AVL List GmbH (Headquarters)

Digital Twins for Dependability Improvement of Autonomous Driving

EuroSPI, Edinburgh, Sept 18th- 20th, 2019

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Agenda

- Automotive market & trends
- Market transformation
- ICT & CPS in the Automotive domain
- Digital Twin roles for autonomous & connected vehicles
- Dependability engineering of intelligent systems

Automotive Market & Trends

Automotive Domain in Europe

- Production figures
  - 99 million motor vehicles produced worldwide
  - **19.6 million of vehicles** produced in Europe (20%)

- Economy figures (Europe)
  - **Jobs: 13.3 million people** – 6.1% of EU employed population
  - 11.3 % of EU manufacturing employment is in the automotive sector
  - Revenues for government (VAT, fuels, sales an registrations taxes): 413 billion €

- European automotive sector in the world
  - 5.8 million vehicles exported by EU
  - **Trade balance: 90 billion €**

Source: https://nocloudinthesky.wordpress.com/2013/01/25/alan-turing-car-production-and-machines/

The automotive industry – Pocket guide 2018-2019, Editor: European Automobile Manufacturers Association, available at http://www.acea.be/publications/archives/category/acea-pocket-guide

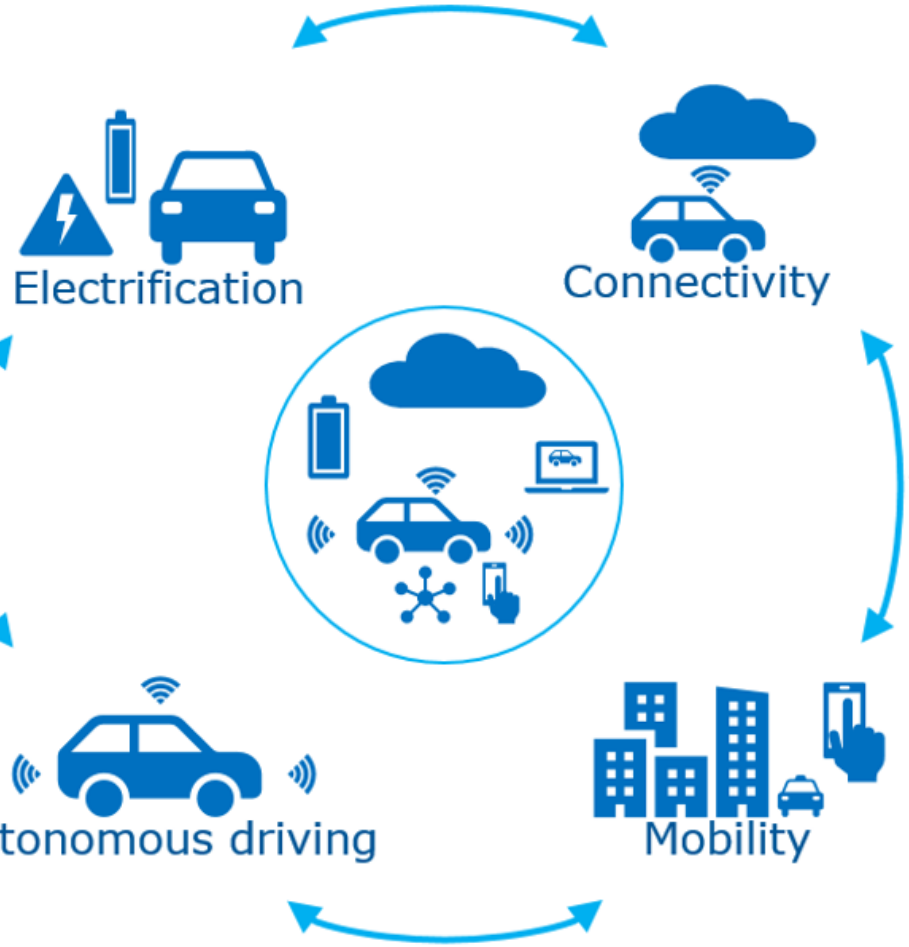
Trends in the Automotive Domain

- **CPS** → digitalisation
- **IoT** → connectivity
- **Data analytics and AI** → knowledge

Technology push:
ICT

Societal challenges:
Legislation

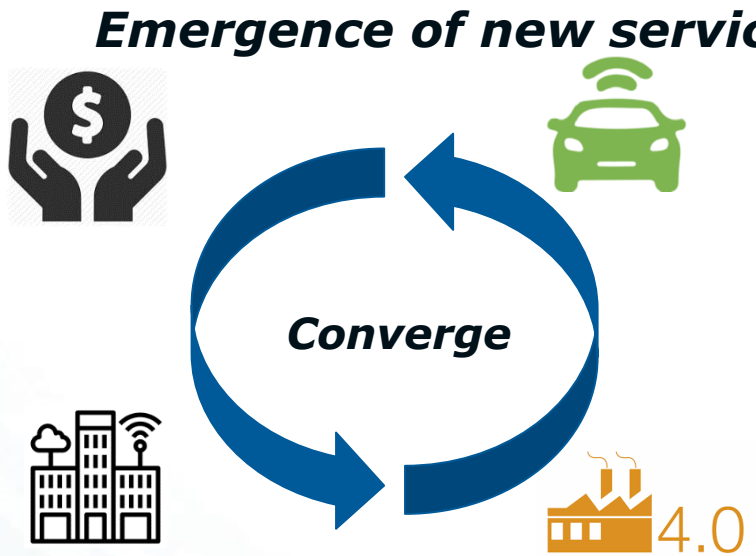
- **Reduced pollution**
- **Reduction of road fatalities**
- **Increased mobility**
- **Reduced congestion**



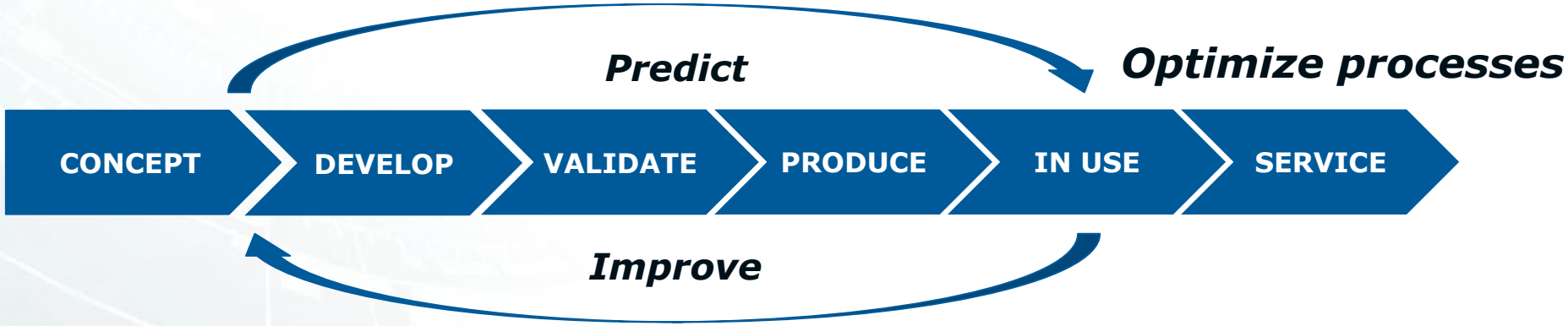
Market pull:
evolving consumer needs

- **Infotainment & connectivity**
- **Human-machine interaction**
- **Customisation**
- **Mobility as a service**

Opportunities for Value Creation



Digitalization as ***game changer*** to address grand societal challenges by ***removing the silos*** between the different application domains, over the supply chain and along the entire product lifecycle



Automotive Market Transformation

Prediction is very difficult – especially if it's about the future

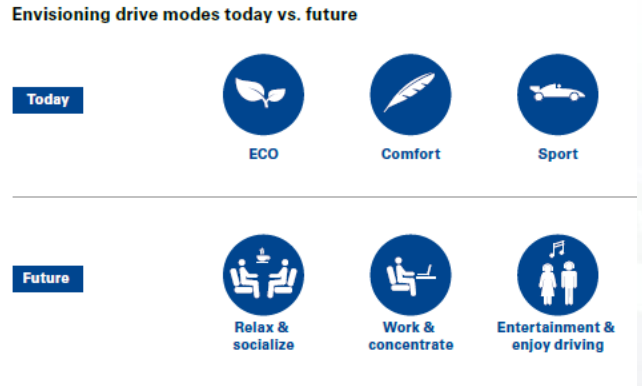
[Niels Bohr]

Market trends autonomous driving

1. Similarly, the **market evolution is very unpredictable**

2. Similarly, the technology path is not clear – it is expected that during maturation **several technologies will co-exist**

3. Autonomous driving tightly related to **innovation based on digitalization** and data-driven business models

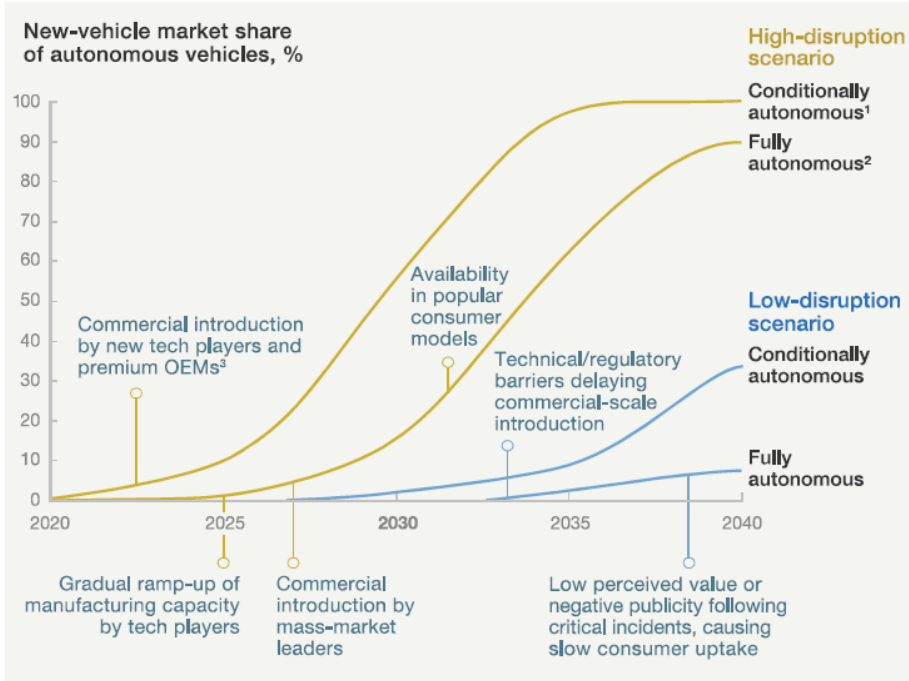


[KPMG, Global Executive Automotive Survey 2017]

Seung Hoon Wi
Asia Pacific Head of Automotive

"Driving out of focus: Autonomous driving will redefine the utility of vehicles and is the enabler for service- and data-driven business models."

How many new cars may be fully autonomous by 2030?



Factors in disruption scenarios	High disruption	Low disruption
Regulatory challenges	Fast	Gradual
Safe, reliable technical solutions	Comprehensive	Incomplete
Consumer acceptance, willingness to pay	Enthusiastic	Limited

[1]Conditionally autonomous car: the driver may take occasional control.
[2]Fully autonomous car: the vehicle is in full control.
[3]Original-equipment manufacturers.

McKinsey&Company

[McKinsey, Disruptive trends that will transform the auto industry]

Emergence of data market

85% of executives absolutely or partly agree that the **digital ecosystem will generate higher revenues** than the hardware of the car.

76% absolutely or partly agree that one **connected vehicle generates higher revenue** streams than 10 vehicles which are not connected.

[KPMG, Global Executive Automotive Survey 2017]

[McKinsey, Monetizing Car Data]

Emergence of data market

"Car-generated data may become a USD 450 - 750 billion market by 2030"

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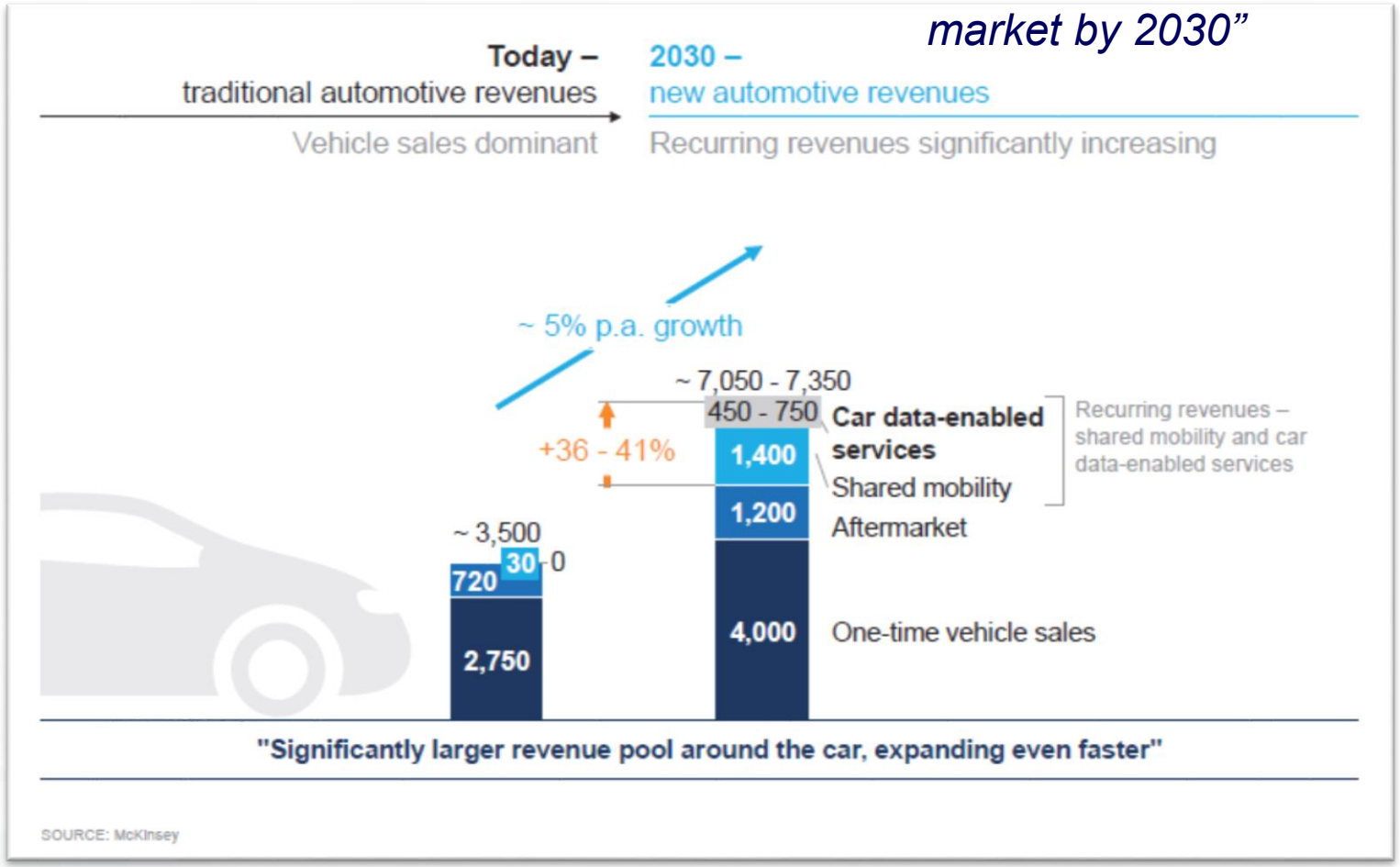

[KPMG, Global Executive Automotive Survey 2017]

[McKinsey, Monetizing Car Data]

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SOURCE: McKinsey

Car data ecosystem

In-car technologies

Infrastructures

Back-end processes

Where is the value creation located?
What is the impact on market organization?

SOURCE: McKinsey

[KPMG, Global Executive Automotive Survey 2017]

[McKinsey, Monetizing Car Data]

IOT4CPS – Factsheet

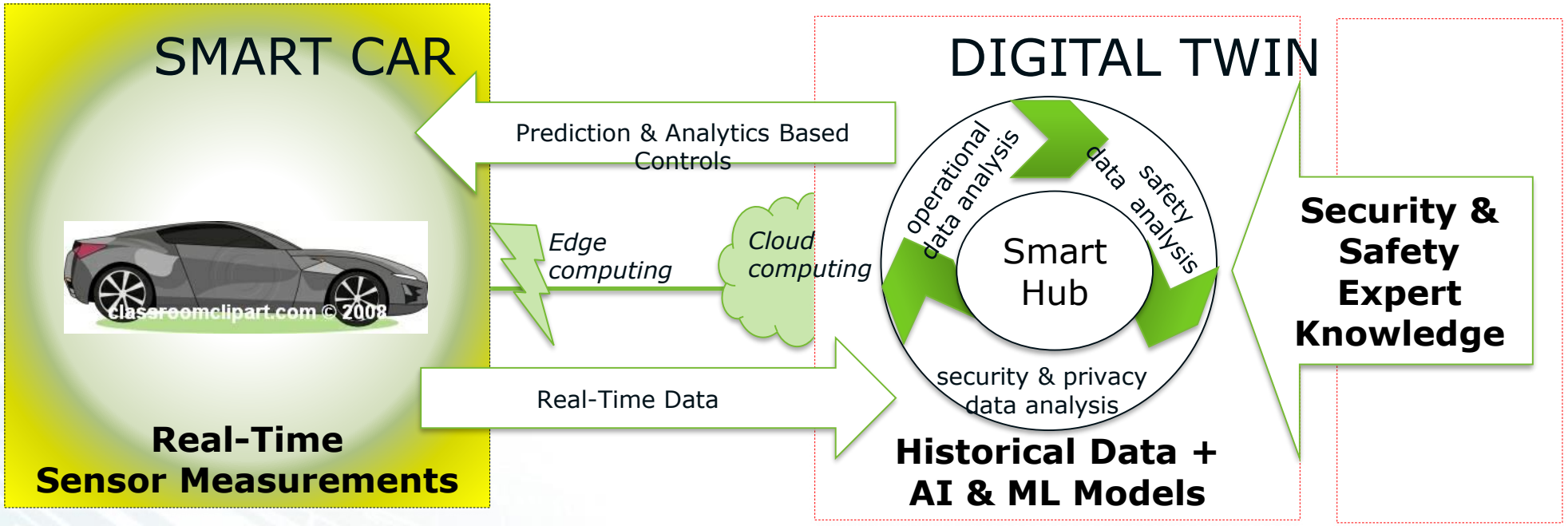
- **Full title: "***Trustworthy IOT for CPS"*
- **Austrian Flagship Project** on „Internet of Things - Safe, Secure and Usable"
- >5 Mio. € overall budget, 3 Mio. € public funding
- **Project duration** from Dec. 2017 – Nov. 2020 (36 month)
- **16 Austrian project partners**
- **Coordinator**: AIT
- **Link:** https://iot4cps.at/

- Consortium of **industry partners** covering the major aspects of the **CPS value chain**
  - Semiconductors
  - Control systems
  - Applications – automotive, production
  - Infrastructure, connectivity
- Consortium of **scientific partners** covering the **key technology innovations**

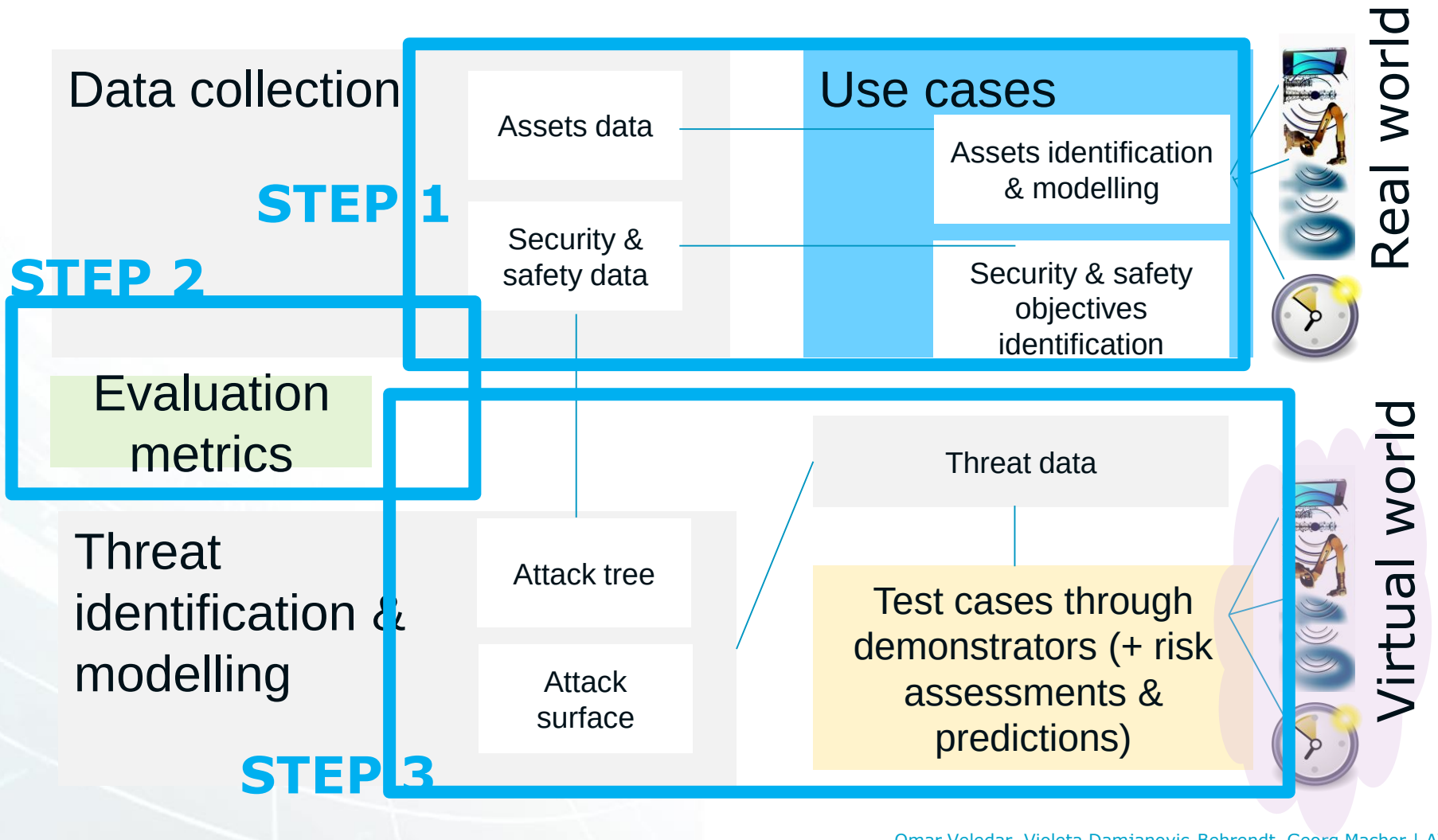
Partially funded by the "ICT of the Future" Program of the Austrian Research Promotion Agency (FFG) and the Austrian Ministry for Transport, Innovation and Technology (BMVIT)

Digital Twin Roles for Autonomous & Connected Vehicles

The Use Case: Autonomous Driving



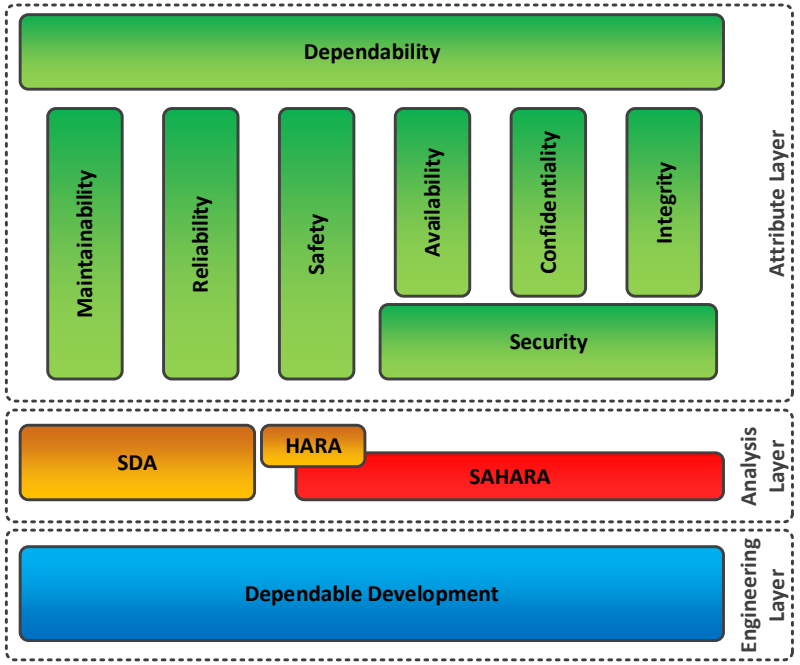
Design & Implementation Methodology for Automotive Security & Safety Validation Using the Digital Twin concept



Dependability Engineering of Intelligent Systems

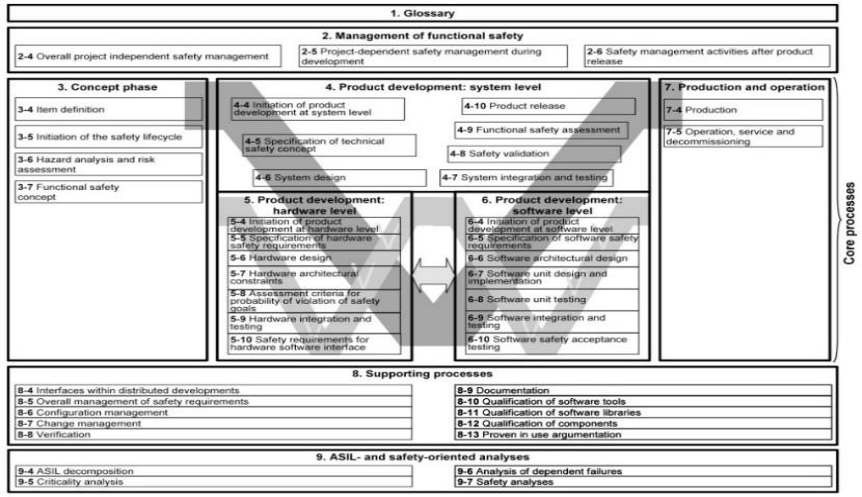
Dependable Development

- Dependability features are **system-wide features** with mutual impacts and interdisciplinary values
- Dependability attributes have **major impact on product and company brand reputation** (either show stopper or unique selling point)
- Individual system components have variegating impact on system dependability
- High importance to identify these impacts in early development phase (**front loading**)

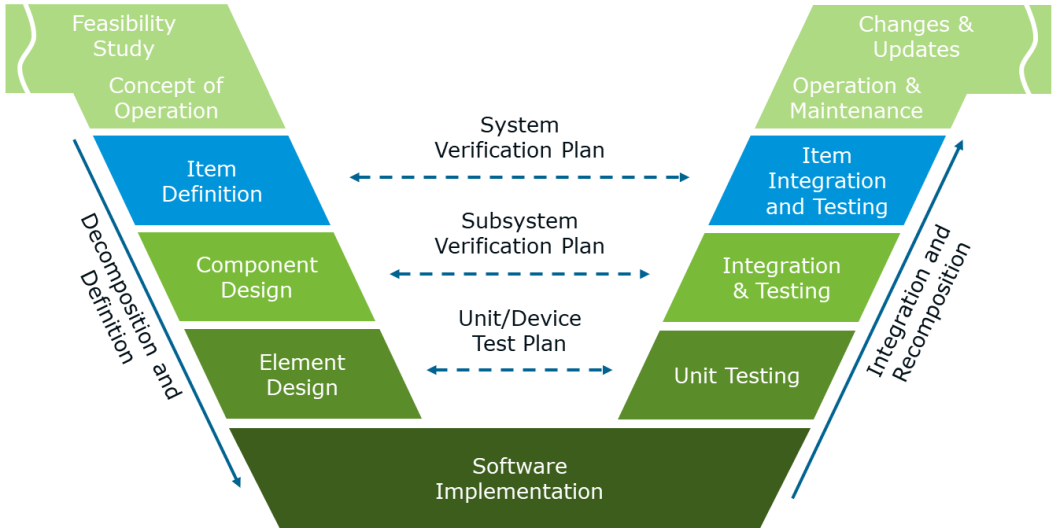


Integration of Environmental Information

- Currently **static automotive E/E Architectures**
- ISO 26262 **safety measures** must be established **at development time**
- **Currently very limited run-time/ adaptive dependability assurance approach**
- Integration of external information rarely done for mission-critical functionalities
- AUTOSAR Adaptive Platform – SoA approach for future usage for ADF and ADAS in development



© ISO 26262



New Challenges and Research Approaches

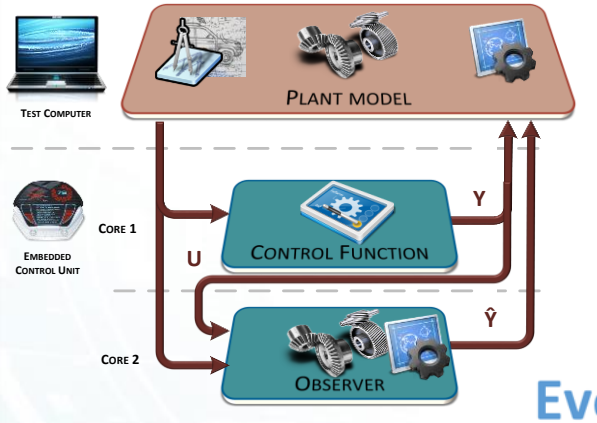
Resilience in Industrial Settings (IIoT)

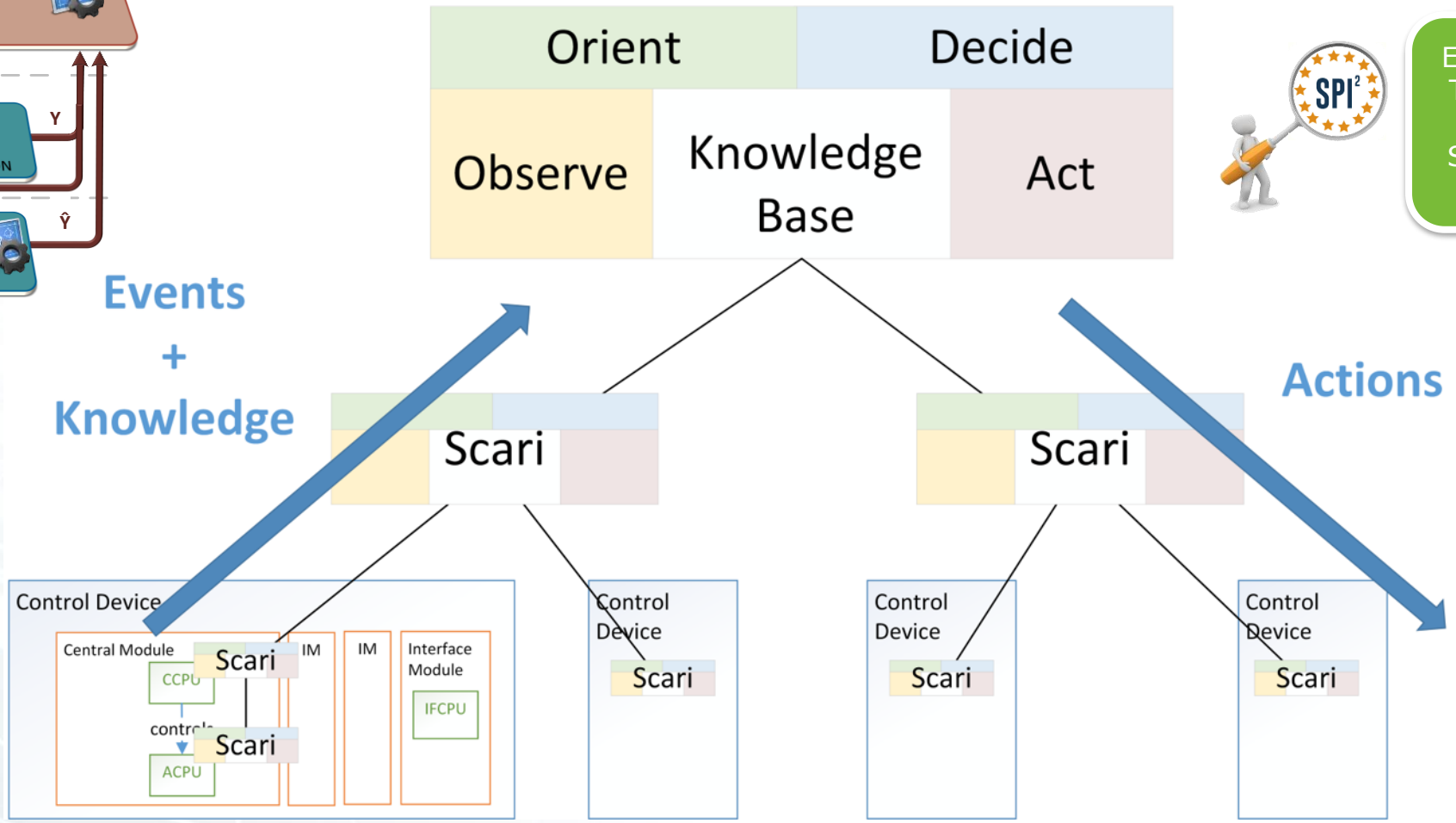
- Self-Adaptive Systems – e.g. SCARI
- Secure and Reliable Infrastructure

Safety & Security in Dependable Systems

- Risk Management Processes
- Uncertainty & Risk Propagation
- Executable Dependability Properties

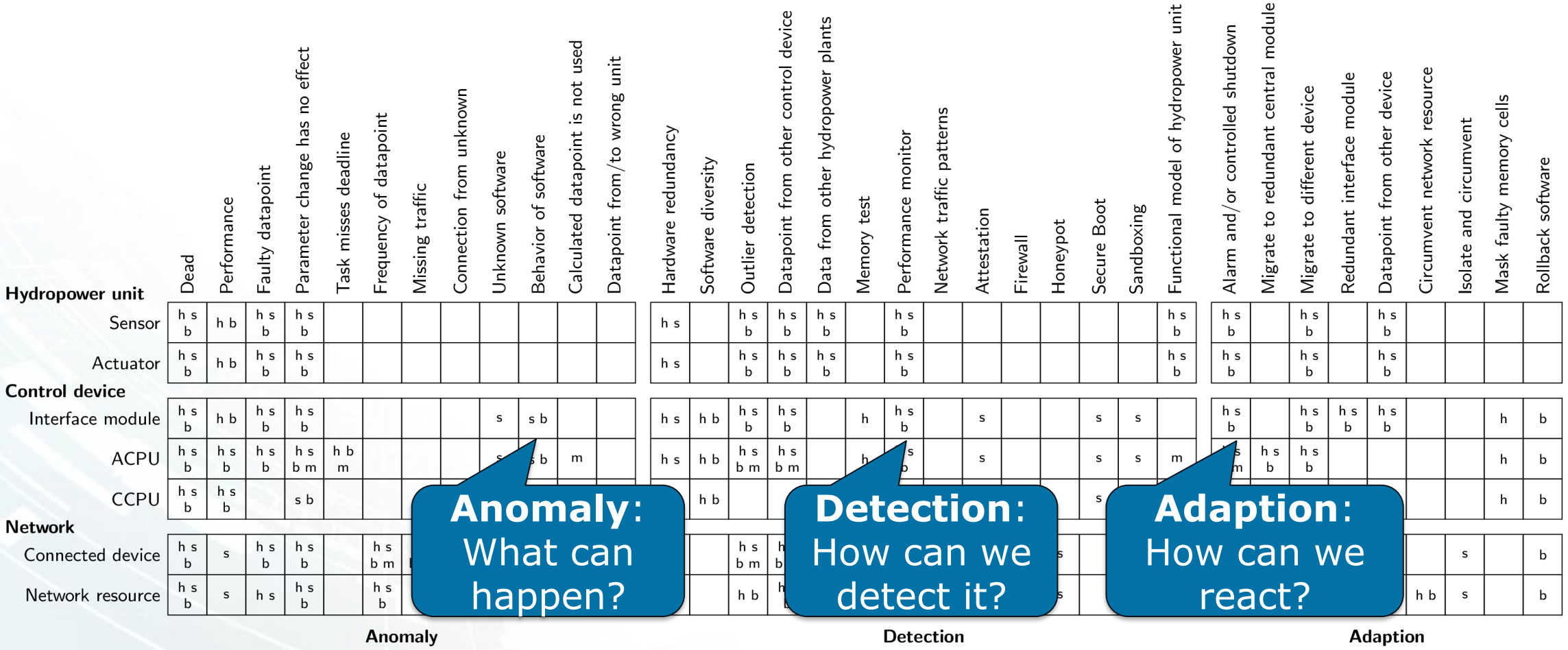
SCARI Multi-Layer for SCADA Systems





EuroSPI17: Iber et al. The Potential of Self-Adaptive Software Systems in Industrial Control Systems

Resilience Architecture



h = hardware fault, s = security attack, b = bug, m = misconfiguration

New Challenges and Research Approaches

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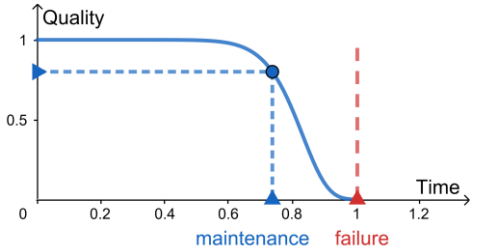
EuroSPI19: Krisper et al. RISKEE – A Risk-Tree Method for Cyber-Security Analysis

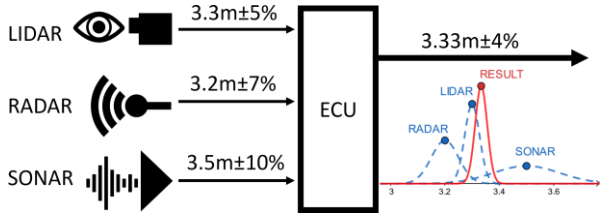
EuroSPI19: Interactive WS Gamification about Expert Judgement

Uncertainty Propagation in IoT

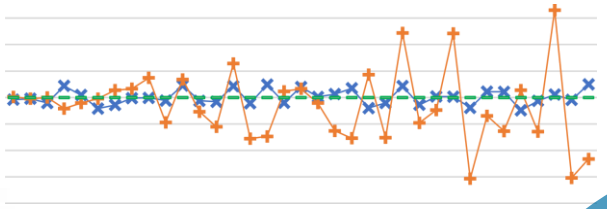
Predictive Maintenance

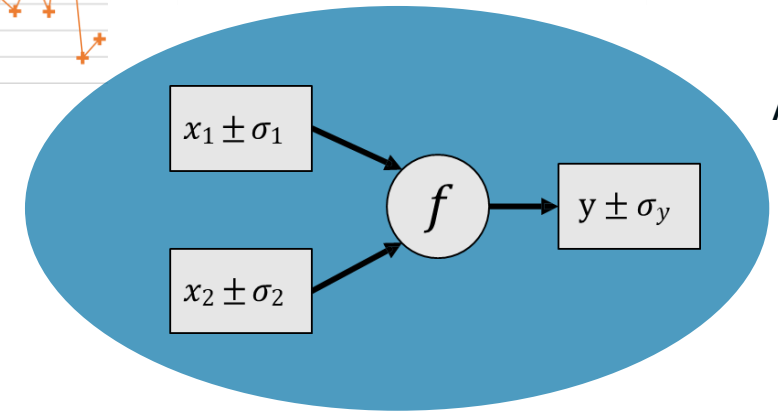


Sensor Fusion

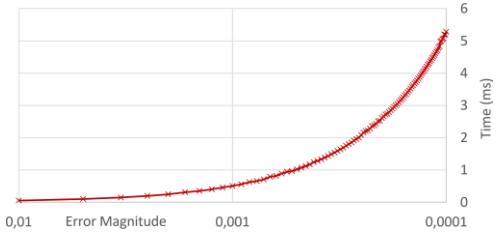


Quality Evaluation



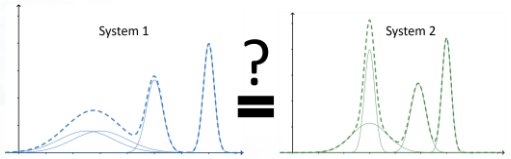


Approximate Computing

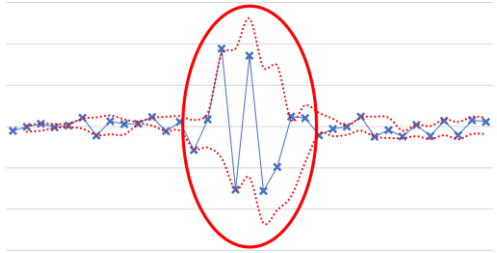


Graceful Degradation

Sensor Fingerprinting



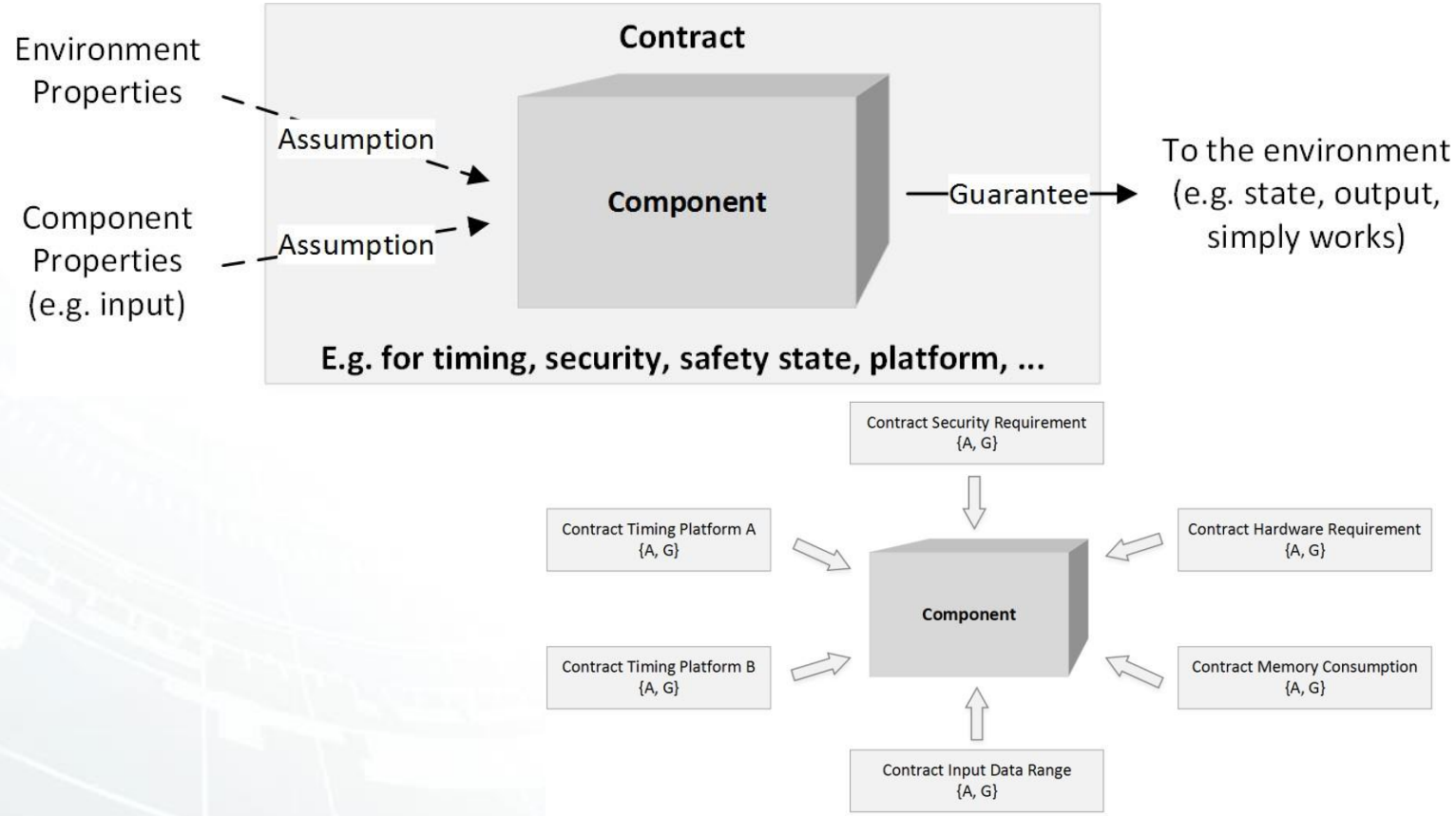
Fault Detection



EuroSPI18: Krisper et al. Use-Cases for Uncertainty Propagation in Distributed Control Systems

Contract-Based Development Approaches

Contract-Based Design



Digital Dependability Identity (DDI) Concept

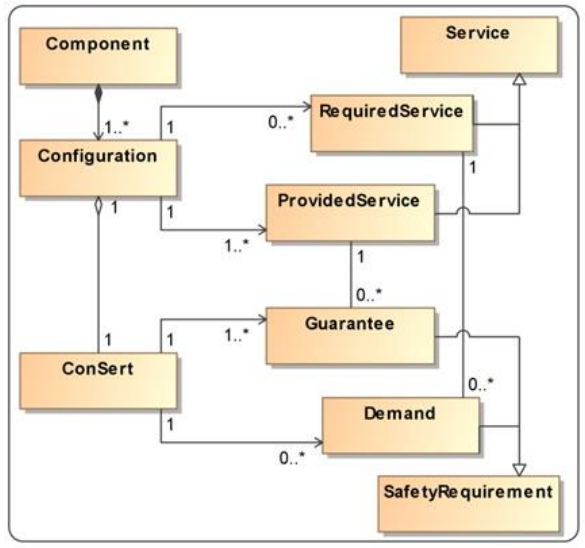
DDI – data that uniquely describe a thing and contains information about the subjects relation

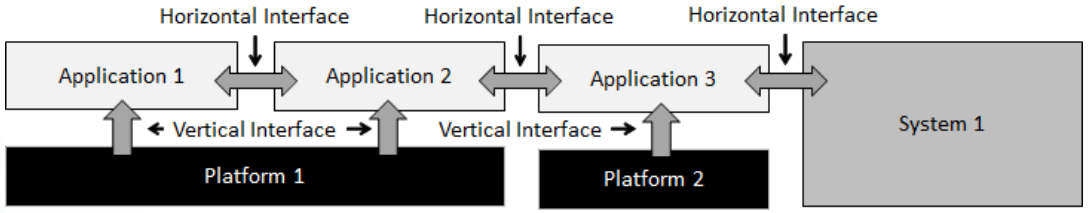
DDI – an executable specification

Meta-information produced during design and maintained over lifetime

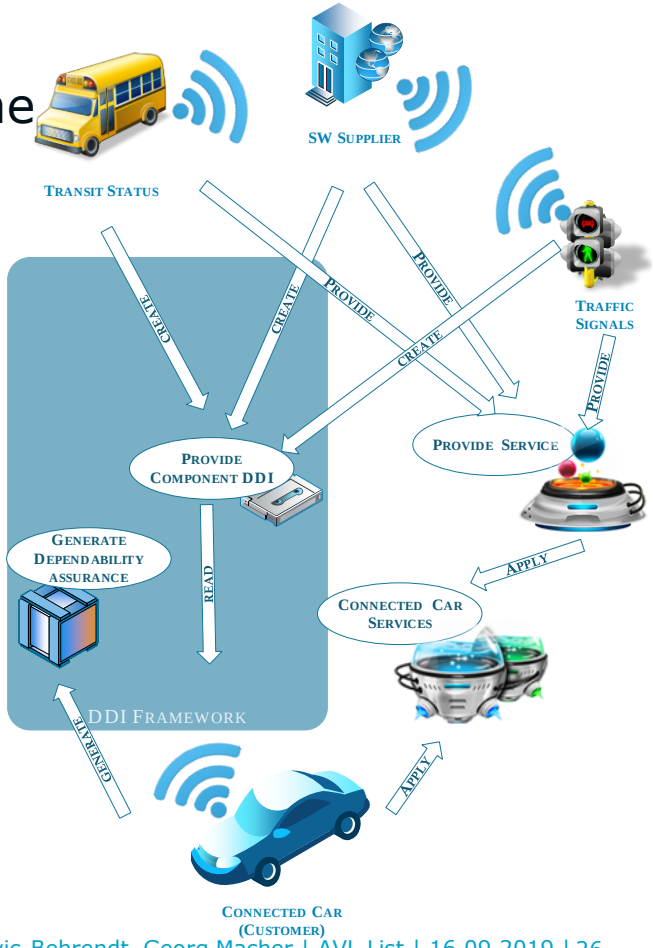
Concept for dynamic integration and evaluation of services

DDI base on and extend ConSerts M approach



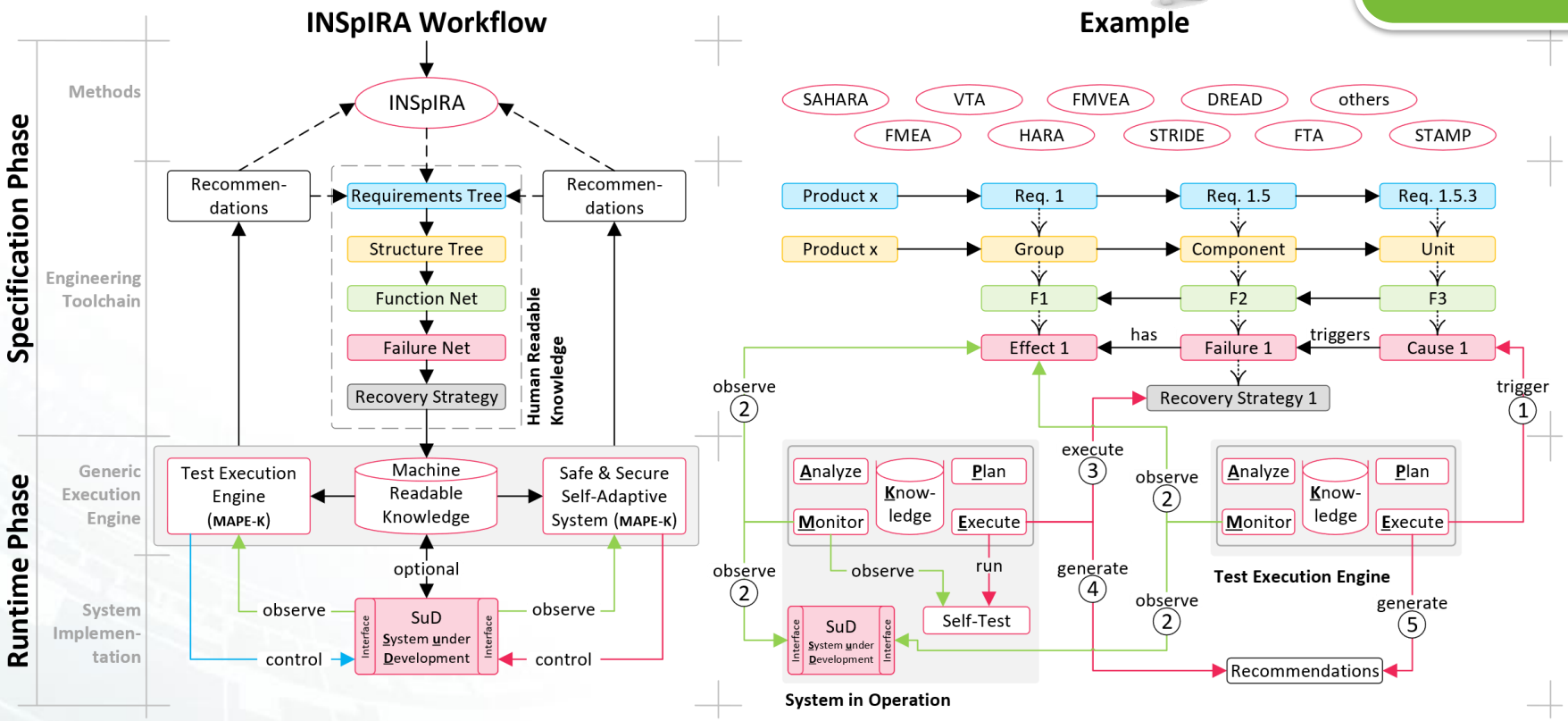


EuroSPI17: Macher et al. Towards Engineering of Cooperative Automotive Cyber-Physical Systems



INSpIRA: Integrating Security Into Risk Assessment

EuroSPI18: Dobaj et al. Towards Executable Dependability Properties



Summary

- **Digitalization is a game changer**
- Connected car features and Industry 4.0 approaches pose **dynamic integration needs**
- **Integration of external information** is needed to be done for mission-critical functionalities
- Show-stopper: **run-time / adaptive dependability assurance** approach
- safety and security aspects need to be considered in a holistic manner
- IoT4CPS: **making use of virtualization through digital twins** of complex systems
- Digital twin is **applied during the development process and refined at runtime operation**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