DLR Projektträger

GEFÖRDERT VOM
Bundesministerium
für Bildung
und Forschung

From SPES to CrESt

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History: From SPES 2020 to CrESt

Vision of the SPES Projects

The vision of SPES 2020 is that in the not too distant future, the development of systems with a high proportion of embedded software can be accomplished through a set of integrated modeling techniques, the use and integration in the development of which is fully understood.

History: From SPES 2020 to CrESt

From classical embedded systems to collaborative, software defined embedded systems in open environments

CrESt Methods, Tools and Demonstrators

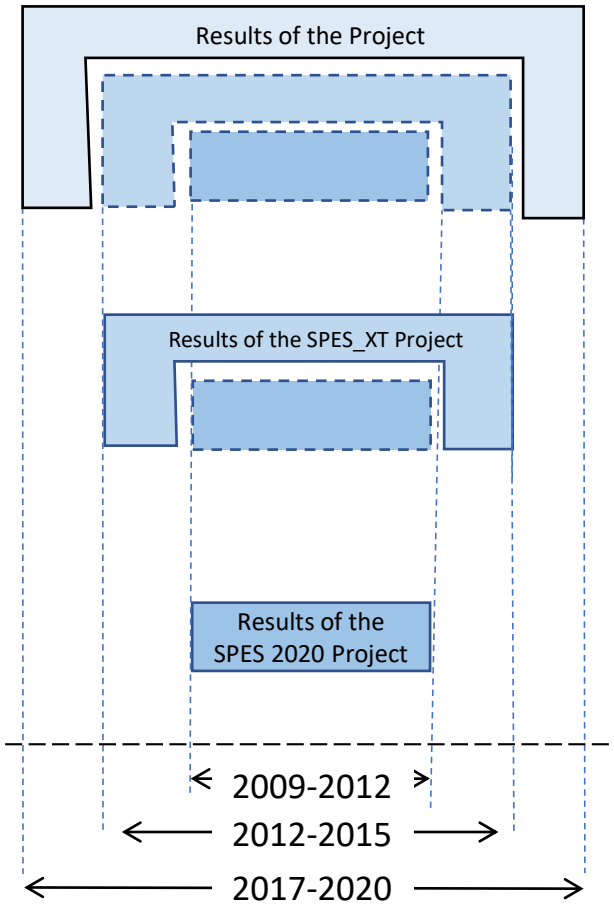
Dynamic networking of embedded systems to collaborative system networks in open and uncertain contexts

SPES XT Methods, Tools and Demonstrators

Specific challenges in Engineering of embedded systems: modular safety and certification, mechatronics, optimal deployment, variability

SPES 2020 Methods, Tools and Demonstrators

Basic formally sound, model-based development methodology for embedded systems



Line of Research

Generic Architecture: Development Philosophy

Basic Ideas

How-to Concepts

Pragmatic Architecture

based on the existing (often highly fractal and isolated approaches) step-by-step integration in the sense of the generic architectural approach

Concrete Architecture

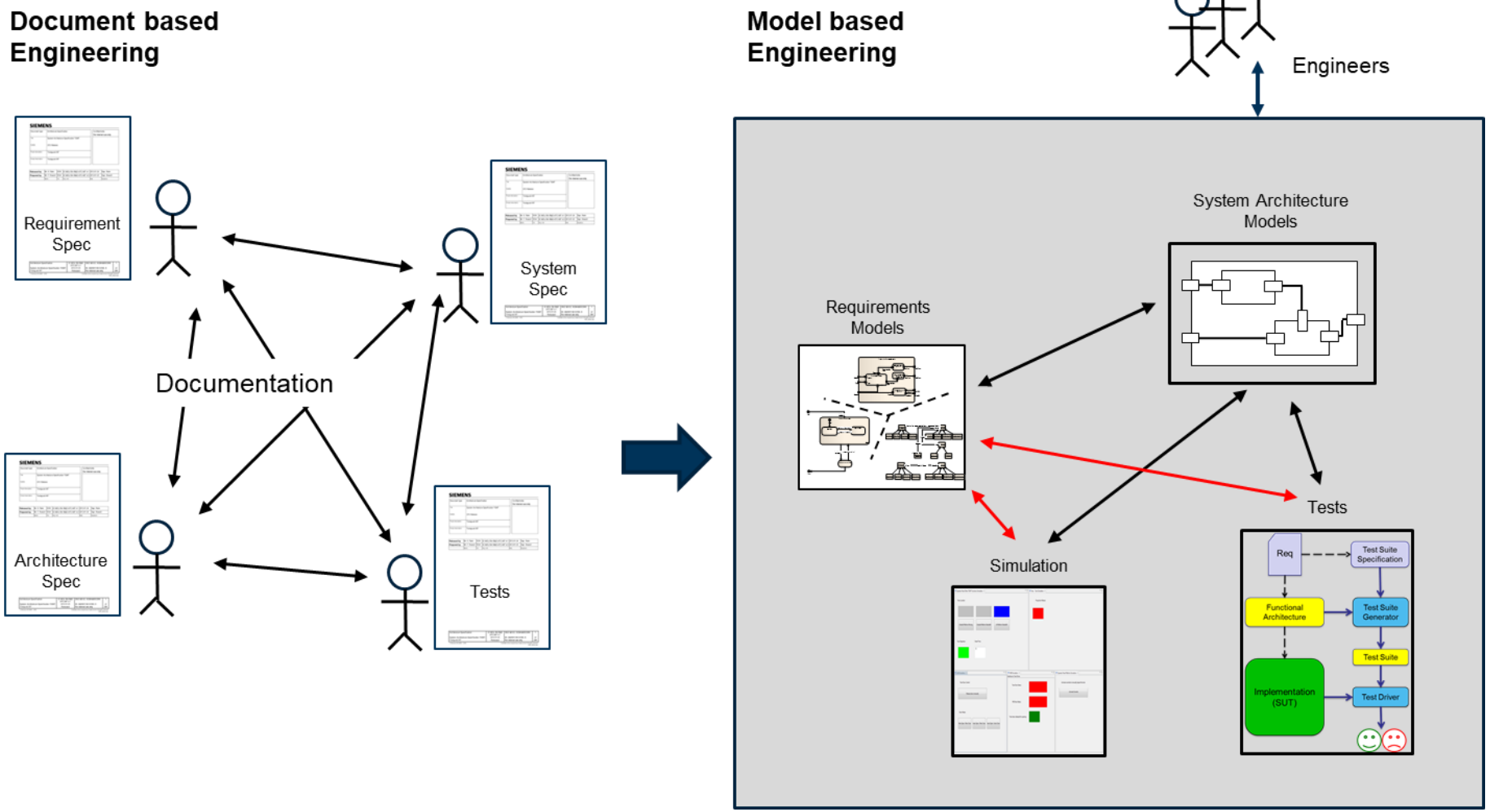
starting from the generic architectural approach, using clean terminology, developing clear concepts and gradually promoting understanding in practice

Scientifically Sound Architecture: Modeling Theories

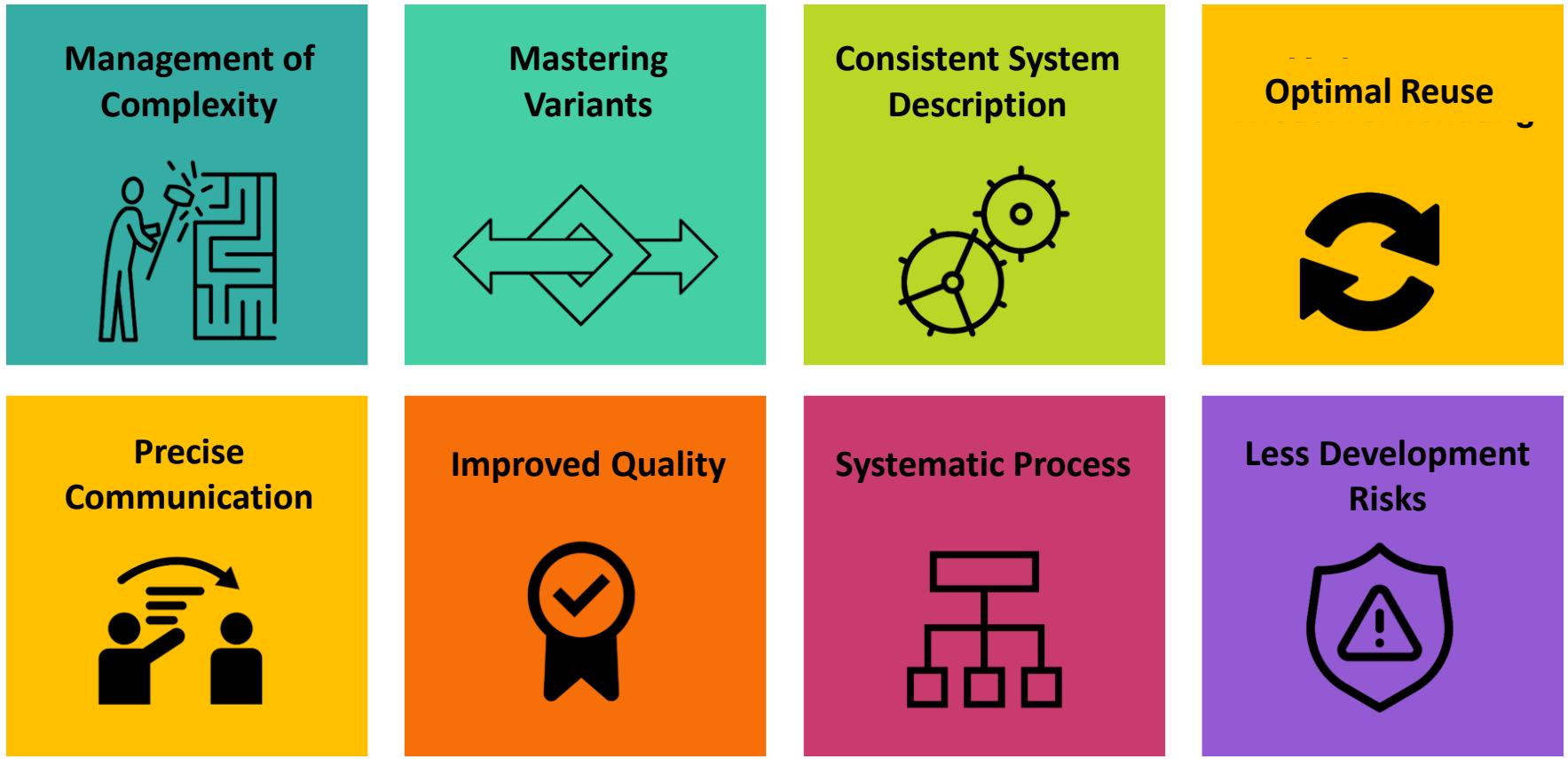
Establishment of a comprehensive theory of model-based development with all foundational elaborations

Model-based Systems Engineering

… from Documents to Models



Where can MBSE help?



Universal Interface Concept (FOCUS)

- Central element of the SPES / CrESt approach
  - Interfaces everywhere
  - Scientifically sound theoretical basis
- Key characteristics
  - Composability and modularity
  - Encapsulation and information hiding
  - Seamless methodical transition between "Systems Engineering" and "Software Engineering
  - Integration of engineering disciplines by providing a common semantics of system models
  - Semantic coherence – (refinement) relations between model classes
  - Overall modeling consistency
  - System reuse

Requirements

C/S Observations

Context

Properties

Black Box

System interface

Glass Box

Architecture

Decomposition

Sub-systems

Connections

Interaction

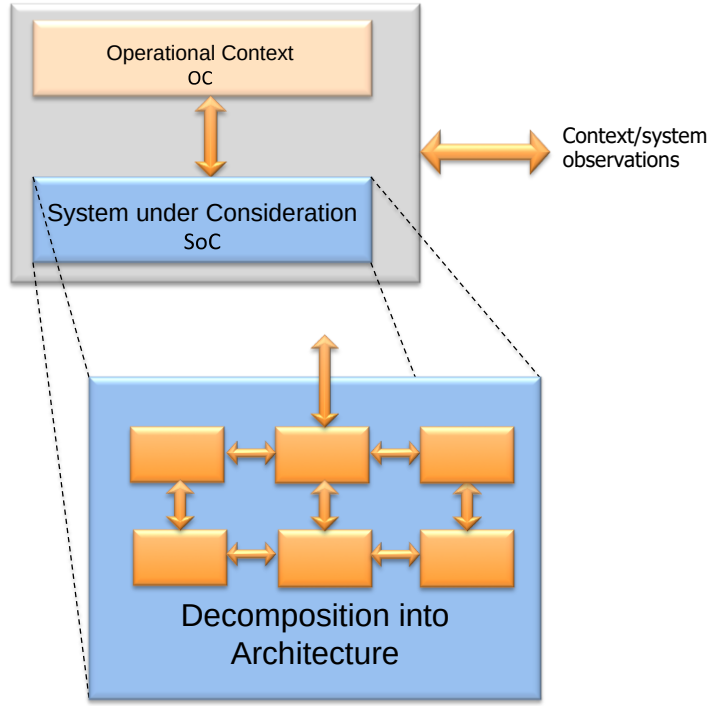
Interfaces

State View

State Space

State transition relation

Models



SPES Principles

- Definition / application of different **viewpoints** (according to ISO / IEC 42010) for differentiation and for a structured transition between:
  - … Problem analysis, requirements specification, and solution construction
  - ... logical and technical solution
- Explicit distinction between **level of granularity** of the system view and associated decomposition relationships (System of Systems)
- **Artifact model** with defined general model theory of the artifacts and the relationship between artifact types (in the model theory initially independent of a syntactic modeling language)
- Definition of **cross-cutting system properties**
  - ... consistently via the viewpoints
  - ... consistent across the granularity levels

Artifact Oriented System Development

- Comprehensive Artifact Model
  - Artifacts Based on models/MBSE
- Artifact Model Data Backbone
  - Integrated Coherent Models: No data/model silos
  - Single point of truth
- Tool support
  - Various authoring tools
  - Automation of development steps

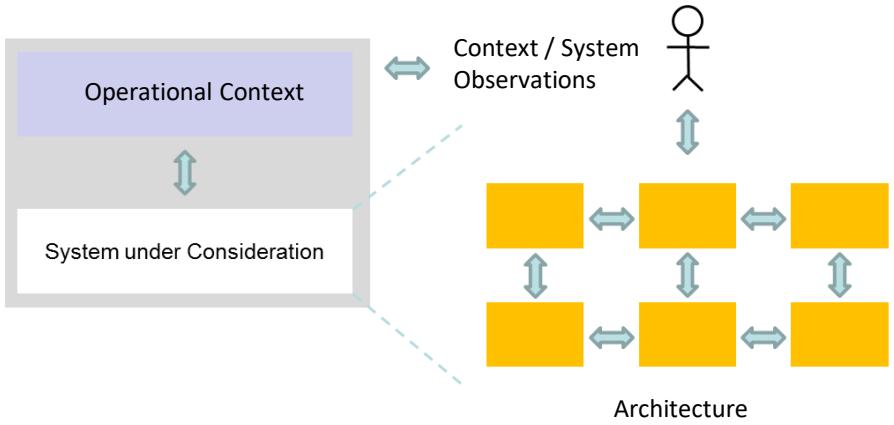
Elements of the SPES Approach

Requirements
- Goals
- Observations
- Context
- Interfaces
- Functional architecture

Architecture
- Sub-Systems
- Interfaces
- Behavior
- Configuration

Abstractions / Views
- Functions (Black Box View & White Box View)
- Logical View (abstracts from Implementation)
- Technical View
  - Separation of Engineering Disciplines
  - SW Tasks & Schedules (abstracts from Deployment)
  - Deployment View (abstracts from Code / HW Components)

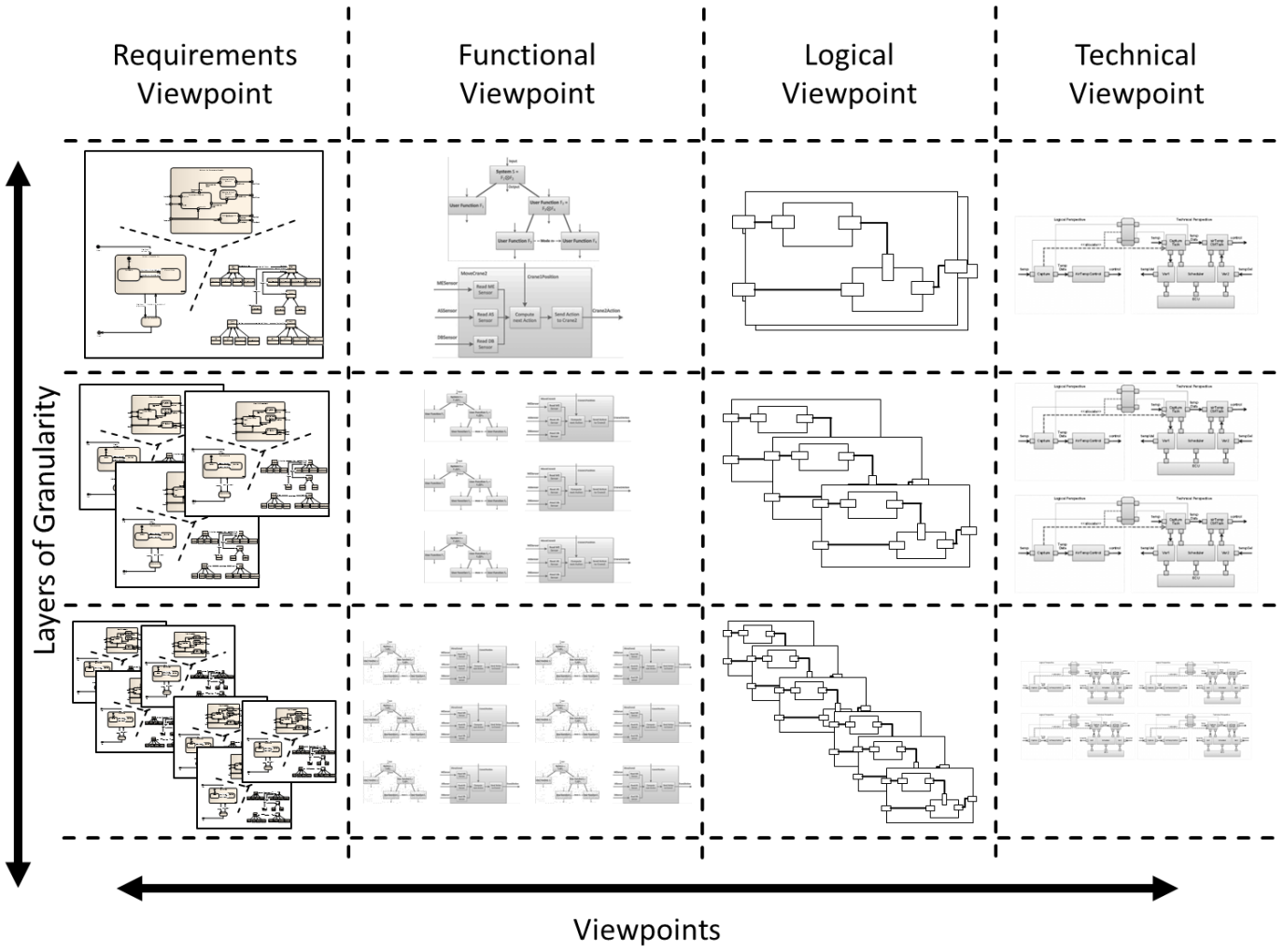
Refinements
- Scope (System under Consideration, Layers of Granularity)
- Interfaces, Properties and Behavior



Relation and Consistency between
- Requirements and System Specifications
- Context and System Behavior and Observations
- Refinements
- Layers of Granularity (Scope)

Artifacts for Documentation
- Level of Formalization (formal / semi-formal / non-formal)
- Artifact Verification and Validation (V&V)
- Level of Formalization determines V&V Options

The SPES Matrix

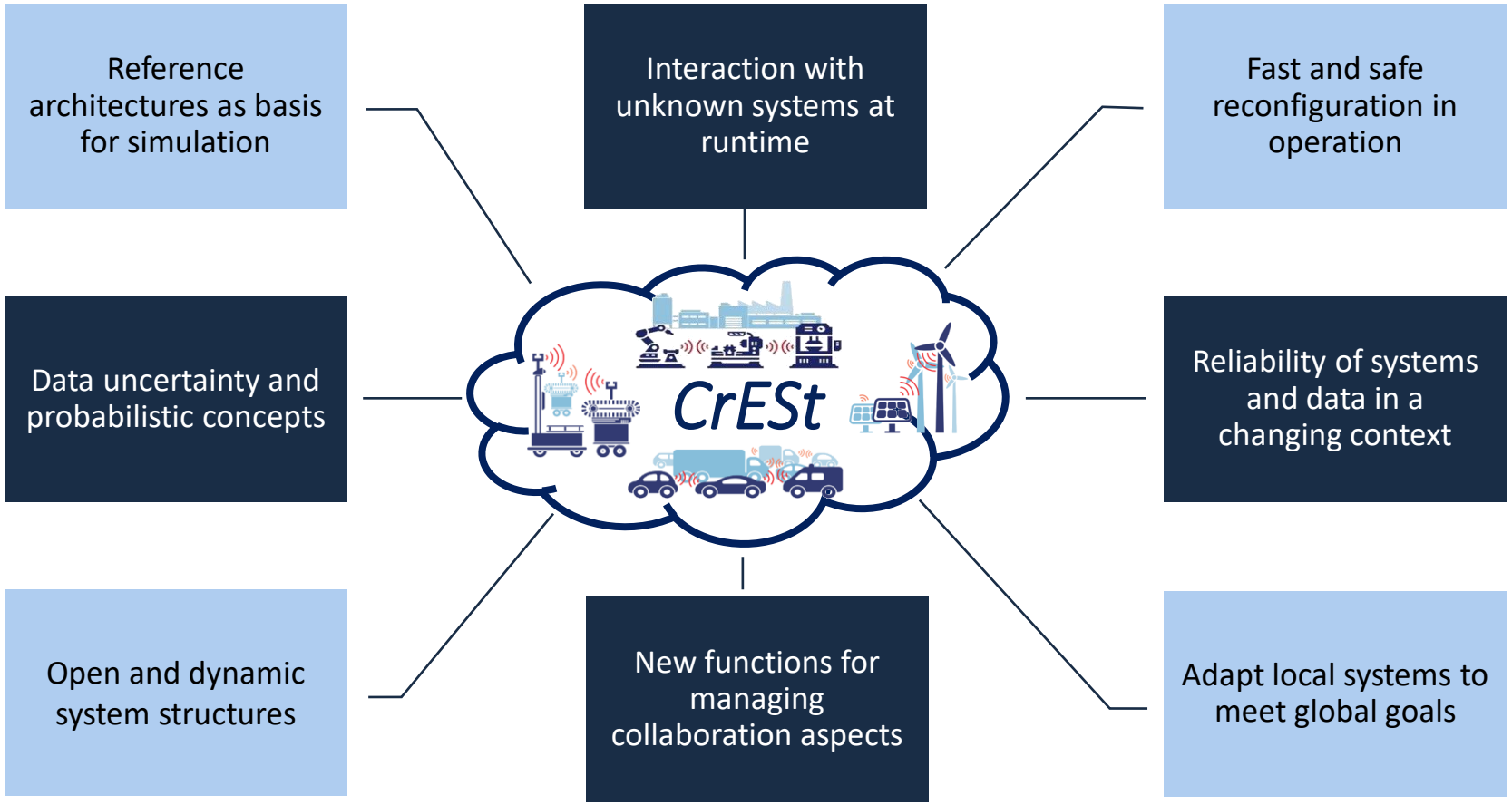


Collaborative Embedded Systems (CrESt)

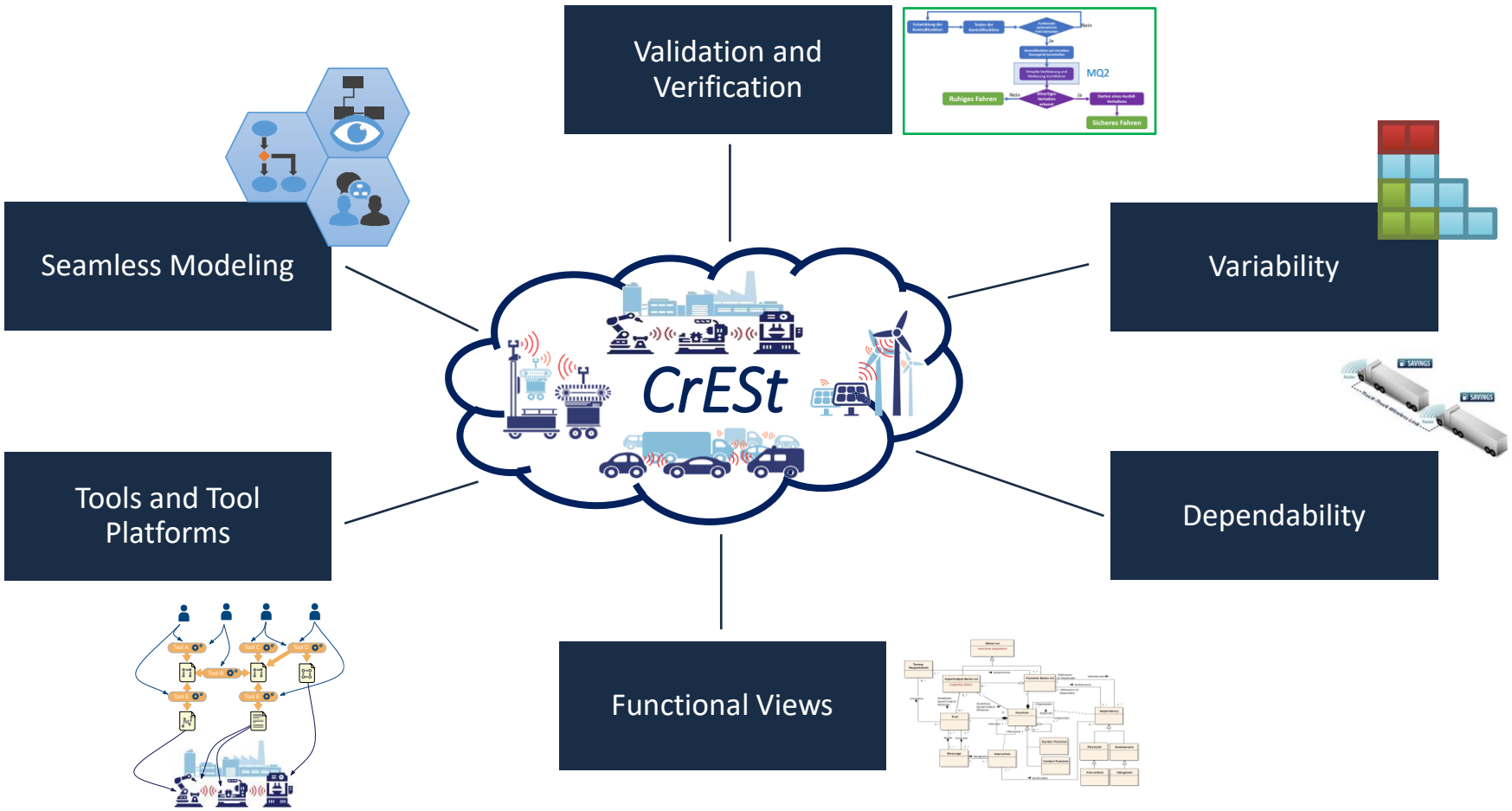
Objective: Create an engineering framework for the modeling of collaborative embedded systems (collaborating Cyber-Physical Systems) that gives a competitive advantage for German industry in this important forward-looking field using the results available from the SPES projects.

- Foundations:
  - Comprehensive results from SPES/SPES_XT project available
  - Successful SPES_XT approach:
    - Dedicated engineering challenges
    - Cross-cutting questions to guarantee project wide consistency
- Extend the SPES_XT framework that allows for modeling of CPSs (not a full-blown solution for all related aspects)
- Selected (new) applications and use cases to prove concepts
- Application domains (Automotive, Automation, Energy, …)

New Challenges attacked in CrESt



Crosscutting Technologies



Use Cases

1. Cooperative Vehicle Automation

- ”Cooperative Adaptive Cruise Control” (CACC)
- General topic: ”Autonomous driving” Here: “Platooning”

2. Changeable Factory

- "Flexible manufacturing cells" and its networks (Industrie 4.0)
- General goal: coordination of resources so that a desired product mix can be produced efficiently under changeable framework conditions (e.g. availability of resources)

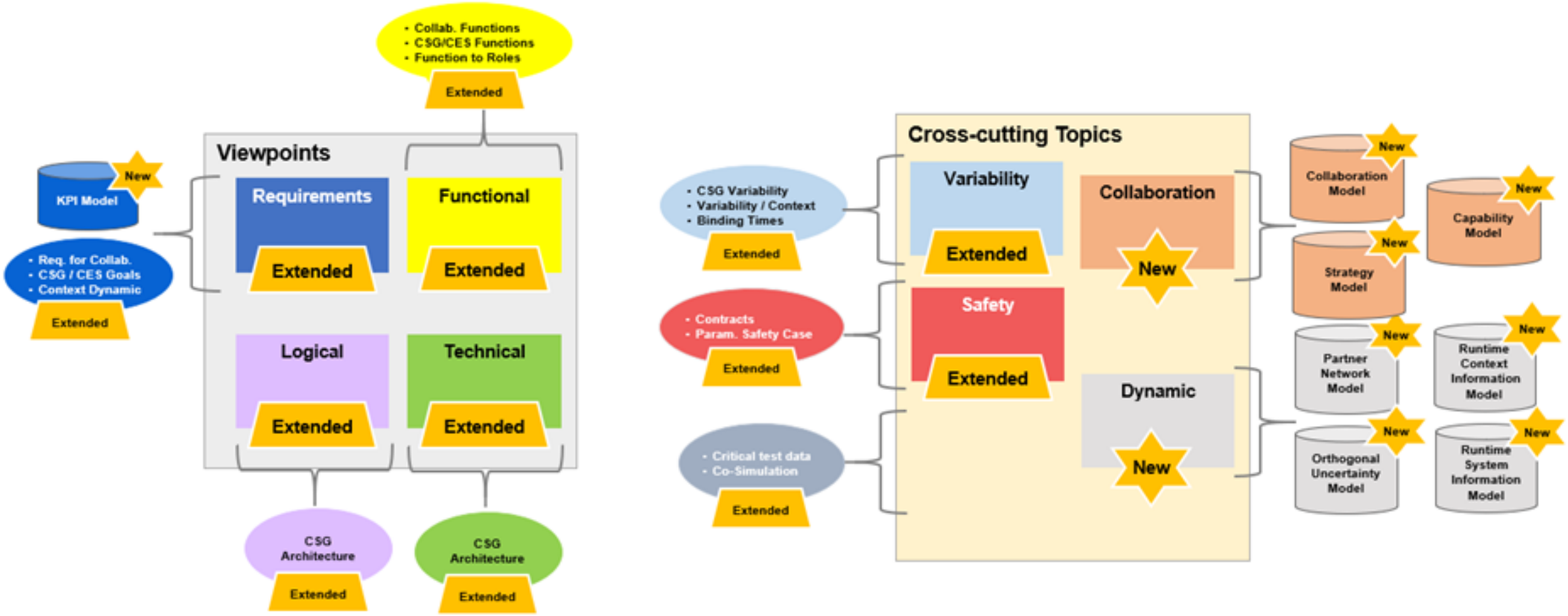
3. Distributed Power Generation

- ”Energy Management System”
- General goal: create new decentralized solutions in combination with greater autonomy of the in-field systems for fleet management of energy producers

4. Cooperating Transport Robots

- ”Decentral Order Management”
- General goal: decentralized system of autonomous, independently cooperating agents

Extended Modeling Framework



SPES / CrESt Methodology @ Work

SIEMENS
Ingenuity for life

BOSCH

SCHAEFFLER

DAIMLER

FEV

Continental

JOHN DEERE

PHILIPS

PHILIPS

LUK

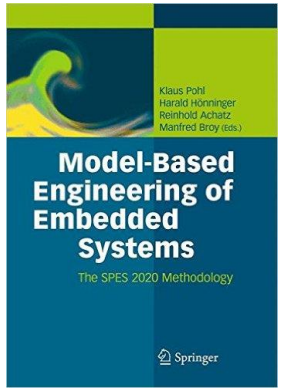
expleo
Think bold, act reliable

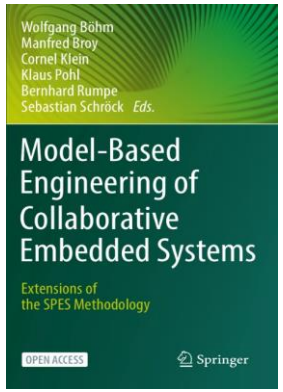
Berlin Heart

ptc

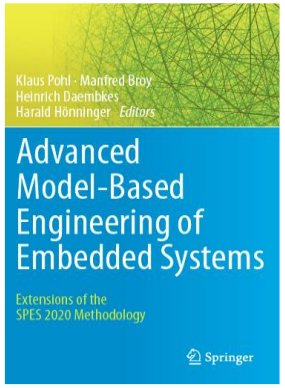
AIRBUS

SPES / CrESt Methodology: Continuity and Sustainability





- Since 2009, the SPES approach has been continuously developed in a national research network.
- **SPES / SPES_XT:** Consistent model-based methodology for the development of embedded cyber-physical systems based on a scientific foundation.
- **CrESt:** Extension of the methodology to the engineering of collaborative embedded systems in highly dynamic, uncertain contexts.
- **SPEDiT:** MBSE maturity model, introduction systematics and open source training material from the BMBF technology transfer project SPEDiT with the goal to support the introduction of the approach into broad industrial application.



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CrESt

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Questions ?