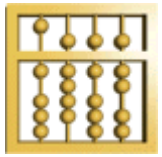
Opportunities and Challenges in Software Engineering for the Next Generation Automotive

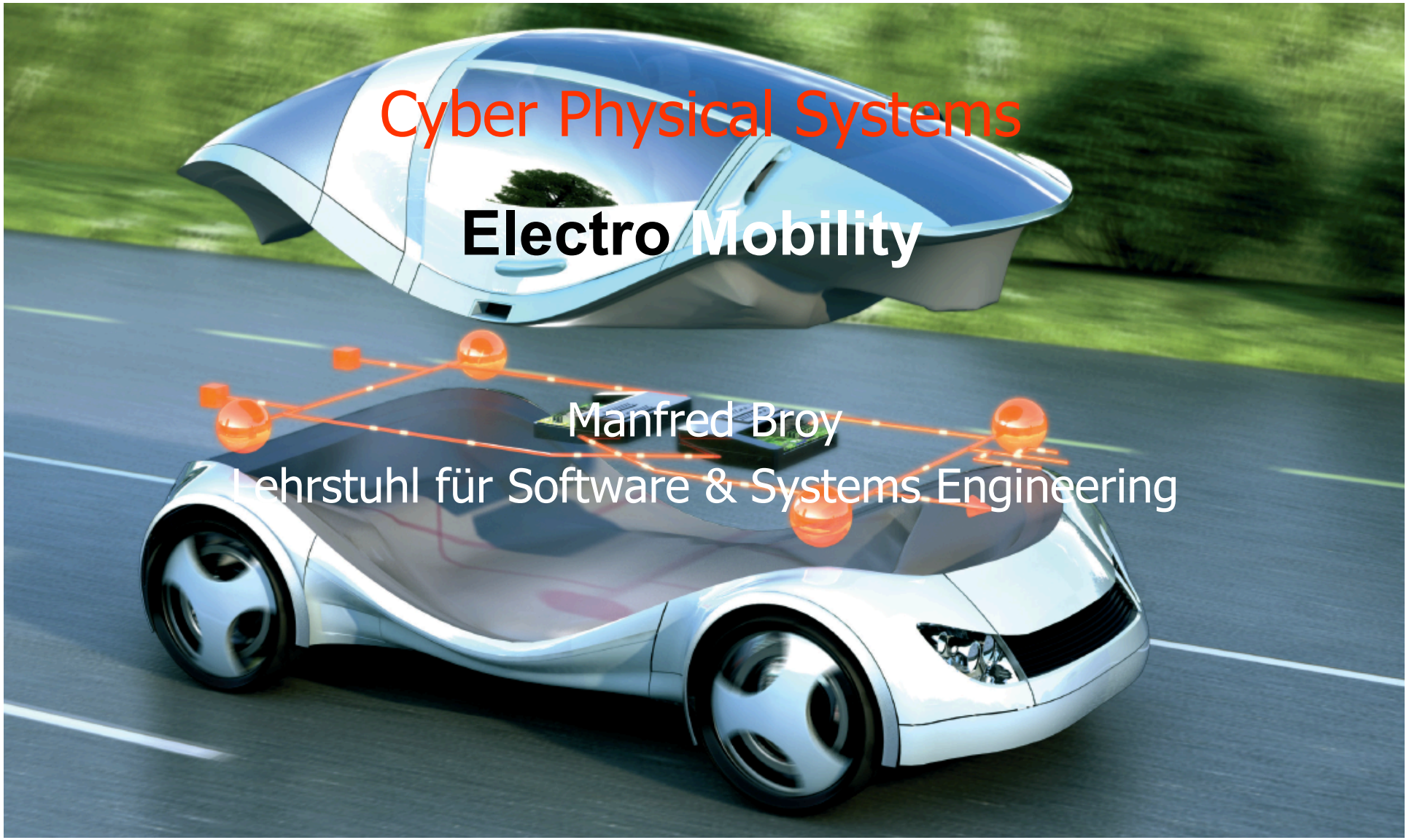
Cyber Physical Systems

Electro Mobility

Manfred Broy
Lehrstuhl für Software & Systems Engineering

Technische Universität München
Institut für Informatik




Cyber Physical Systems
Electro Mobility
Manfred Broy
Lehrstuhl für Software & Systems Engineering

Change of paradigm in the design of E/E systems

There is a high degree of

- innovation and functionality

but also

- increasing costs and complexity

in the design of E/E systems asking for new approaches and paradigms in engineering and development:

- Systems Engineering
  - ◇ instead of assembling components - integration of subsystems

  requires emphasis on
  - ◇ requirements engineering
  - ◇ architecture and integration
  - ◇ comprehensive quality assurance
- Function orientation
  - ◇ instead of developing components developing functions
  - ◇ functional view part of architecture

Paradigm shift development E/E

... and new development principles:

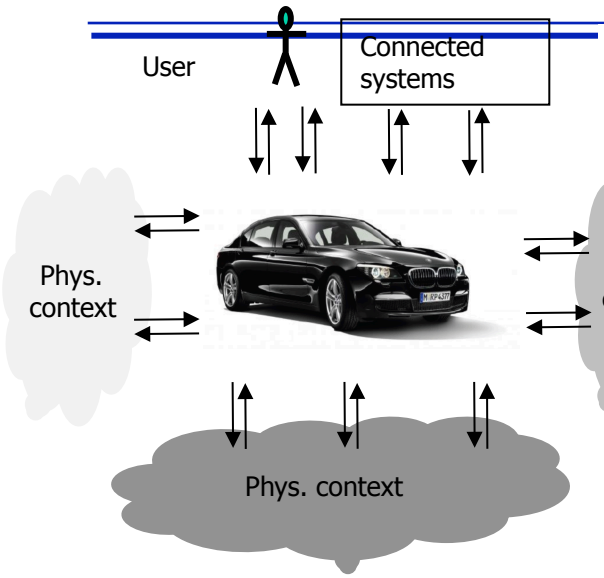
- Front loading
  - ◇ shift in expenditure on early phases
  - ◇ instead of eliminating errors in the integration error prevention
- Model based development
  - ◇ structuring
  - ◇ automation
  - ◇ seamless use of all models
    Example: Functional models for testing, diagnostics, maintenance
- Artefact orientation - PLM E/E
  - ◇ archiving of all development results in databases
- Product lines
  - ◇ modular function construction kit
  - ◇ mastering variability
  - ◇ systematic reuse at all levels

Comprehensive architecture - what is it

Views onto structure - structuring views of a system

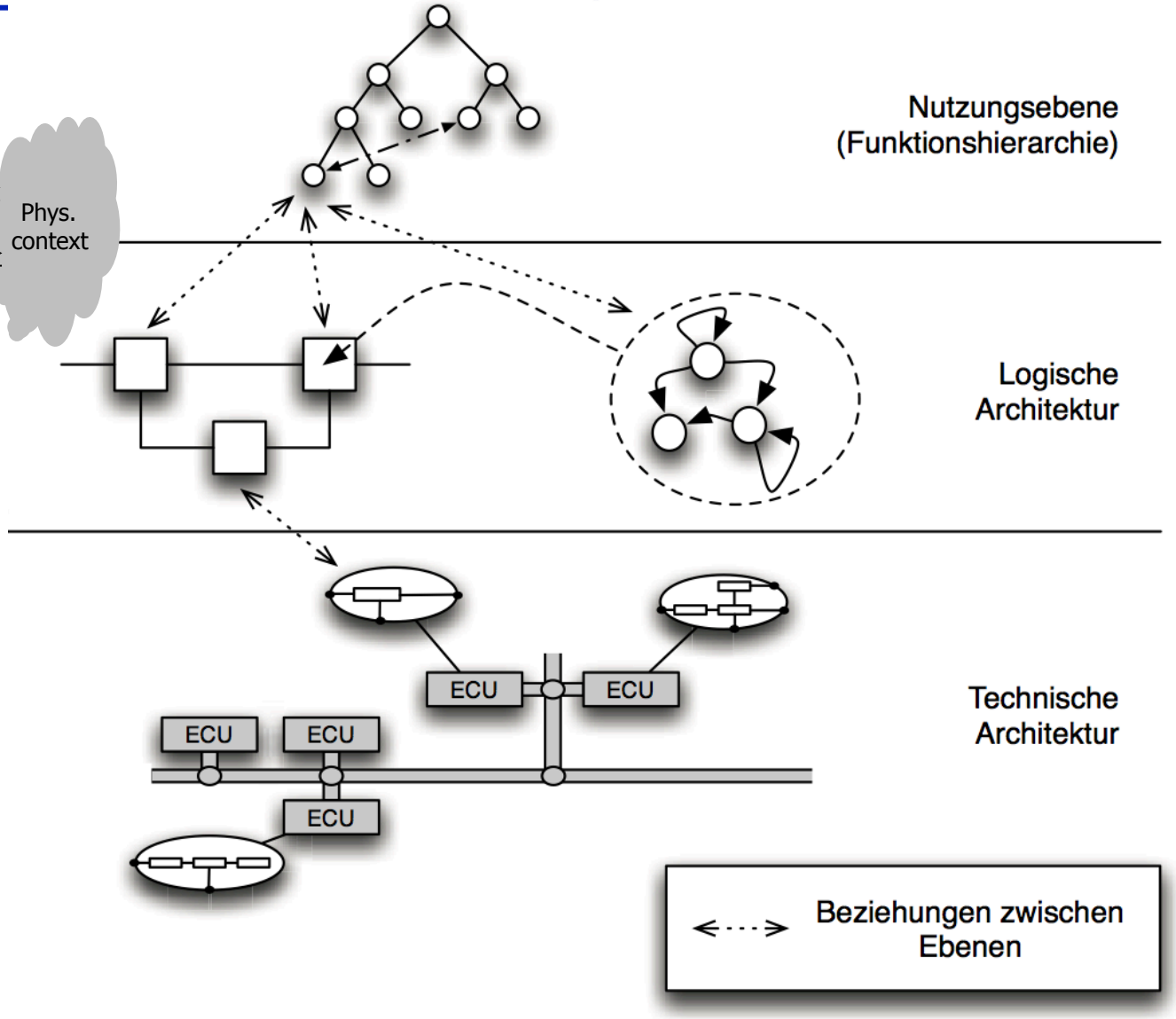
- context - domain model
  - ◊ relevant properties of the system environment
- functional view - system level interface
  - ◊ functionality - function hierarchy
  - ◊ dependencies
  - ◊ non-functional requirements (quality: safety, reliability, performance, ...)
- logical component view
  - ◊ architecture of components - component hierarchy
  - ◊ Logic of the signal / message flow between components
- technical view
  - ◊ deployment, scheduling

Structured architecture views: abstraction levels



Requirements

	Interface assertion	Safety	Priority	Component	Function
R_1	...	Yes	high		
R_2	...	No	medium		
R_n	...	no	low		



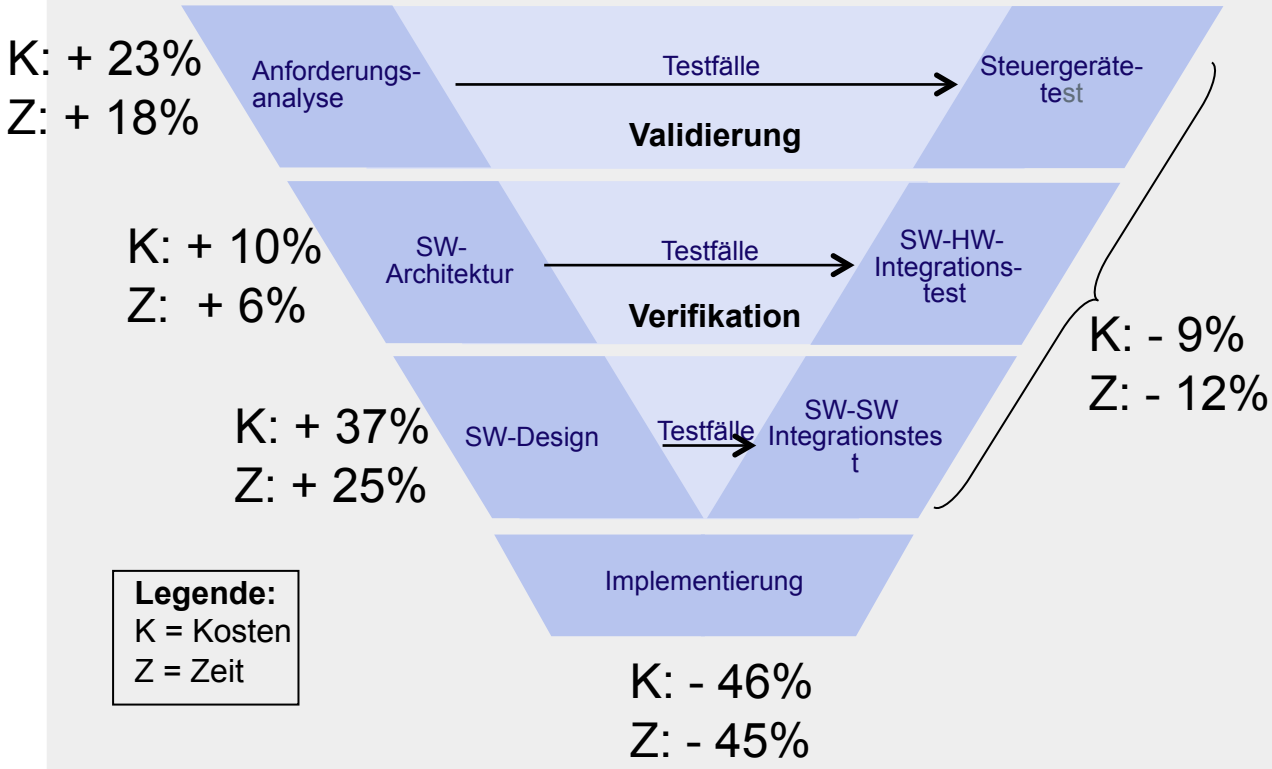
Comprehensive architecture as backbone

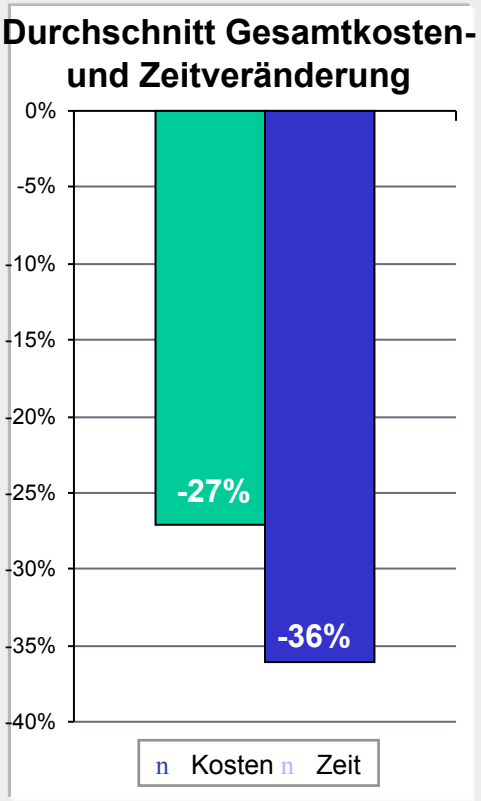
- organisation of engineering
  - roles
  - process
  - artefacts - PLM
  - requirements
- early system verification & validation
  - simulation
  - test
- supplier management
  - contracts and specifications
  - integration of supplier designed sub-systems
- quality assurance
  - test
- systematic reuse
  - product lines

Gesamtsicht – Kosten- und Zeitveränderung (Diss. Kirstan)

Die Frontloading-Effekte der modellbasierten Entwicklung sind deutlich in den Kostenveränderungen der einzelnen Entwicklungsphasen zu sehen.

Kosten- und Zeitveränderungen durch die modellbasierte Softwareentwicklung entlang der einzelnen Entwicklungsphasen und in Gesamtsicht





Result: function based structuring/architecture

Modeling:

- Function hierarchy
  - Structured list of all functions
    - user functions
    - system functions
  - Mode view
  - Modular specification of each function
    - dependencies by modes
- Logical components (sub-systems)
  - Tracing: understanding which of the sub-systems and which of their properties contribute to which function
- Technical level
  - Automatic generation of code
    - Parameterized by technical architecture

Seamless usage:

- Analysis
  - feature interactions
  - completeness of specification
- Validation
- Simulation
- Generation of system test cases
- Configuration planning
  - when is which function available
- Impact analysis
- Generation of integration test cases

Research

- Consistent modelling of all aspects of an E/E Architecture
  - form of variants
  - generating the implementation for different platforms
  - automated Quality Assurance
  - calibration functions
- Integration of data and services into global networks of embedded systems
  - Cyber -Physical Systems
  - interoperability
  - service modelling
- The vehicle as a hub in the network
- Car 3.0 - the semantic car
  - recording all data and functions in the vehicle from semantic point of view