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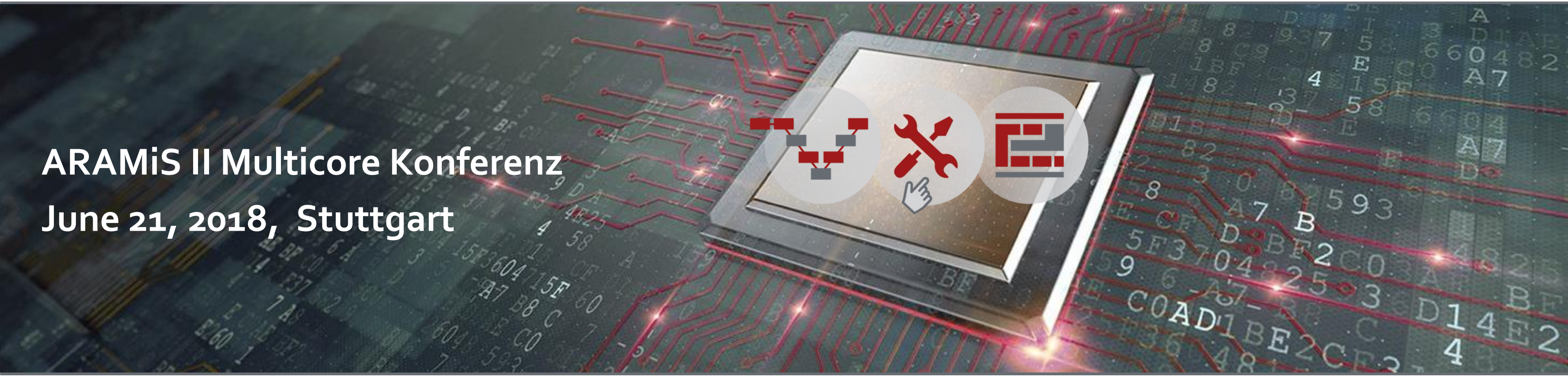
DEVELOPMENT PROCESSES I TOOLS I PLATFORMS
FOR SAFETY-CRITICAL MULTICORE SYSTEMS



ARAMiS II – Project Overview

Prof. Dr.-Ing. Dr. h. c. Jürgen Becker, Karlsruhe Institute of Technology (KIT)

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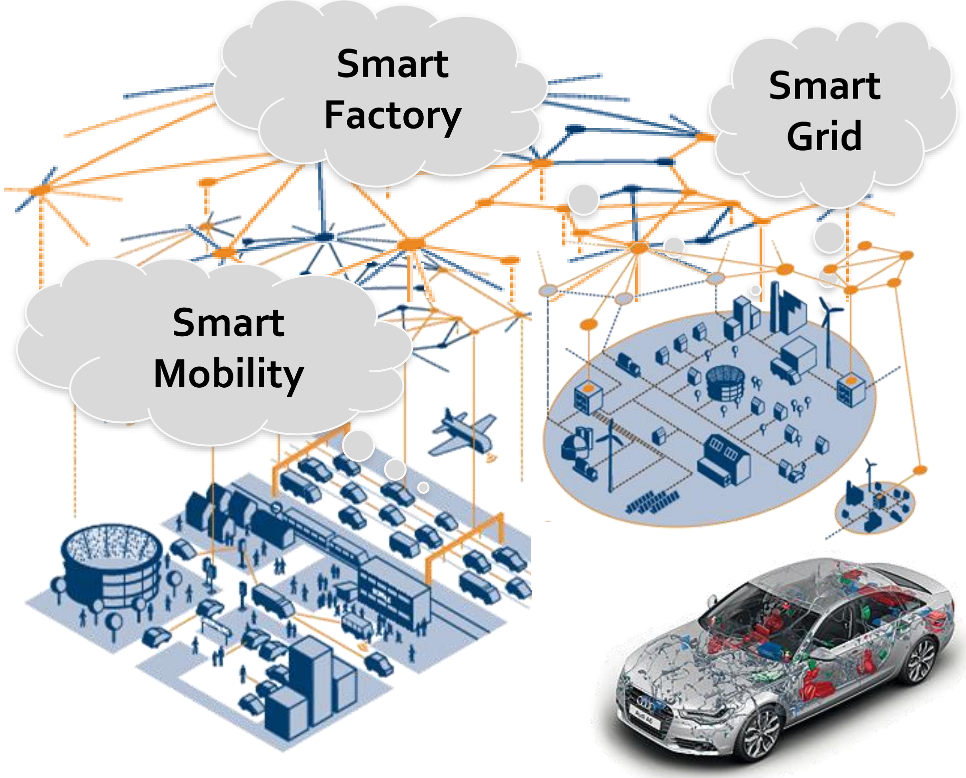
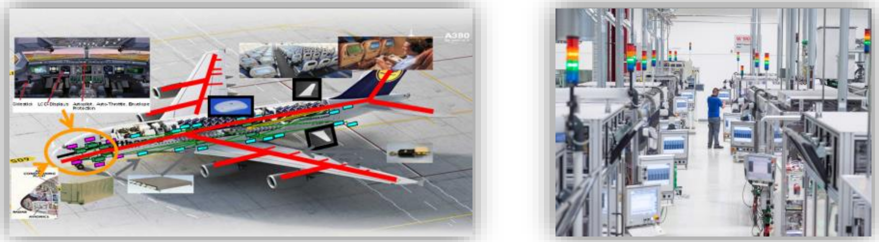
Electronic Components & Systems



Increase of Electronic Systems (HW + SW) is required

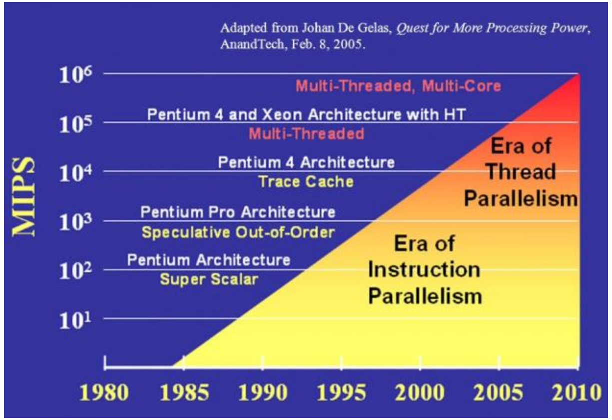
- … to integrate additional features
- … to meet environmental challenges
- … to enhance competitiveness
- … to improve cost efficiency

Degree of automation will directly depend on embedded computing power !

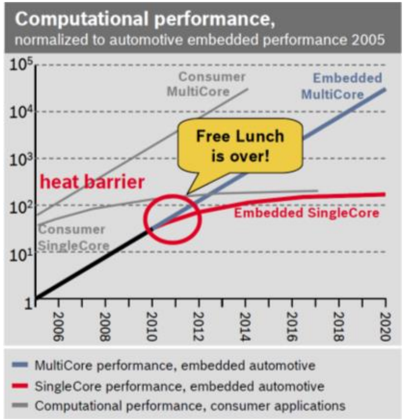


Embedded Computational Performance

- **Singlecore will not provide enough computing power in the future (scaling is over)**
- **Multicore is the best known solution that is able to provide sufficient performance**

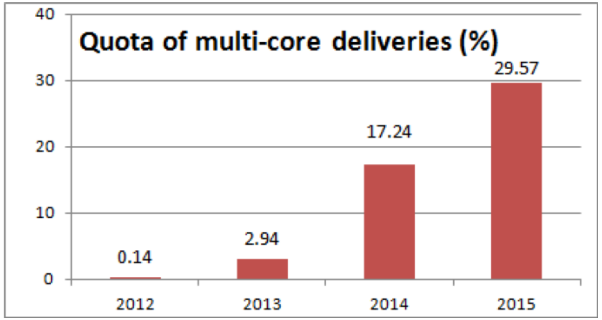


[Source:The Quest for More Processing Power: "Is the single core CPU doomed?", Johan De Gelas, 2006]



[Source: The Challenge of Mastering Parallelism in Real-Time Systems, J. Haerdtlein, 2014]

Quota of deliveries based on multi-core CPU at VW/AUDI (not yet in safety critical applications):



[Source: Shared SW development in multi-core automotive context, L. Michel, et. al, 2016]

Key Enabling Technology Embedded Multicore

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- **Singlecore will not provide enough computing power in the future (scaling is over)**
- **Multicore is the best known solution that is able to provide sufficient performance**

Smart Mobility & Manufacturing → More **functionality** on less HW platforms ← Technical Constraints (Volume, Cost, Energy, …)

↓

Embedded Multicore
=
Key technology to provide the necessary computing power

↑

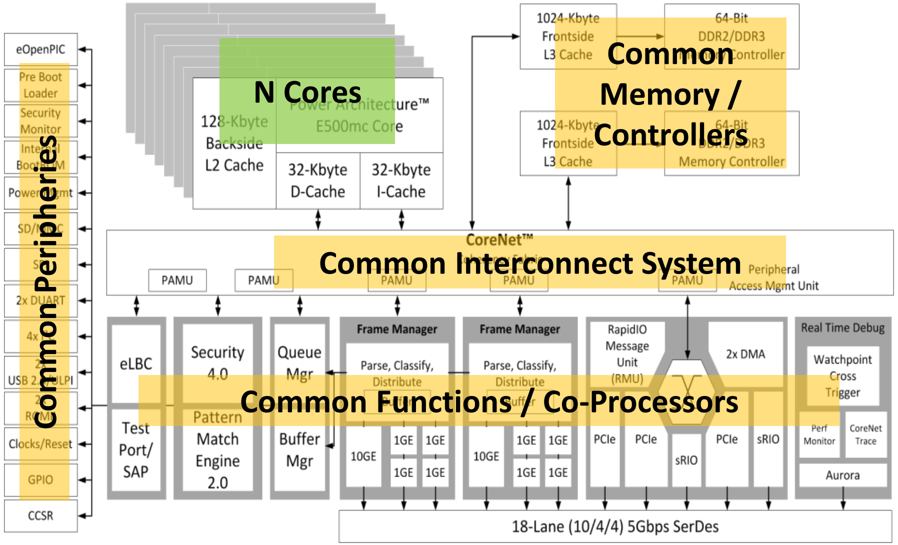
Future System Aspects and Characteristics

- **Functionality is safety critical in many cases**
- **Systems are highly connected in networks**
- **Evolutionary Development (Legacy Code)**
- **User friendliness and smart ecosystems: Use of APPS**
- **Cyber Physical Systems with mixed criticality and dynamic reconfiguration of structures and services**

But: Multicore comes with challenges …

Common resources shared between different execution units can lead to system dysfunction (loss of functions / malfunctions) caused by:

- Time interferences (determinism issues)
- Space interferences (segregation issues)
- Common Cause Failures (e.g. SEE, electronic fail)
- Race Condition (Time-of-check vs. Time-of-use)



Issues depend on multicore architecture:

- Mono-Bus / Multi-Bus / Crossbar / NoC / etc.
- Core local memory or only shared memory
- Lock-Step-Mode core / end2end ECC / etc.

Mitigations needed for safe and secure usage (per SW or HW):

- **Failure Detection**: Monitoring, Voting
- **Failure Isolation**: Partitioning, Time Slicing / Deadlines, Budgeting
- **Failure Correction**: Function Recovery, Redundancy, Architectural Patterns

Summary on Results of ARAMiS

- **Improvement of Basic Software Architectures**
- **Improvements of platforms on system, hardware and software level.**
- **First Results on holistic tool support**
- **Work on Methodologies**
- **Prototypical implementations and evaluations in laboratory setups**
- **Demonstrators as feasibility studies and proof for deployment of multicore systems in real industrial environments**

→ **ARAMiS** proved successfully the applicability of multicores in Safety-critical applications in principal…

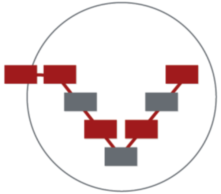
… **but** uncovered further challenges in multicore development

Presentation of ARAMiS Results at CeBIT 2016, Hannover

From ARAMiS to ARAMiS II

ARAMiS
proved the applicability of multicores in
safety critical applications in principle

ARAMiS II
targets the efficient use of multicores in safety critical applications
in practice by preparation of:



STRUCTURED MULTICORE DEVELOPMENT

MULTICORE METHODS AND TOOLS

INDUSTRIAL PLATFORMS FOR MULTICORE SYSTEMS

Challenges for Multicore-System Development

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1. **Separated steps in multicore development are not sufficient for a structured development of multicore-based systems**
   - **Process:** How could a superior (generic) multicore development process look like?
   - **Continuity:** How can continuity in the process be achieved and which artefacts are needed?

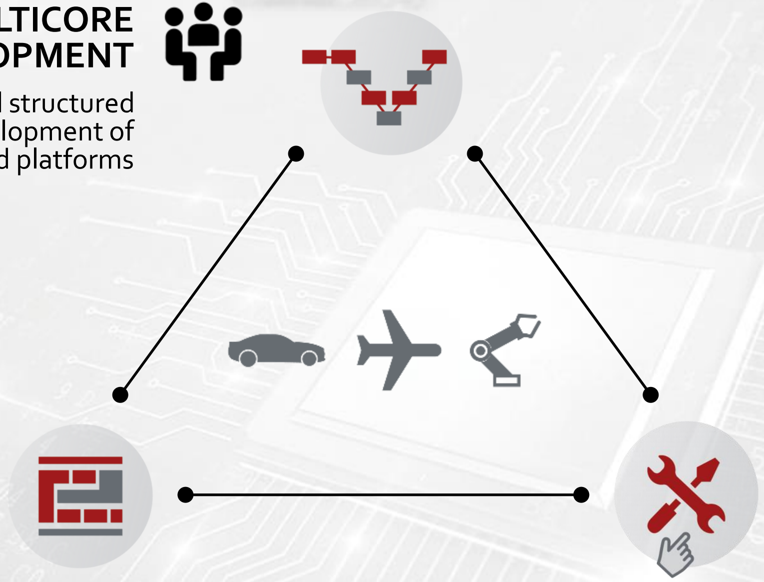
2. **Available methods and tools are not sufficient to master the complexity in the development of multicore-based systems**
   - **Partitioning:** When and where to split and distribute functionality?
   - **Allocation:** Which could be the right platform for a certain application scenario?
   - **Binding:** Which deployment of (basis-) software components is the most optimal solution?
   - **Scheduling:** Which schedule of software can be run most efficiently?
   - **Guarantees:** How can platform aspects (e.g. WCET, Safety, Security, correctness) be ensured?
   - **Design Space:** How can a design space exploration be performed in such complex systems?

3. **Well established platform standards and software architectures are not supporting the requirements of multicore-based systems (e.g. segregation, synchronization, communication)**

Summarized Working Focus and Project Goals

STRUCTURED MULTICORE DEVELOPMENT

Provision of systematic and structured approaches for the development of multicore software and platforms



INDUSTRIAL PLATFORM ARCHITECTURES

Development and extension of established industrial platforms with respects to multicore requirements

METHODS AND TOOLS

Development of methods and tools supporting the structured multicore development

Scientific and Technical Approach

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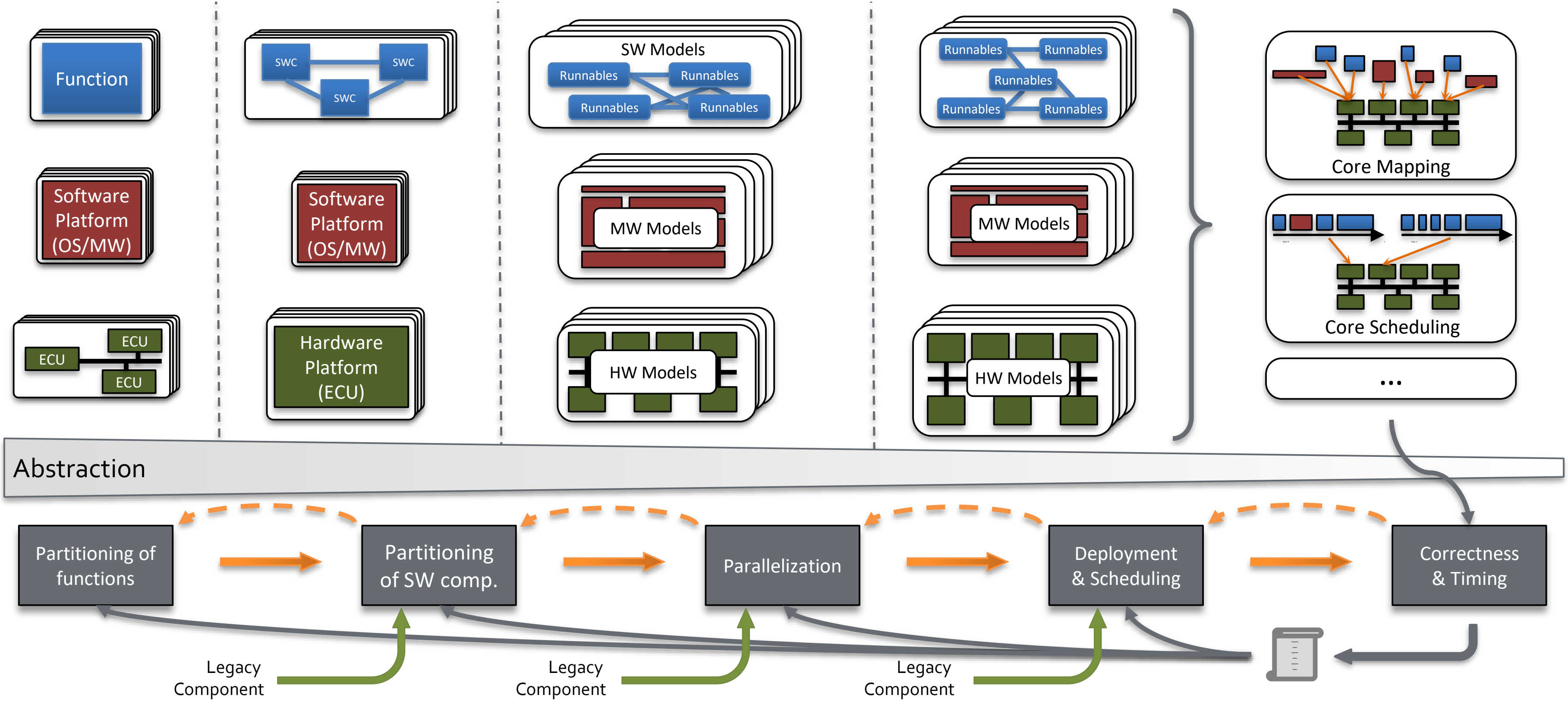

Subproject 2: Structured Multicore Development

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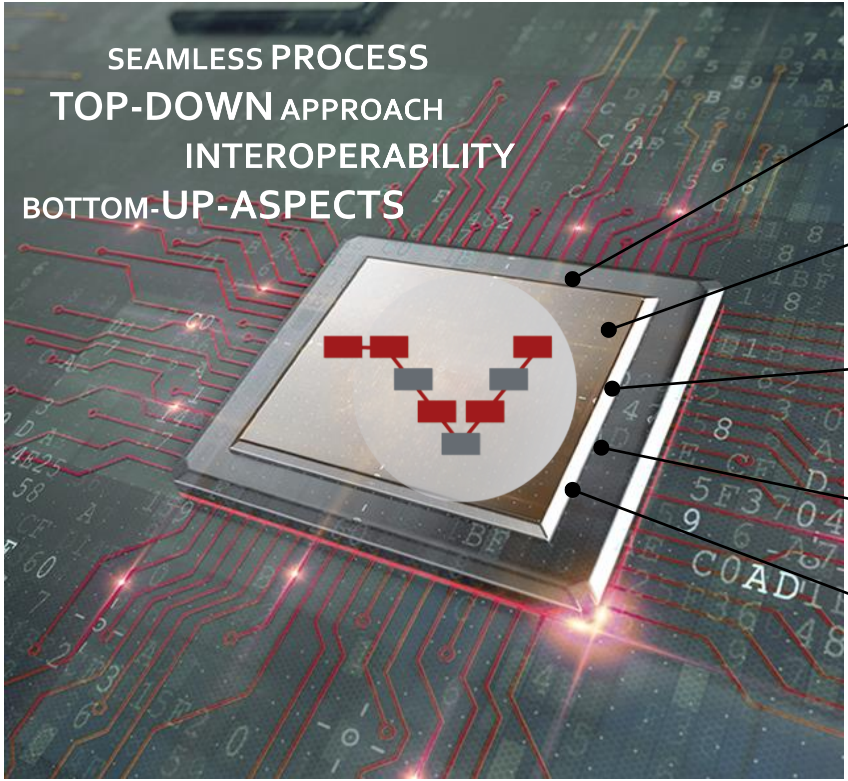

Structured Multicore Development

- Definition of a generic and seamless development process for multicore systems
- Model based "Top-Down" development process, avoiding unnecessary iterative loops…
- … but considering bottom-up and legacy aspects
- Implemented by methods and tools developed in ARAMiS II

Subproject 3: Multicore Methods and Tools

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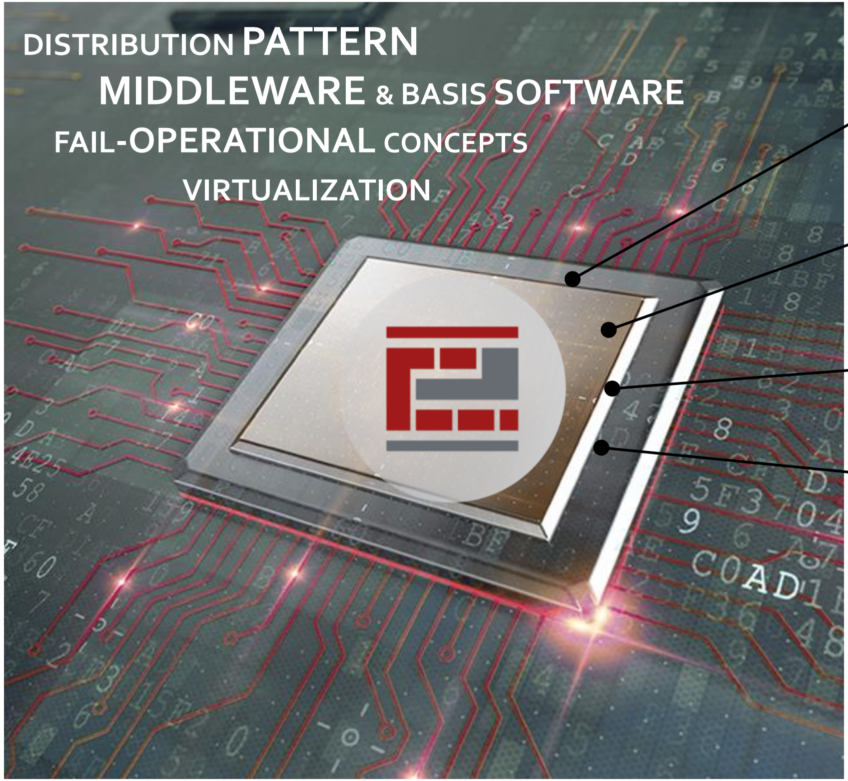
DEVELOPMENT PROCESSES I TOOLS I PLATFORMS
FOR SAFETY-CRITICAL MULTICORE SYSTEMS

Multicore Methods and Tools

- Development of specific methods and tools to support the structured multicore development
- Extension of methods for all steps in the development process (e.g. partitioning, deployment, scheduling, design space exploration)
- Higher degree of automation in the development due to tool support

Subproject 4:
Industrial Platforms for Multicore Systems



Industrial Platforms for Multicore Systems

- Development and extension of established industrial platforms for the use in multicore-based systems
- Investigation of basis software, middleware and operating systems
- Evaluation and development of lightweight fail-operational concepts for multicore platforms

Involved Domains for the Validation of the Results

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Automotive

Avionics

Industry Automation

Subproject 5: Use Case Implementation and Evaluation

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Chassis	Audi
Power-Train	DENSO
E-Drive	SCHAEFFLER LuK INA FAG

Multicore Observer	AIRBUS
Jet Engine Control	GE
Flight Control	LIEBHERR
ECAM	DIEHL Aerospace

Mobile Machine Sensor	WIKA MOBILE CONTROL
Pump Control	KSB

Facts and Figures

DEVELOPMENT PROCESSES I TOOLS I PLATFORMS
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Automotive

Avionik

Software & Tool Hersteller

Industrie-automatisierung

Forschungs-einrichtungen

- **Coordination:** Karlsruhe Institute of Technology (KIT)
- **Duration:** 10/2016 – 09/2019
- **Consortium:** 33 Partner
- **Budget:** > 26 Mio.€
- **Web:** www.aramis2.de
- **Publications up to now:** >40 (www.aramis2.de/publikationen)

FUNDED BY: Federal Ministry of Education and Research

PROJECT MANAGEMENT AGENCY: DLR Projektträger

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ENTWICKLUNGSPROZESSE I WERKZEUGE I PLATTFORMEN
FÜR SICHERHEITSKRITISCHE MULTICORESYSTEME

Thank you for your attention!

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