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SAFETY IN TRANSPORTATION SYSTEMS

National Roadmap Embedded Systems

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EADS DEFENCE & SECURITY

OFFIS INSTITUT FÜR INFORMATIK

DAIMLER

Fraunhofer IESE

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Participating organisations

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- Automotive
  - Audi, Bosch, Continental, Daimler, Volkswagen
- Aviation and astronautics
  - Astrium, Airbus, EADS
- Automation/ robotics
  - KUKA
- ICT
  - IBM, Microsoft, Siemens
- Semiconductor chips
  - Infineon
- Telecommunication
  - Telekom/EICT, Nokia-Siemens-Networks
- Research
  - DFKI, DLR, Fortiss, Fraunhofer IESE, Fraunhofer Institute for High-Speed Dynamics, OFFIS, RWTH Aachen, TU Berlin, TU Brunswick, TU Munich, U Heidelberg, U Karlsruhe
- Associations
  - BITKOM, VDI, VDE, VDMA, ZVEI

Embedded systems

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Embedded system = central nervous system

- “observe”
- “analyse”
- “decide”
- “act”

of products in leading German economic sectors

Embedded systems

- Without these central nervous systems
  - no cars would drive today
  - no planes would fly today
  - no factory would work today
  - no thorough assessment of the security situation would be possible
  - no mobile communication would be possible

Embedded systems Germany

- More than 3 million high-tech jobs depend on embedded systems in Germany.

- The automotive, automation and medical industries invest approx. 15 billion € in R&D on embedded systems each year. Their yearly turnover exceeds 500 billion €.

- Innovation leadership in embedded systems: Germany is among top 3

Importance for societal challenges

The central economic and sociatal challenges can not be solved without the cross-cutting technology embedded systems.

Examples for use cases:

- **Medicine:** *Seamless Interaction* enables doctors to access patient bio data anytime anywhere.

- **Mobility:** Safe and green mobility is possible because of intelligent vehicles and coordinated traffic management systems with the help of *distributed real-time situation awareness and solution finding.*

- **Safety and security:** Effective crisis management under extreme conditions is guaranteed through *autonomous systems.*

ES in German Industry

Industry	Employees	Turnover in bn Euro	R&D Efforts in bn Euro	Key figures embedded systems
Automotive	834 000	293	20,9	**Share of costs for embedded systems Development** worldwide: 51,4%; **51,4% equals approx. 10,7 bn € in G**
Machines and equipment	965 000	205	5,6	**Share of costs for embedded systems Development** worldwide 50,1%; **50,1% equals approx. 2,8 bn € in G**
Aerospace	93 000	22	3,25	**Value share of embedded systems** to an airplane: 12%
Medical	170 000	17	1,5	**Share of costs for embedded systems Development** worldwide : 47,6%; **47,6% equals approx. 0,7 bn € in G**

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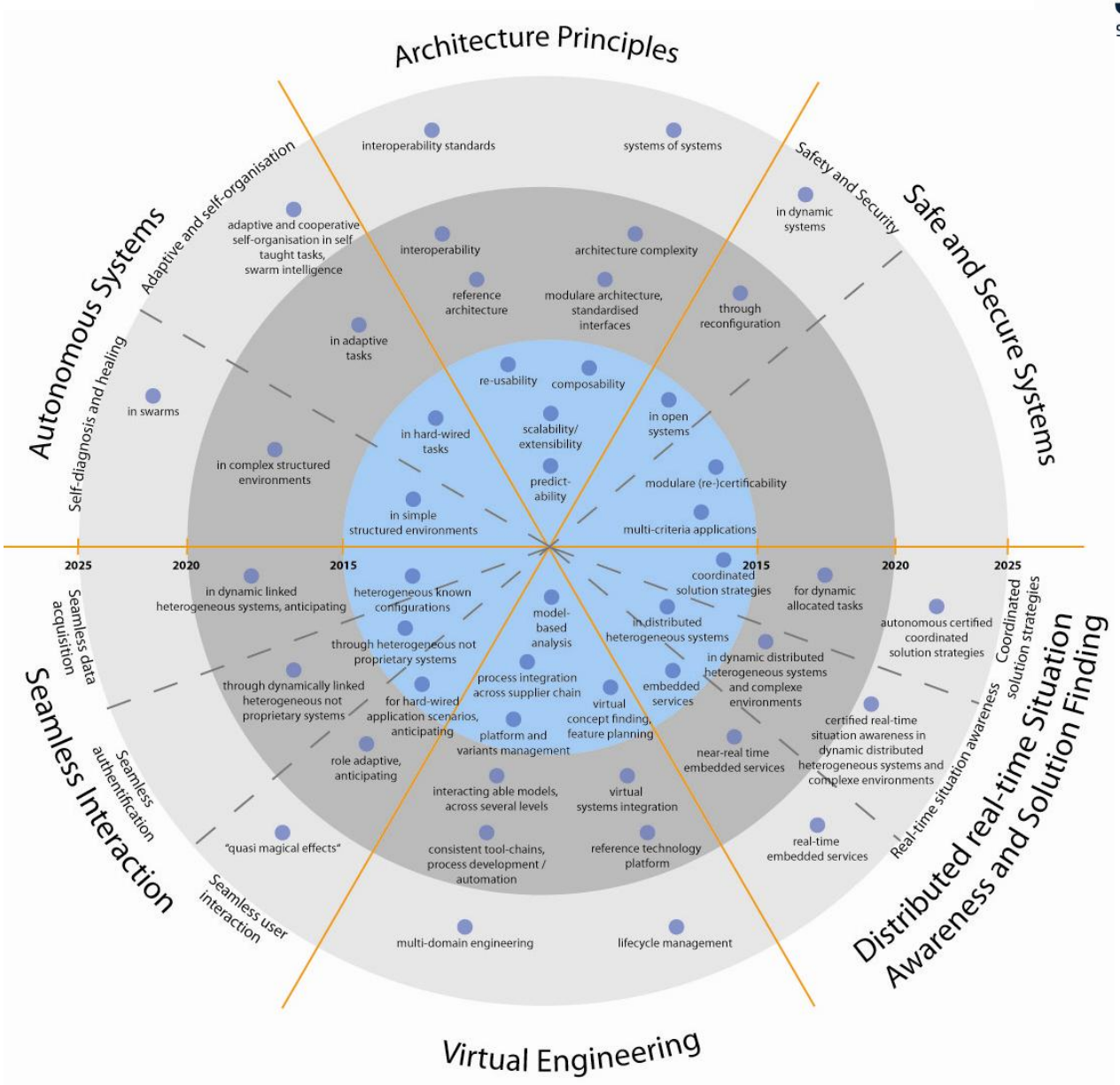
Importance of embedded systems

- Cross-sectional technology and innovation driver
  - Essential for unique selling points and market leadership in many important industries
  - Leading position in embedded systems is essential for preservation of jobs and competitiveness of industries

→ **Mastering embedded systems is necessary to master product development**

→ **Resolving technical challenges is necessary to master embedded systems**

Research Areas



Seamless Interaction

FSP Seamless Interaction: To access relevant information in real-time is equally important for the monitoring of patients, as it is for crisis management; in intermodal logistics applications, as it is in smart shops, which almost ''magically'' meet tailored customer requirements. In addition to solutions from IT systems, for Embedded Systems "language barriers“ between different technical systems have to be overcome, tools for secure authentication have to be established and innovative "thinking" interaction interfaces have to be build.

Seamless Interaction

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Societal and economic challenges

Ageing society and healthcare

Mobility

Safety and Security

Knowledge society

Urbanisation

Capabilities

Seamless Data Acquisition

Information access in real-time/ Data integration in in real-time; active adaptive wireless and energieefficent communication

Seamless User Interaction

Intuitive human-machine interface

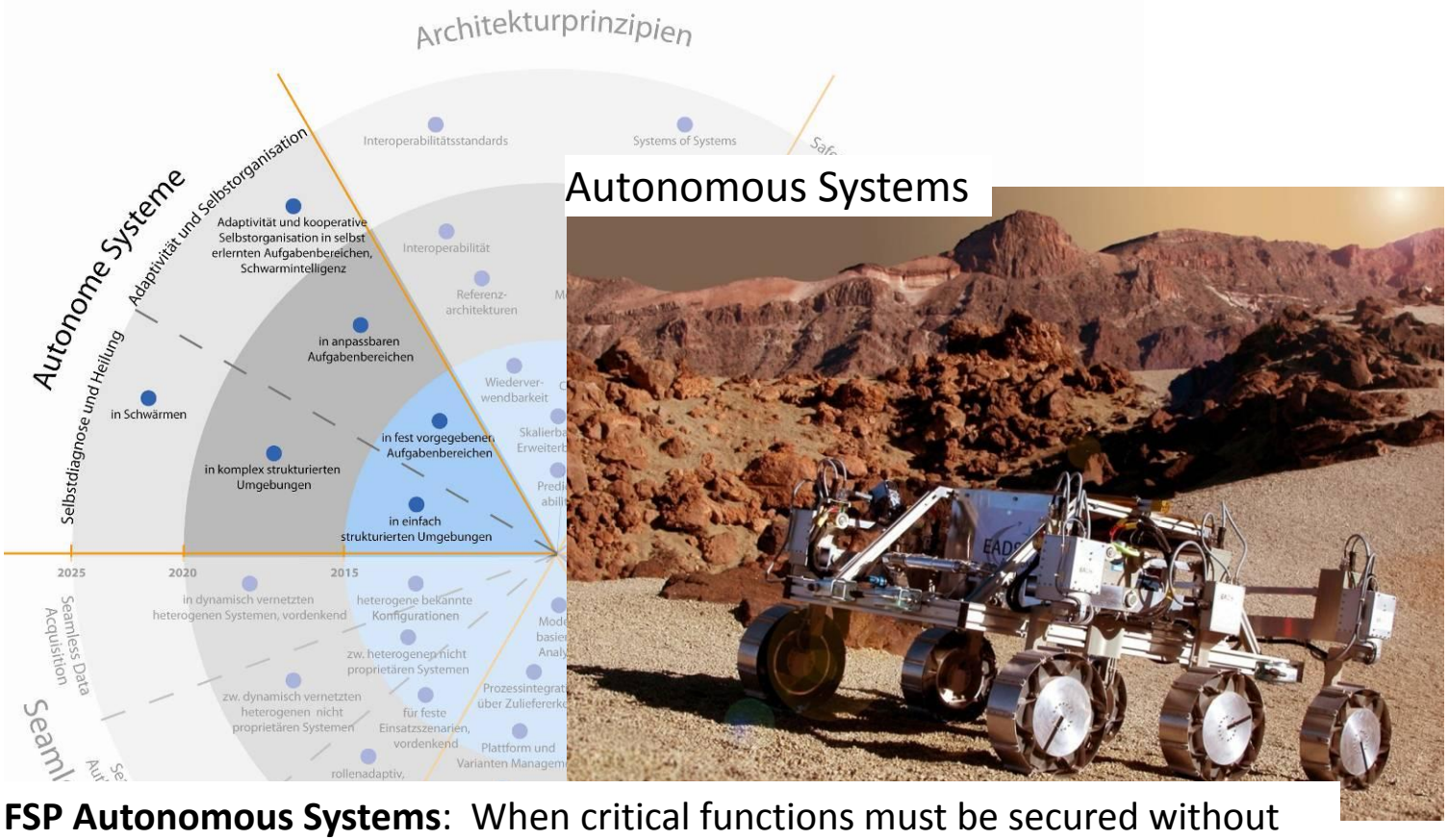
Seamless Authentification

Safe authentication of interacting systems

Process and technology innovations

- Safety and security
- Model-based user-centred and automated system design
- Innovative interaction interfaces
- New sensor technologies
- Adaptive interaction interfaces and computing devices

Autonomous Systems



FSP Autonomous Systems: When critical functions must be secured without human intervention under extreme conditions (tapping resources on the seabed, crisis / disaster management, in space), Autonomous Systems are the technology of choice. They need to adapt themselves so that they provide a specified performance in a hardly predictable environment and under hardly known conditions.

Autonomous Systems

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Capabilities

Adaptive

Capability to adapt to changes in environment during runtime (within certain limits)

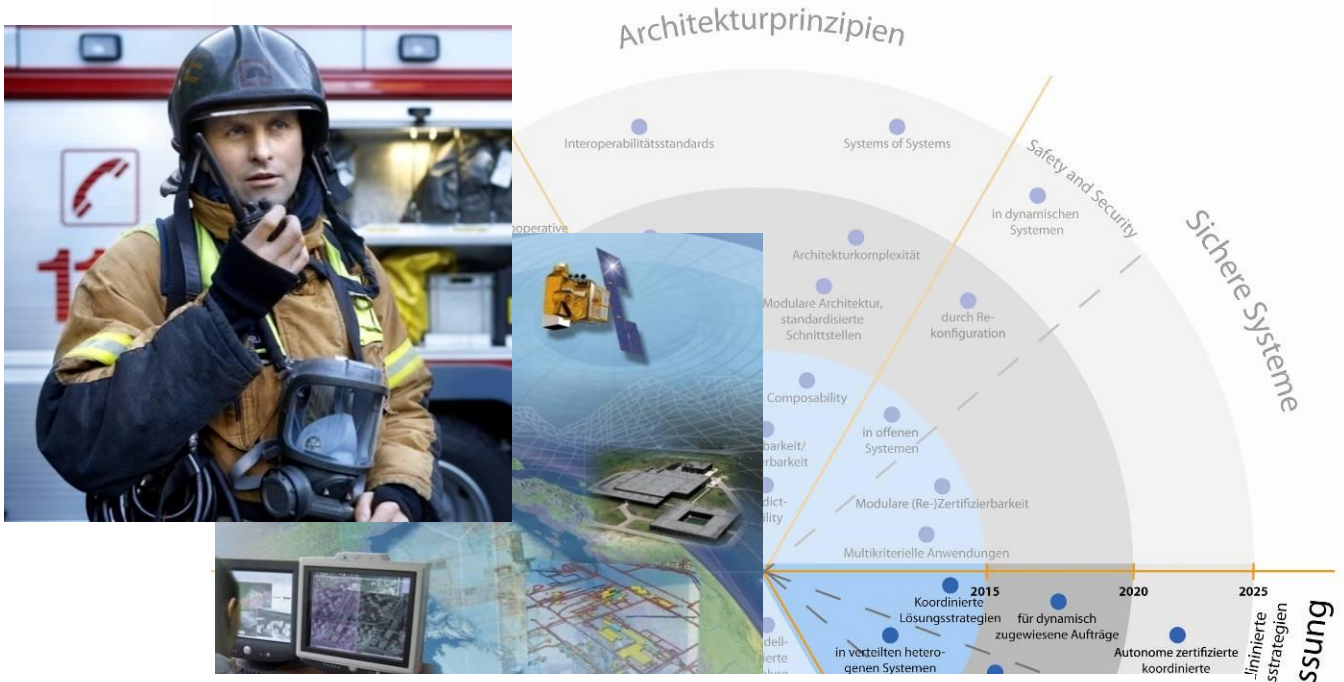
Self-healing

Capability to detect errors in and failures of system components and to stay operational in spite of these failures

Technology innovations

- ➔ Distributed control systems
- ➔ Cooperative embedded systems
- ➔ Reference architectures
- ➔ Innovative user interfaces
- ➔ Cognitive embedded systems

Distributed Real-time Situation Awareness and Solution Finding



Distributed Real-time Situation Awareness and Solution Finding: Coordinated situation assessment and solution strategies are essential to such diverse fields of activity as crisis management, patient monitoring and coordinated driving to reduce pollution and increase traffic safety. This requires that a common operational picture can be established between the acting (semi-autonomous) sub-systems under real-time conditions in an accurate way, on the basis of integrated, heterogeneous, intelligent sensors and static situation awareness, such that conflict strategies can be established by coordinated maneuvers in real-time.

Distributed Real-time Situation Awareness and Solution Finding

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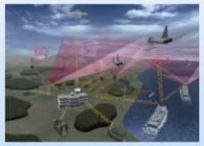


Capabilities

Real-time situation detection and validation in dynamic distributed systems

Aggregation of distributed, uncertain information about the environmental situation as a basis for situation awareness

Coordinated strategies

Coordinated actions of the subsystems, taking the dynamics of the system and uncertainty resulting from autonomous subsystems into account

Embedded Services

Integration of information with web and database applications

Technology Innovations

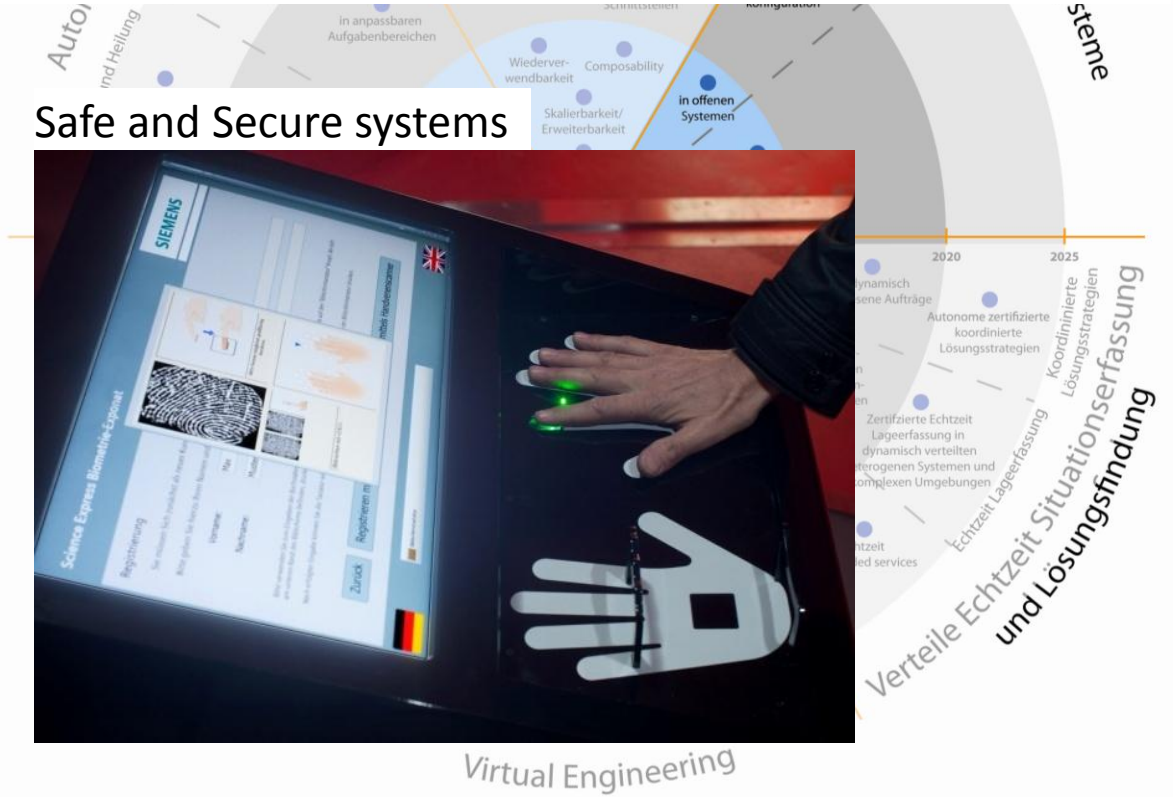
- Computing devices of the future
- Resource-optimizing technologies
- Cooperative embedded systems
- Innovative user interfaces
- Cognitive embedded systems
- Distributed control
- Reference architectures
- Safety and security

Process Innovations

- Architecture design and evaluation
- Requirements management
- Life cycle management
- System analysis

Safe and Secure Systems

Safe and Secure Systems: Creation and preservation of confidence in embedded systems are indispensable pre-conditions for the acceptance of complex, cross-linked embedded systems needed to solve societal and economic challenges. To achieve this, IT security concepts are useful, but not sufficient, since they often focus on security aspect. For embedded systems, the aspects of safety and impact of (missing) security on safety are key issues.



Safe and Secure Systems

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Societal and economic challenges

Ageing society and healthcare

Mobility

Safety and Security

Knowledge society

Capabilities

Safety and security in open systems

Active establishment of safety and security through reconfiguration

Safety and security in dynamic systems

Integration and segregation of multi criteria applications

Modular certifyability

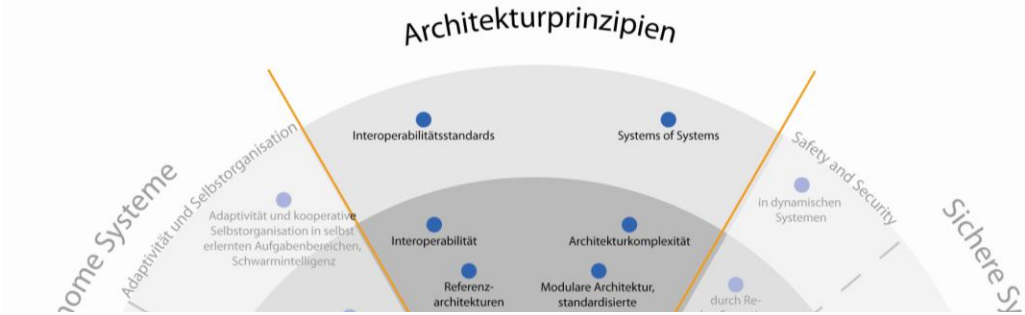
Technology Innovations

- Reference architectures
- Safety analysis
- Autonomy / cooperation

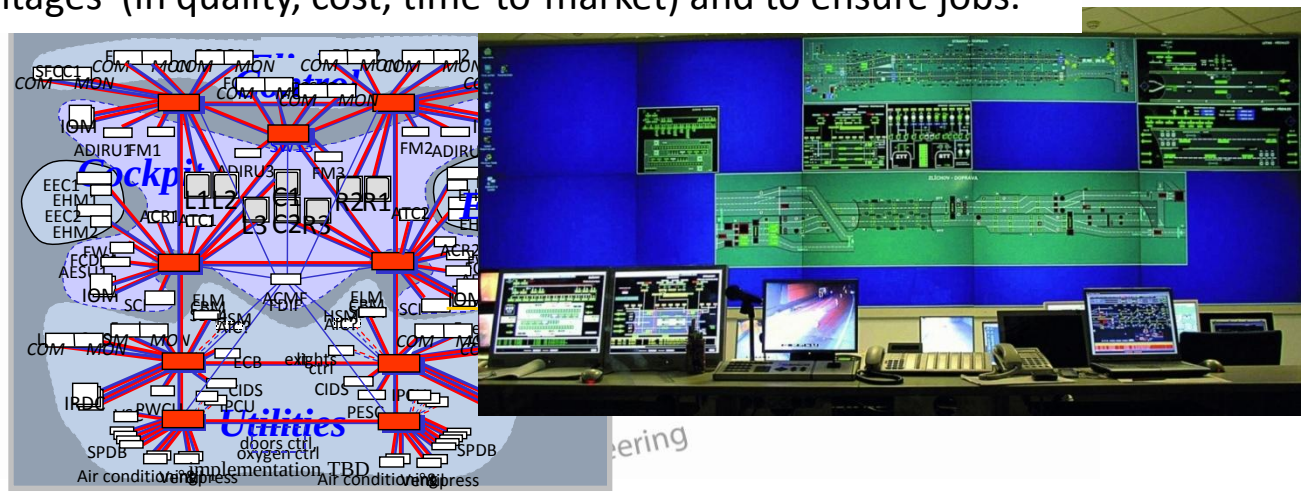
Process Innovations

- Requirements engineering
- Architecture
- System analysis
- Systematic re-use

Architecture Principles



Architecture Principles: Environment-friendly mobility in cars through minimizing emissions and energy consumption ("green mobility") is just one example of applications in which solutions of complex systems from different domains and sectors have to be combined. Therefore, standardised, manageable, domain-independent architectures are key factors to achieve competitive advantages (in quality, cost, time-to-market) and to ensure jobs.



Architecture Principles

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Societal and economic challenges

Mobility

Safety and security

Capabilities

Composability

Formal description of functional and non-functional properties

Re-usability / extensibility

Standardised interfaces

Reference architectures and interoperability standards

Mastering heterogeneity

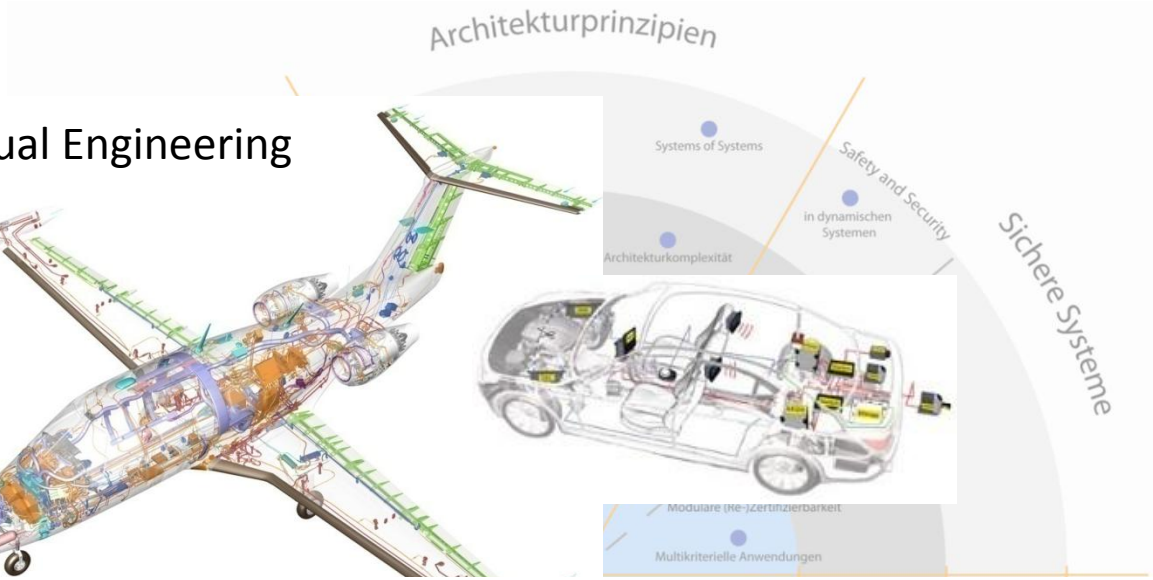
Technology Innovations

- Reference architectures
- Safe, secure, distributed, cooperative embedded systems

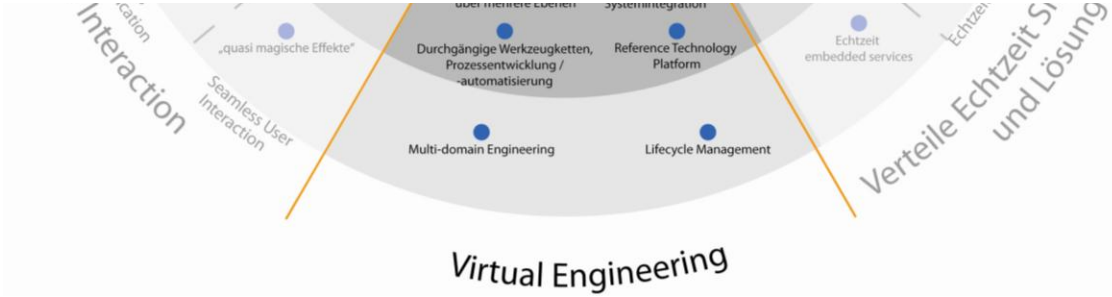
Process Innovations

- Systematic re-use
- Architecture design and evaluation
- Life cycle management
- Hardware virtualisation

Virtual Engineering



Virtual Engineering: Improved development processes, methods and tools are required to realise embedded system applications with the needed qualities. These will increase efficiency, early concept validation, and productivity in terms of quality, cost, time, safety and reliability, and will in addition allow us to master the complexity of cross-domain systems.



Virtual Engineering

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Societal and economic challenges

Ageing society and healthcare

Mobility

Urbanisation

Environment and energy

Capabilities

Virtual concept creation

Process automation

Virtual system integration

Process integration across supplier chain

Model based analysis

Reference technology platform

Technology innovations

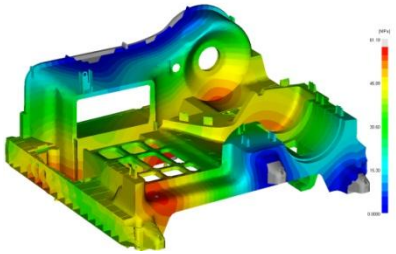
- Reference architectures
- Reference technology platform for developing/ testing of embedded systems
- Autonomy / Cooperation
- Cognition

Process innovations

- Requirements engineering
- Life cycle management
- Systematic re-use
- Model-based development
- Process organisation
- System analysis

Industrial investment Germany 2010-2020

- Total volume for R&D on embedded systems is more than 150 bn €
- Research effort in public funded programmes needed to reach the goals of this roadmap is estimated to be at least 2,5 bn €
  - More than 500 mill € for research areas autonomous systems, architecture principles, virtual engineering and distributed real-time situation awareness and solution finding, each.
  - More than 200 mill € for research areas seamless interaction and safe and secure systems, each.



Recommendations

A substantial increase of public funding for research areas of the National Roadmap Embedded Systems is necessary

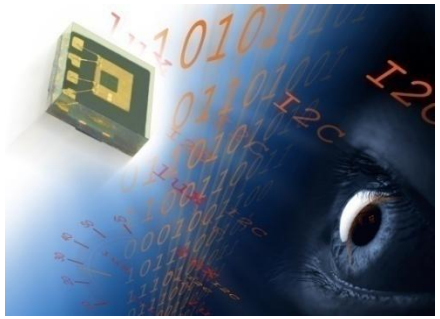
- To retain leadership in innovation of major industries with a turnover of more than 750 bn €
- To protect more than 3 million high tech jobs in Germany
- To stimulate the required cross-industry cooperation

On a national level, the German Innovation Alliance **SPES 2020** is suggested for implementation of projects; on the European level, **ARTEMIS** is recommended.

Additional recommendations

1. Establishment of **open industry standards for interoperability** → Creation of appropriate European regulatory frameworks in coordination with national rules → Recommendation: Harmonisation of European wide initiatives under the ARTEMIS umbrella

2. Establishment of **Reference technology platforms** to ensure sustainablility of R&D results → Recommendation: Coordination of European wide initiatives with initiatives of ARTEMIS

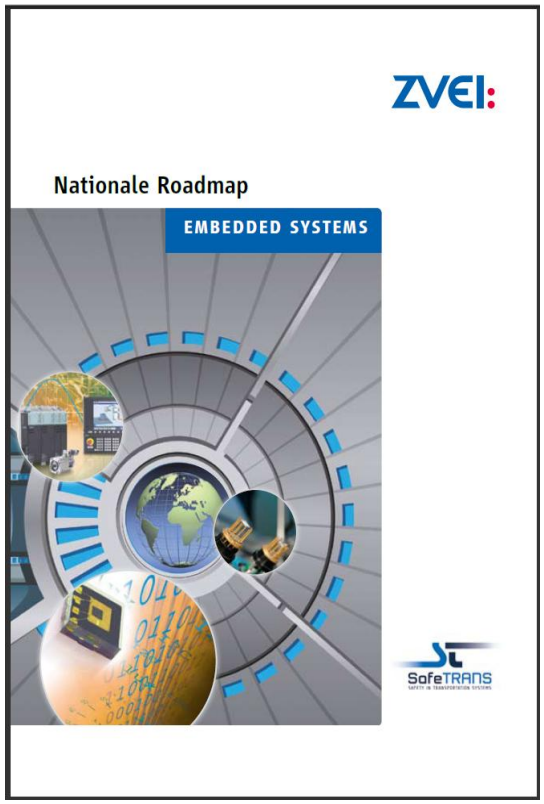


Additional recommendations

3. Guarantee the availability of **qualified employees** →
   Increase coordinated efforts to ensure appropriate training at all levels of education including vocational training

4. Establishment of **cooperation between experts of embedded systems technologies and experts of the different application areas** (health, mobility, energy, …) →
   Goal: A coordinated overall strategy to master the societal and economic challenges

National Roadmap Embedded Systems



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