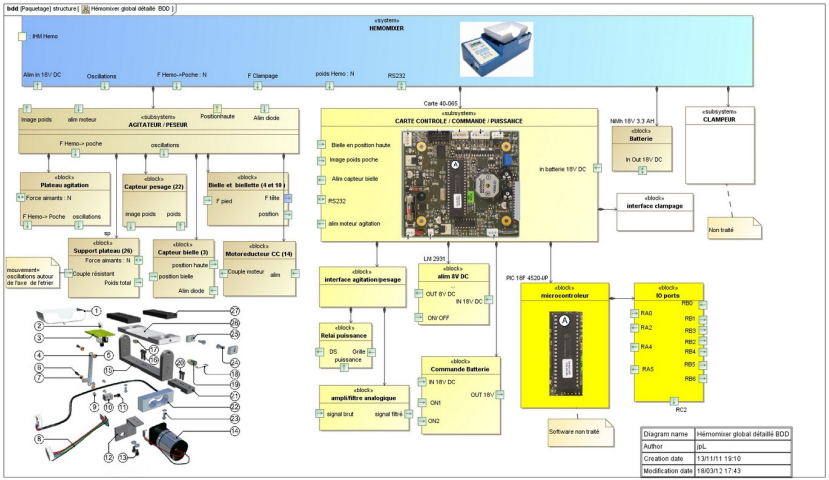


Challenges:

- separation between design phases and operational stage is disappearing
- asynchronous lifecycles of constituent parts
- components are developed independently / insufficient information

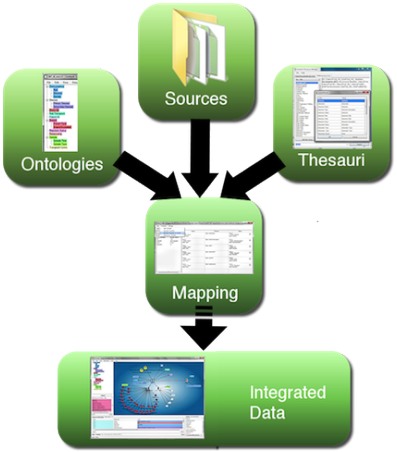
1. Research and innovation needs

- engineering frameworks for specification, adaptation, evolution, and maintenance of requirements, structural and behavioural models, and realizations not only during design, but over their complete life cycle
- engineering frameworks supporting integrated cross-layer design
- model-based analysis to detect design errors and for risk management



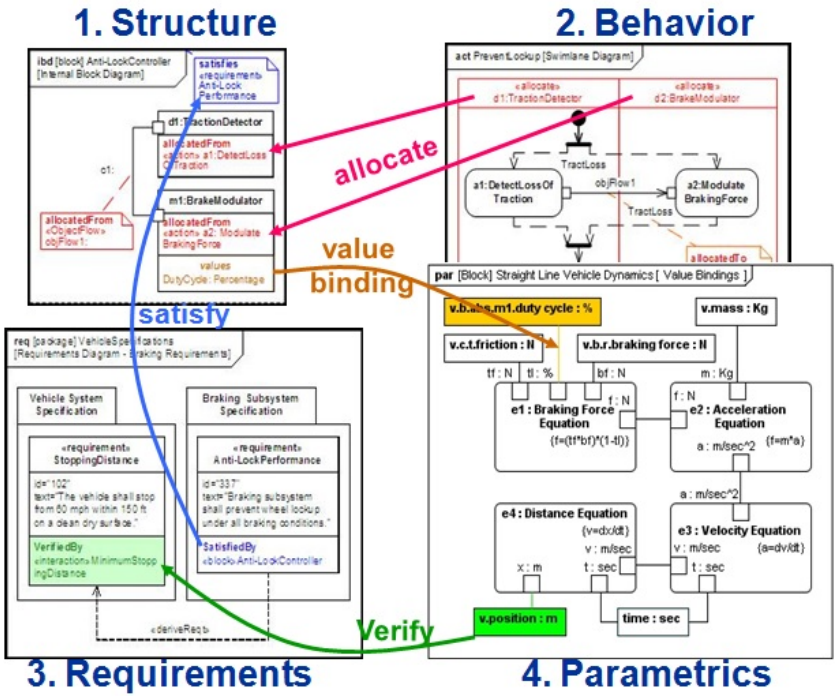
1. Research and innovation needs

- collaborative engineering and runtime environments
- open, easy-to-test interfaces and platforms for integration
- semantic integration
- tools to demonstrate industrial business cases



Challenges:

- high cost for building and maintaining models
- modelling of human users and operators
- simulation and analysis of stochastic behaviour
- models for validation and verification purposes



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2. Research and innovation needs

- software tools for model management and for the integration of models from different domains
- efficient simulation algorithms for system-wide simulation of large heterogeneous CPSoS, including dynamic on-the-fly reconfiguration
- high-level modelling and simulation for performance and risk analysis
- collaborative environments for competing companies
- integration of legacy system simulations as well as open approaches for tight and efficient integration and consolidation of data, models, and engineering tools

Challenge:

- establishment, validation, and verification of key properties of CPSoS

3. Research and innovation needs

- new approaches for dynamic requirements management during the continuous evolution of a CPSoS, ensuring correctness by design during its evolution, and for verification especially on the SoS level
- new algorithms and tools to enable the automatic analysis of complete, large-scale, dynamically varying and evolving CPSoS
- formal languages and verification techniques for heterogeneous distributed hybrid systems including communication systems
- theory for successive refinement and abstraction of continuous and discrete systems so that validation and verification at different levels of abstraction are correlated
- joint use of assume-guarantee reasoning and simulation-based (Monte Carlo) and exhaustive (model checking) verification techniques