ITEA Technology webinar

Cyber-Physical-Metaverse
and why it matters to you

18 July 2025, Online

ITEA4

ITEA 4 is the Eureka Cluster on software innovation

Σ

What is this webinar about?

- Imagine
  - Unlimited edge device resources even for embedded systems
  - Reliable interaction between virtual and real world for humans and machines
  - ….

➔ **<u>This will likely affect your products and business model!</u>**

➔ This webinar will introduce you to the general CPM concept and first examples will be provided

➔ Future webinars will go into more details depending on your interest

This webinar is co-organised by:

Agenda

- Meet the team

- Introduction into Cyber Physical Metaverse

- Use-case Bosch:
  Reliable Distributed Systems – Technological Backbone for the Cyber-Physical-Metaverse

- Use-case Siemens:
  Using Web Technologies to Connect the Real to the Digital World

- Q&A (RD&I demand, topics for next webinars…)

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ITEA Technology webinar on Cyber-Physical-Metaverse

Meet the team

Meet the team

Dirk Elias
ITEA Chairman

Dirk Ziegenbein
Chief Expert for
cyber-physical systems
engineering
at Bosch

Arne Hamann
Chief Expert for
Distributed Intelligent
Systems
at Bosch
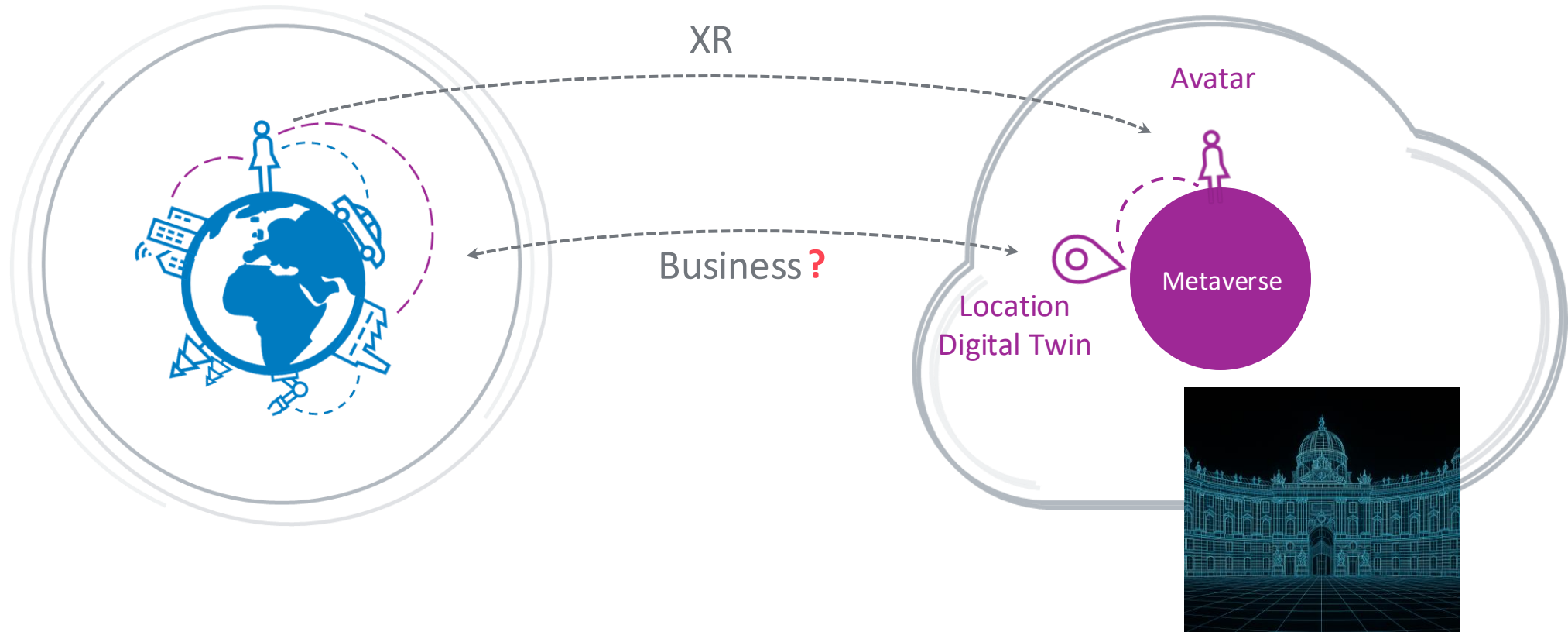
Dominik Tacke
Principal
Key Expert
at Siemens

Sebastian Käbisch
Principal
Key Expert
at Siemens

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Introduction into the Cyber Physical Metaverse

18 July, Online
Dirk Elias - ITEA Chairman

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The Metaverse…
…today's mainstream

XR

Avatar

Business **?**

Location
Digital Twin

Metaverse

Is that enough?

This webinar is co-organised by: **BOSCH** **SIEMENS**

Supersonic change in ICT and the software domain

- Generative AI
- 6G (Joint Communication and Sensing, Edge Processing…)
- Quantum Computing

➜ Each domain standalone with most impressive advances

What's up next?

Imagine bringing it all together…

➔ Ubiquitous and economic access
for any machine to unlimited performance

Imagine reliable real time access...

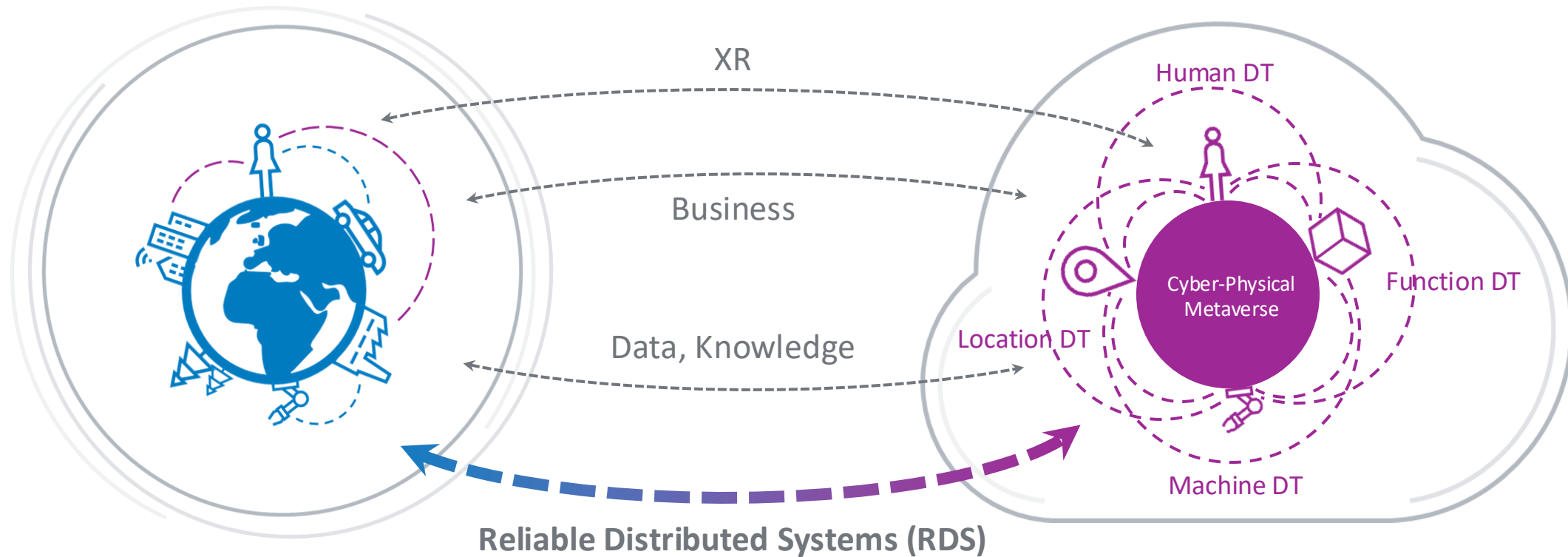➔ Distributed and efficient systems for all kinds of applications

The Metaverse…
…tomorrow

XR

Business

Data, Knowledge

Human DT

Function DT

Cyber-Physical Metaverse

Location DT

Machine DT

Reliable Distributed Systems (RDS)

The Cyber Physical Metaverse!

This webinar is co-organised by: BOSCH SIEMENS

Elements of the Cyber Physical Metaverse

Cloud & XR enable mainstream Metaverse

RDS reliably links physical and virtual worlds

Actionable Digital Twin as API to Cyber Physical Systems (CPS)

Function (SW Service) Digital Twins improve CPS functionality

Cyber-Physical Metaverse is full of business opportunities

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Supersonic change in ICT and the software domain
Mind Ray Kurzweil!

https://alphafold.ebi.ac.uk/

https://en.wikipedia.org/wiki/Ray_Kurzweil

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Reliable Distributed Systems - Technological Backbone for the Cyber-Physical-Metaverse

Arne Hamann, Dirk Ziegenbein
Bosch Research

Public C-SC0

Supported by:
Federal Ministry for Economic Affairs and Climate Action

Funded by the European Union
NextGenerationEU

on the basis of a decision by the German Bundestag

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Reliable Distributed Systems
Impact of cloud in different industries

Industry	Classic	Cloud	Key enabler
Music			Bandwidth
Film			Bandwidth
Navigation			Wireless Coverage
Gaming			Latency

Improving cloud capabilities have already moved applications to cloud

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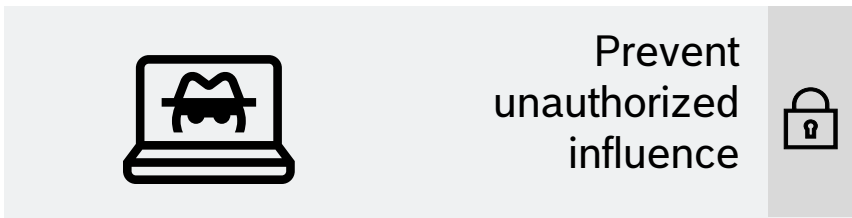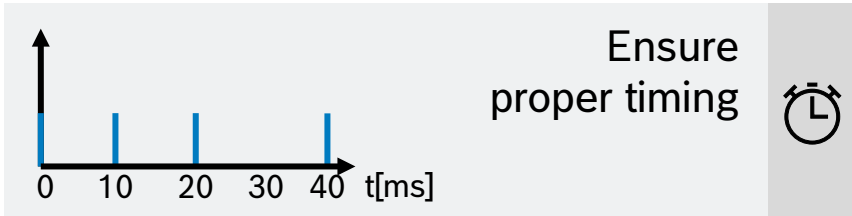# Reliable Distributed Systems
Setting the scene

Distributed Systems
enable

functionality on **off-the-shelf distributed infrastructure** (HW&SW) across all industries

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Reliable Distributed Systems
Setting the scene

Ensure proper timing

Ensure proper operation in case of failure

RISK ASSESSMENT — ISO 26262 21448 — Risk = Severity x Frequency x Controllability — S E C — ASIL

Prevent unauthorized influence

Reliable Distributed Systems enable

🕐 **real-time**,
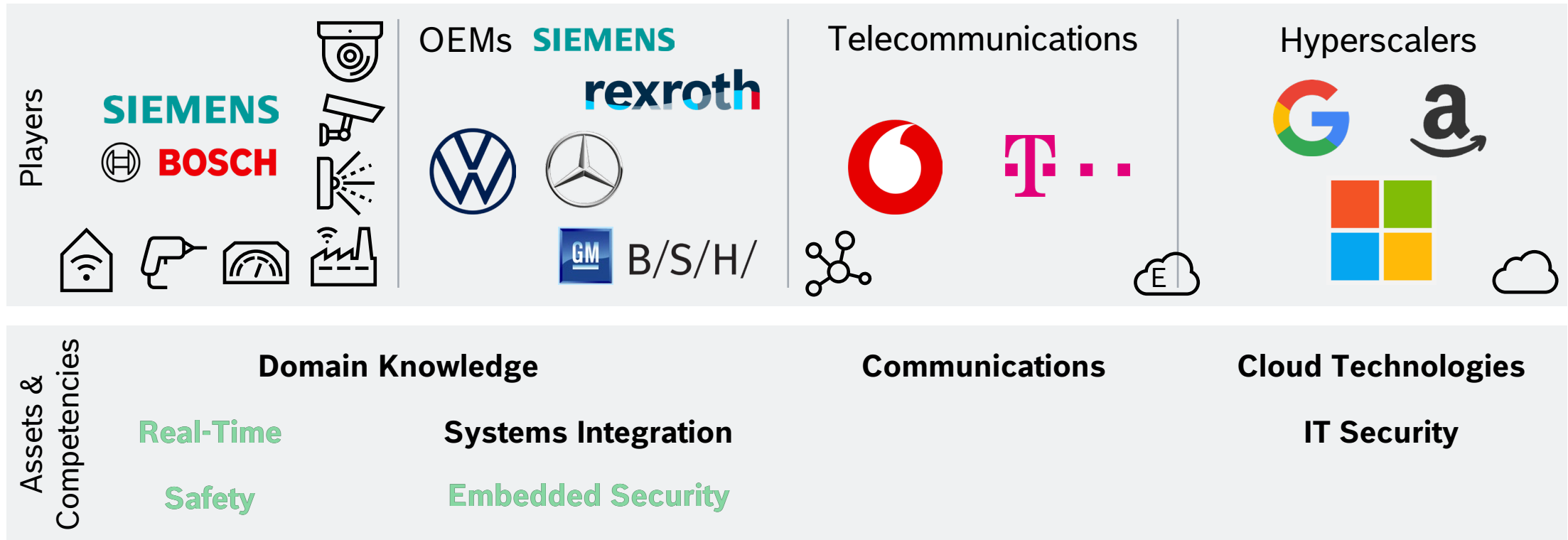
🛡 **safety-critical**, and

🔒 **secure**

functionality on **off-the-shelf distributed infrastructure** (HW&SW) across all industries

RDS

ISO26268: Functional Safety; ISO/PAS21448: SOTIF (Safety of the Intended Function)

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Reliable Distributed Systems
Nobody can build RDS alone – many competencies are needed

Players

OEMs SIEMENS rexroth

Telecommunications

Hyperscalers

Assets & Competencies

Domain Knowledge

Communications

Cloud Technologies

Real-Time

Systems Integration

IT Security

Safety

Embedded Security

▶ RDS can only be built through partnerships

Reliable Distributed Systems
Nobody can build RDS alone – many competencies are needed

RDS Applications

RDS Platform

Domain Knowledge   **IT Security**

Embedded Security   **Real-Time**   **Safety**

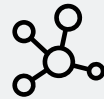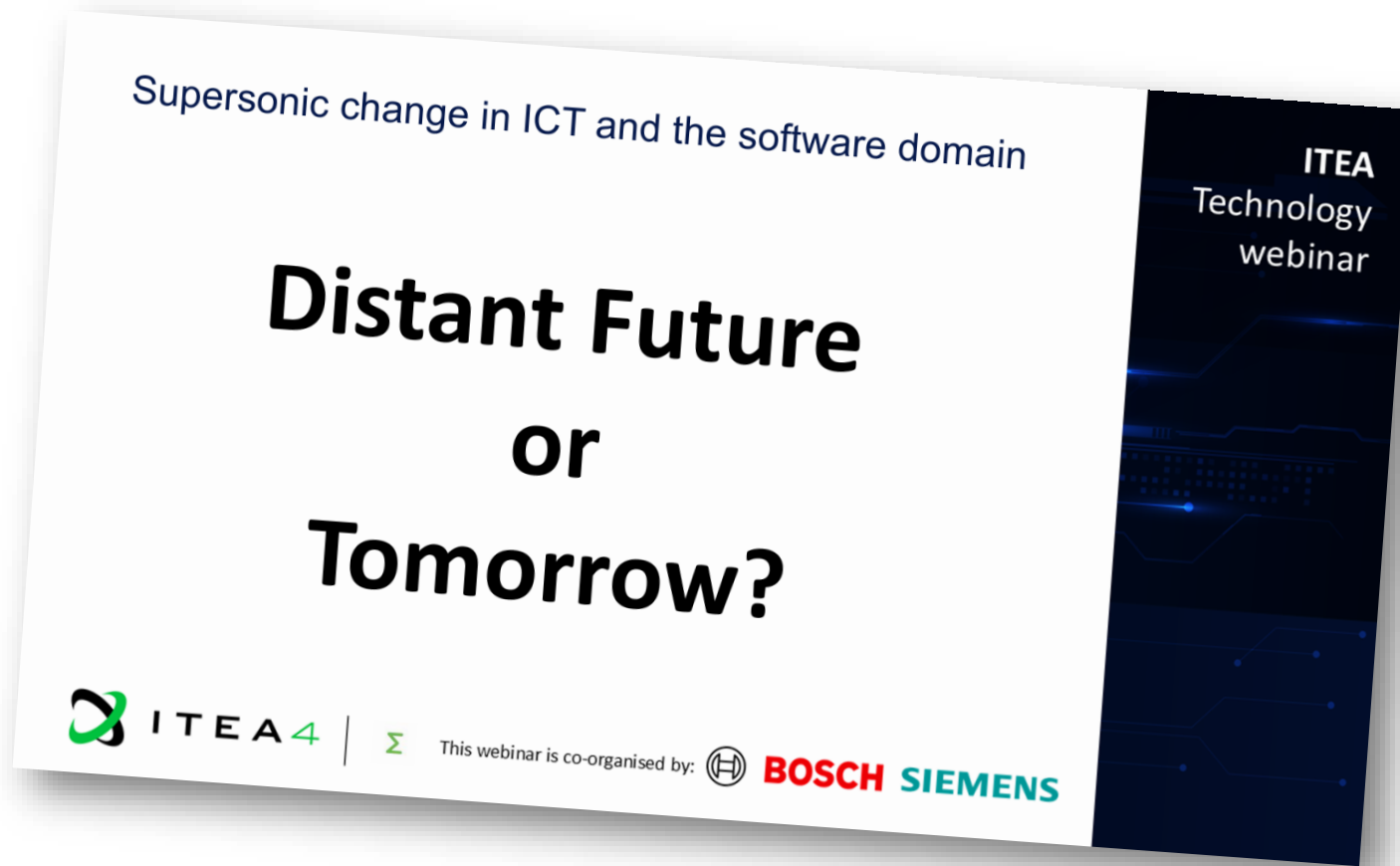**Systems Integration**   **Communications**   **Cloud Technologies**

Devices & Sensors

Comm

Edge

Cloud

▶ An integrated RDS technology stack enables standards and broad usage, CPS competencies remain key

Reliable Distributed Systems

> ▶ **NOW!** At least for RDS…

# Reliable Distributed Systems
Why now?

Demand & Use Cases

Offboarding Intelligence

Infrastructure-Based AD

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Use Case: Offboarding Intelligence

- Shift intelligence from device to cloud
  - Cheaper devices
  - Easier upgrades
  - Less power consumption
  - More sustainable

- Enable additional functional advantages
 - Fleet learning
  - Remote trouble shooting

Perception, SLAM, …

Sensing, Status

Control

Example: Cloud Robotics

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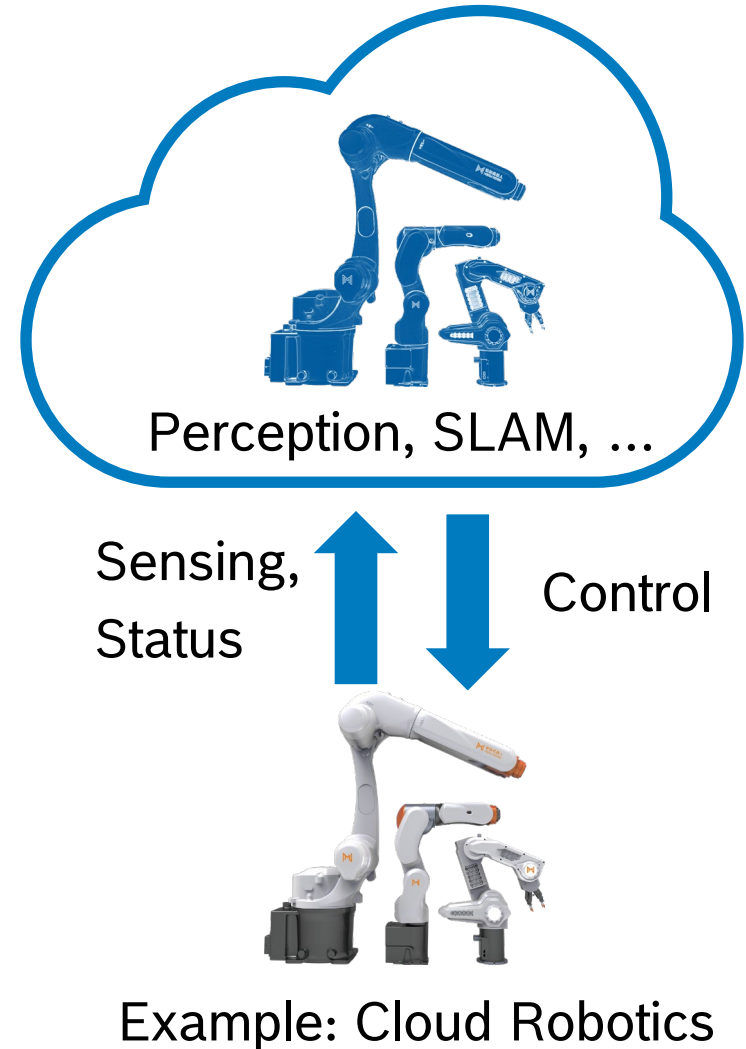
Use Case: Offboarding Intelligence
The energy angle…

Highly-Automated Vehicles Have Power Hungry Computers

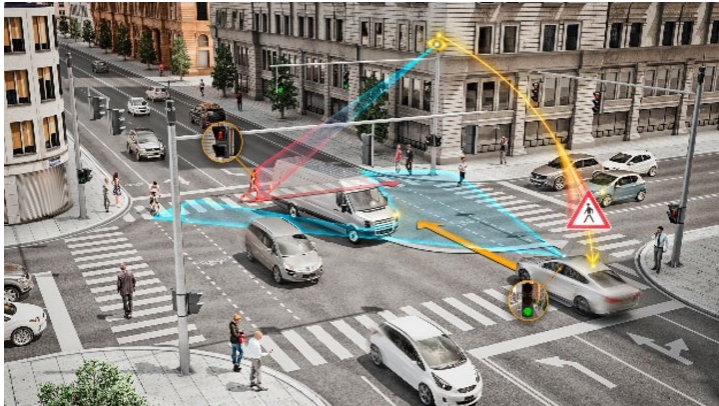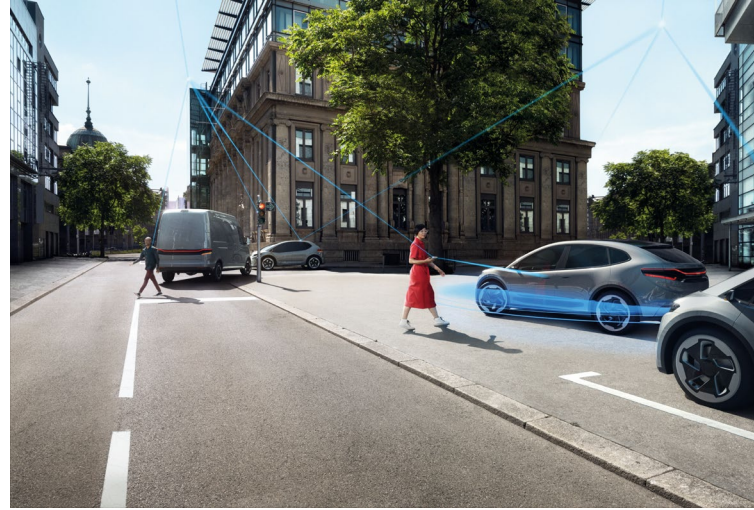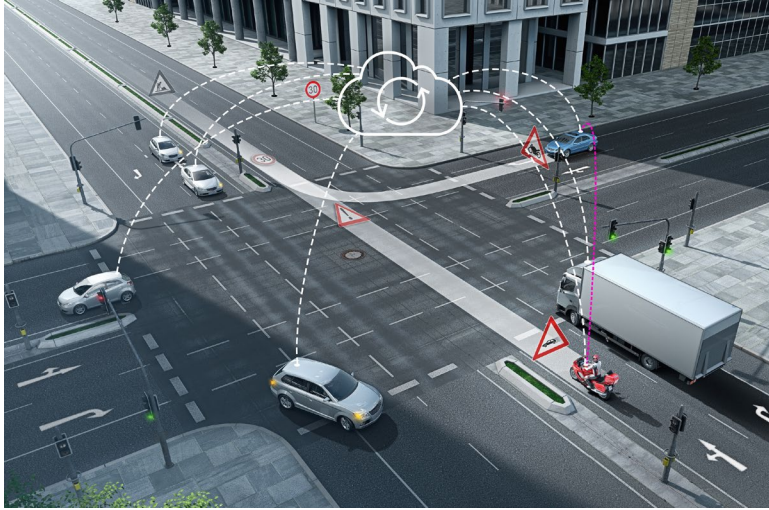Estimate of vehicle-level energy use of different computing loads

■ Computer power consumption ■ Drivetrain power consumption

L2 driver-assist   L3 driver-assist   L4 driverless
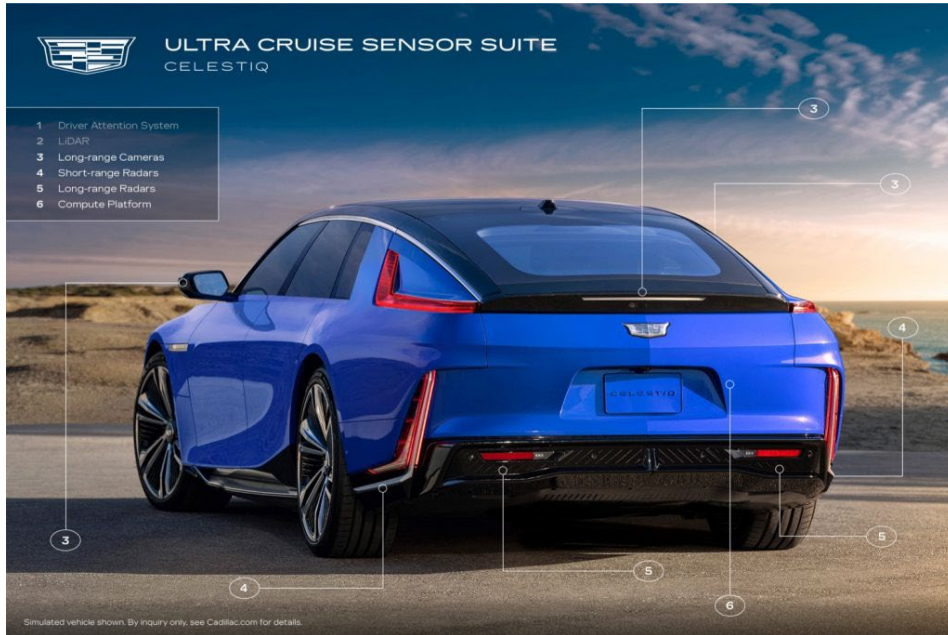
100 %

50

0
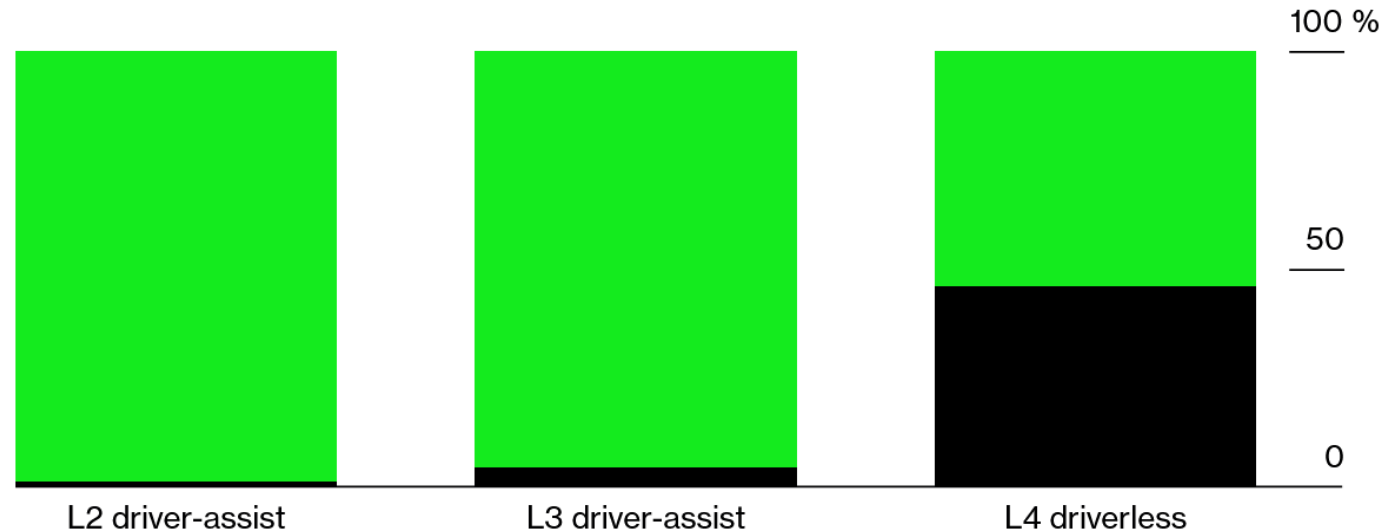
Source: BloombergNEF

For Robotaxis: automation compute uses almost as much energy as driving

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Use Case: Infrastructure-Based Driving

Source: Continental

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Use Case: Infrastructure-Based Driving

Source: GM

7 long-range cameras, 4 short-range and 3 long-range radars,
1 LiDAR, high-performance onboard compute for L2+ system…

… not being used on average 23h per day.

Infrastructure-Based Driving will democratize Automated Mobility

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Reliable Distributed Systems
Why now?

Demand & Use Cases

Offboarding Intelligence

Infrastructure-Based AD

Funding

Large Government Programs
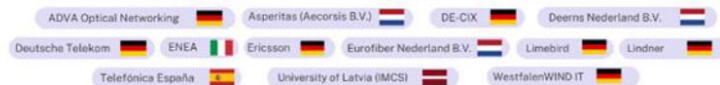e.g., IPCEI-CIS in Europe

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Next Generation Cloud Infrastructure and Services (IPCEI CIS)
European Publicly Funded Project

- Develop an interoperable European multi-provider cloud-edge continuum

8ra CLOUD·EDGE CONTINUUM

- "Will allow for real-time and low-latency (i.e., a few milliseconds) services by distributed computing resources"

- Facts & Figures
  - ~100 participants from 12 EU member states
  - Up to 1.2 billion EUR funding
  - Up to 1.4 billion EUR private investment
  - started 2023
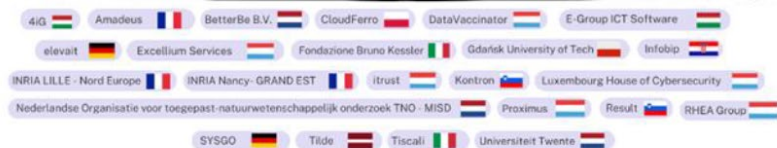 - first industrial deployments in 2027

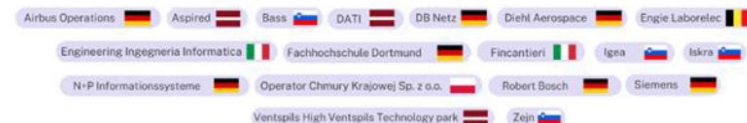**Workstream 1 - Cloud-Edge Continuum Infrastructure**

ADVA Optical Networking | Asperitas (Aecorsis B.V.) | DE-CIX | Deerns Nederland B.V.
Deutsche Telekom | ENEA | Ericsson | Eurofiber Nederland B.V. | Limebird | Lindner
Telefónica España | University of Latvia (IMCSI) | WestfalenWIND IT

Workstream 2 - Cloud-Edge Capabilities

Amiral Technologies | Amsterdam Internet Exchange B.V. | Armadillo | Arsys Internet | Atende Industries
Atos | BIT B.V. | CGI France | CNRS IRISA | CNRS LAAS | CNRS UGA ERODS
CNRS IRIT SEPIA | Hashnet | i3d.net B.V. | Info Support B.V. | Institut Imagine | Ionos
Lacroix Sofrel | Lacroix Electronics Cesson | Leaseweb Global B.V.
Nederlandse Organisatie voor toegepast-natuurwetenschappelijk onderzoek TNO - ECOFED | Ningaloo | No Blue Screen System
Oktawave Spółka Akcyjna | OpenNebula Systems | Orange | Phoenix Systems | Pro-bit
Provenrun | Reply | Rheinmetall Technology | SAP | Secunet Security Networks
Stichting Nationale Beheersorganisatie Internet Providers | Telemach | ThreeFold | TIM | Universite Bretagne Sud
Universite Caen Basse Normandie | Universite de Lille | Universite de Versailles Saind-Quentin-en-Yvelines

Workstream 3 - Advanced smart data processing tools and services

4iG | Amadeus | BetterBe B.V. | CloudFerro | DataVaccinator | E-Group ICT Software
elevait | Excellium Services | Fondazione Bruno Kessler | Gdańsk University of Tech | Infobip
INRIA LILLE - Nord Europe | INRIA Nancy- GRAND EST | itrust | Kontron | Luxembourg House of Cybersecurity
Nederlandse Organisatie voor toegepast-natuurwetenschappelijk onderzoek TNO - MISD | Proximus | Result | RHEA Group
SYSGO | Tilde | Tiscali | Universiteit Twente

Workstream 4 - Advanced Applications

Airbus Operations | Aspired | Bass | DATI | DB Netz | Diehl Aerospace | Engie Laborelec
Engineering Ingegneria Informatica | Fachhochschule Dortmund | Fincantieri | Igea | Iskra
N+P Informationssysteme | Operator Chmury Krajowej Sp. z o.o. | Robert Bosch | Siemens
Ventspils High Ventspils Technology park | Zejn

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Reliable Distributed Systems
Why now?

🏭	**Demand & Use Cases**	Offboarding Intelligence Infrastructure-Based AD
💵	**Funding**	Large Government Programs e.g., IPCEI-CIS in Europe
🖥️	**Technology**	Steady Improvements in Bandwidth, Coverage, Latency

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Technology Enablers
Predictable Low Latency

Increased Comm Performance & Isolation

Source: intel

On-Chip Performance Isolation

Network APIs to control Quality on Demand

Source: vodafone

Telco Edge Clouds

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Reliable Distributed Systems
Challenge: Design Implications

Develop independent of deployment scenario

Specify application & generate deployment

E2E Performance

Application Level

Sensors

Actuators

Execution Time

Memory Bandwidth

Resource Level

Elasticity

Failure Rate

Transmission Time
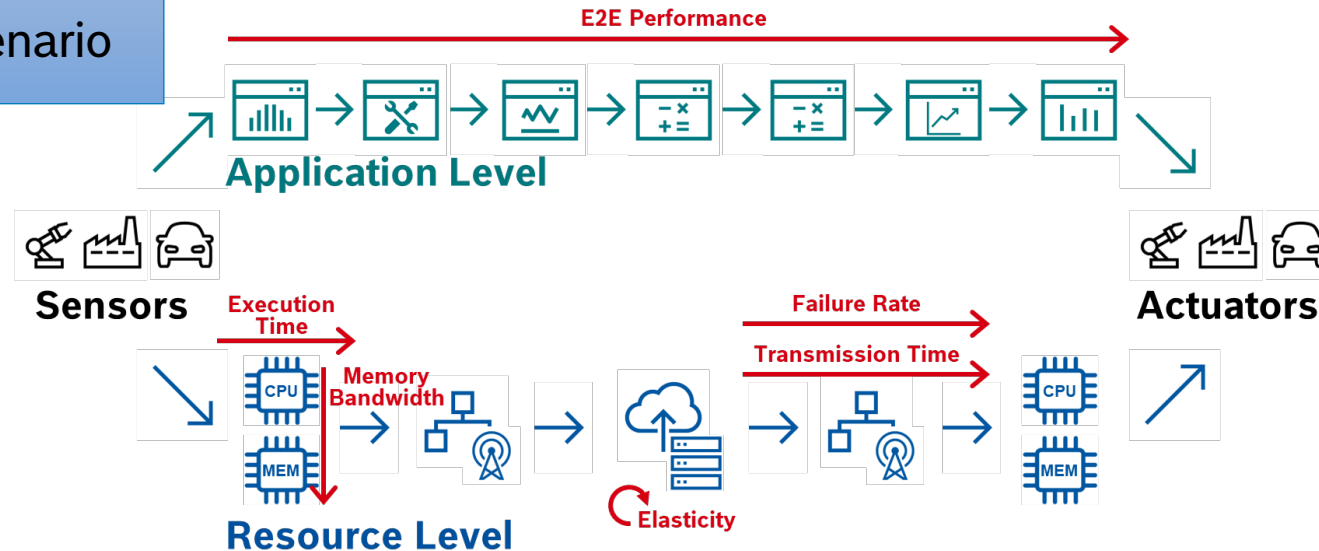
Platform mechanisms for controlling RT behavior

Monitor & adapt platform management

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Reliable Distributed Systems
Challenge: Modern control methods to handle RT uncertainties

Strategy 2: "Be adaptive"

Strategy 1: "Be robust"
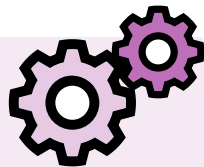
Only at the actuator, the real amount of delay is known!

Multi-mode control
→ *compute multiple control modes designed for different delays*

Smart Actuator: add a little intelligence at the actuator level
→ *applies the right control mode at the right time to the plant*

Smart Actuator → Plant → Sensor

Controller
Remote node
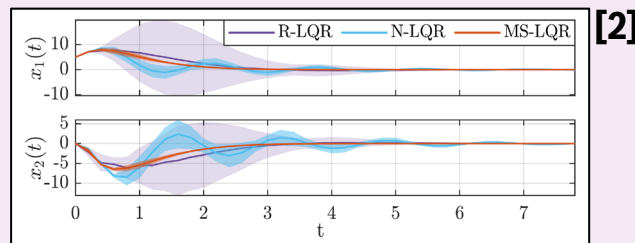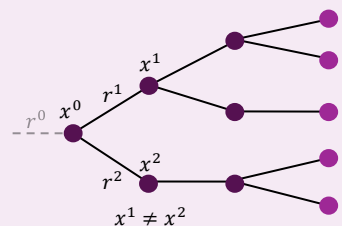
Compensate upstream delays by moving horizon Kalman filtering

→ estimation techniques

However, compute & downstream delays happen after the control was chosen!

→ timing aware **predictive** control with stochastic methods

[2]

$t - \tau_1$

estimation

t

prediction

$t + \tau_2 + \tau_3$

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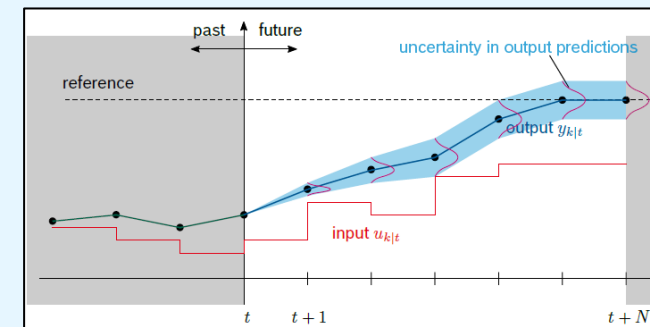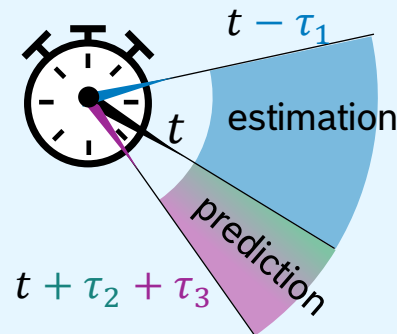
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Siemens use case

18 July, Online
Dominik Tacke, Principal Key Expert at Siemens
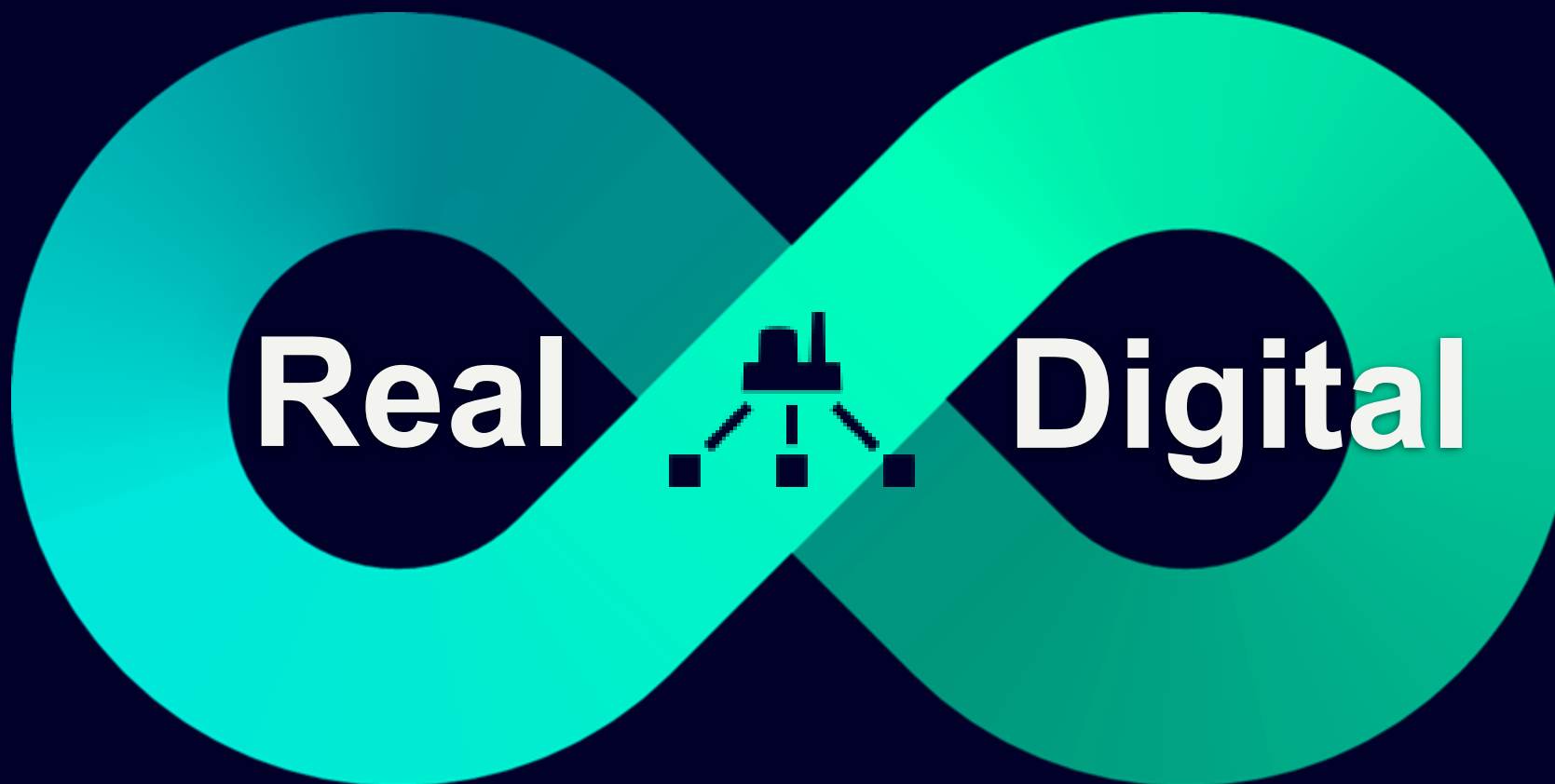Sebastian Käbisch, Principal Key Expert at Siemens

ITEA 4 is the Eureka Cluster on software innovation

Using Web Technologies to Connect the Real to the Digital World

Dominik Tacke, Sebastian Käbisch | Siemens AG

ITEA – Webinar: Cyber-physical Metaverse, 18. July 2025

SIEMENS

Smart field devices
At the intersection between the real and digital world

Field devices are bridging the worlds

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Way forward
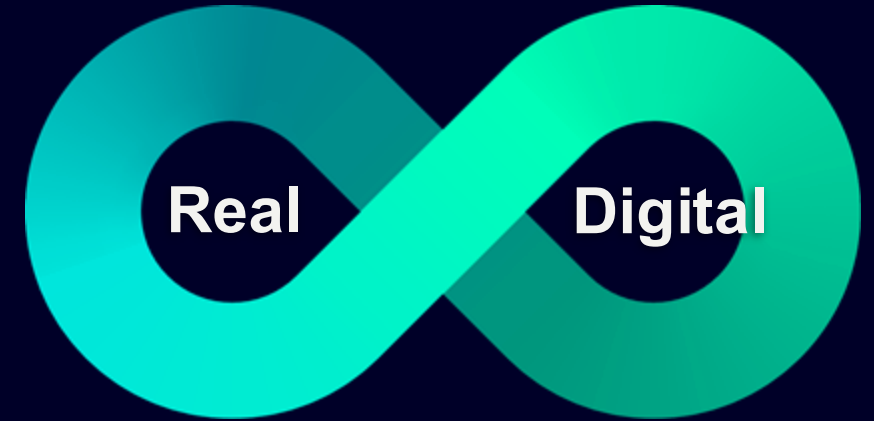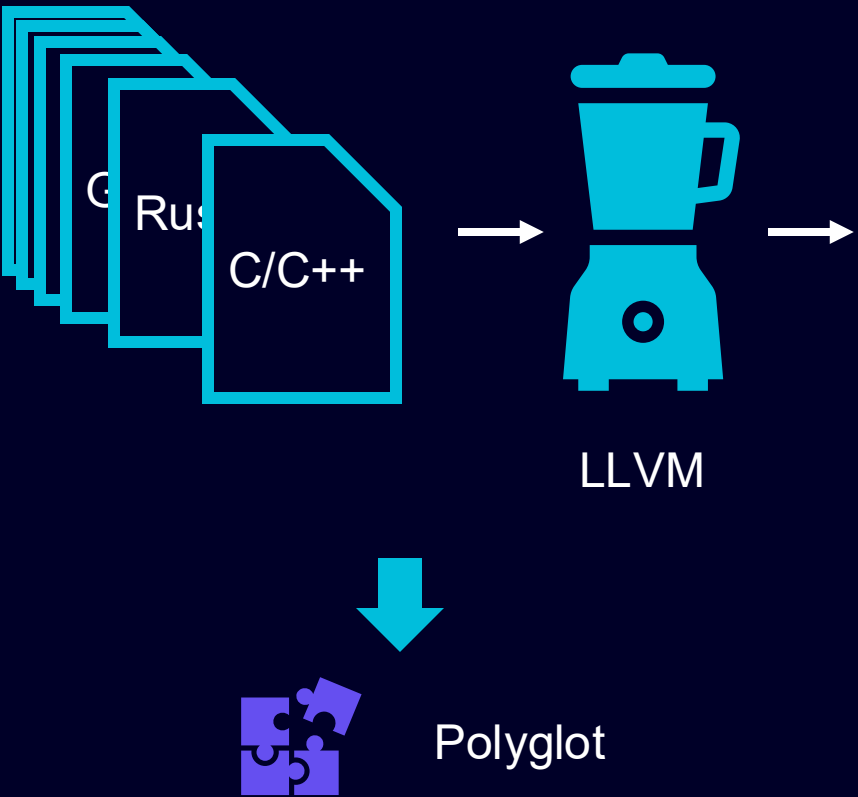# Software Defined Field Devices

Needed Features

Portability

Polyglot

Sandboxing
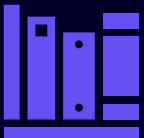
Understandable
and standardized

WA

Real ∞ Digital

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What is Wasm?

Generation

Execution

Rust
C/C++

LLVM

WA

Wasm bytecode

Interpreter

JIT

AOT

Virtual processor
(stack machine)

Polyglot

Sandboxed

Portable

Wasm: WebAssembly

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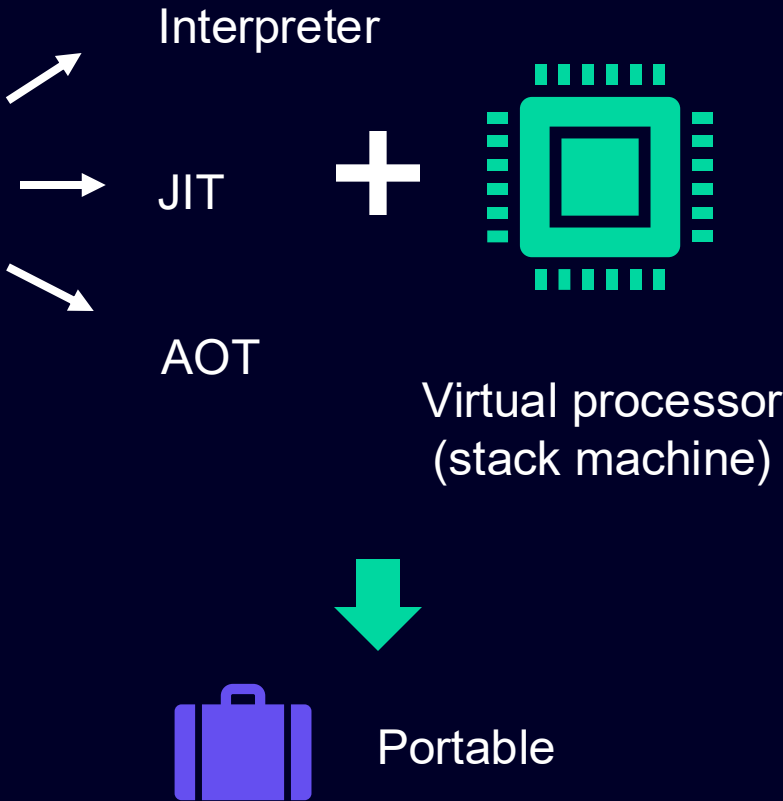
# W3C Web of Things for synchronizing real and digital world

W3C Web of Things

- IT-Friendly technologies, reuse established Web standards

- Protocols agnostics (works with Modbus, OPC UA, MQTT, …)

- Adapts to any application domain

- Local, Edge, Cloud

- Key technology: Standardized *Device Description Language* called **WoT Thing Description (TD)**

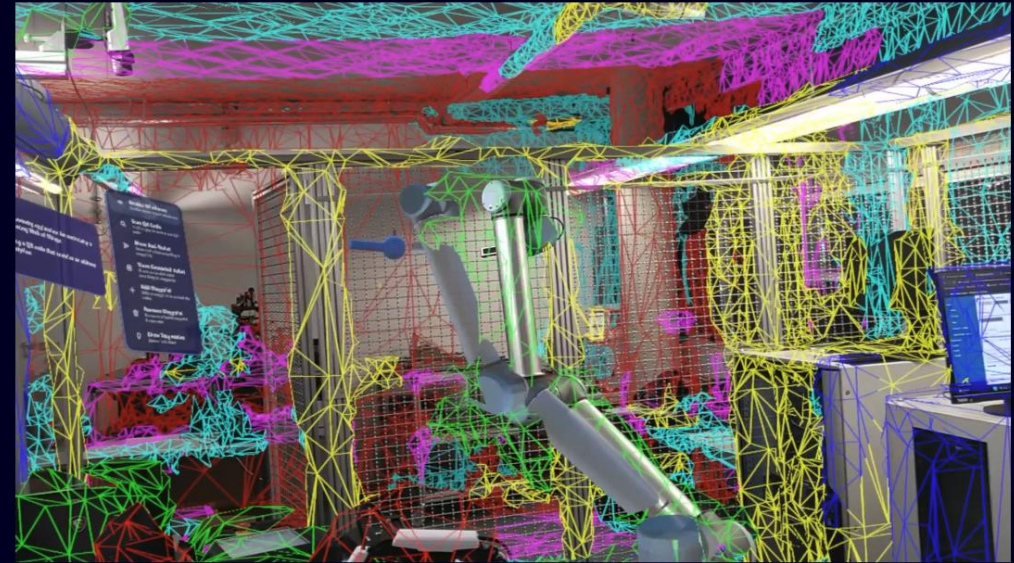- WoT TD adopted in Asset Administration Shell (AAS) by the Asset Interfaces Description (AID) Submodel

SIEMENS

Examples from TUM* – Siemens Research Cooperation
WoT for CPS, Robotics, etc.

Web of Things - Simultaneous Control

Real Lab Setup | Lab Digital Twin
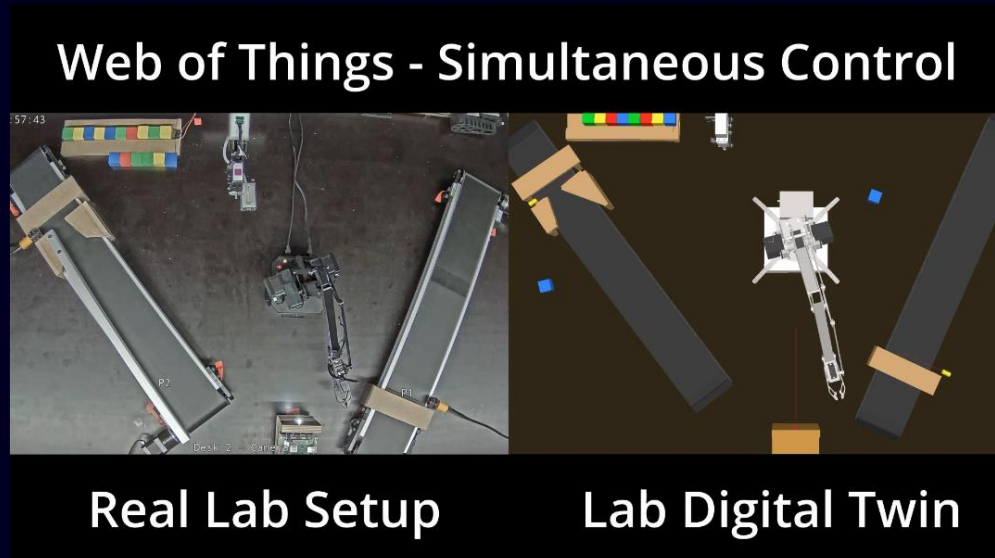
Video

Video

Fady Salama, Zucheng Han, Ege Korkan, Sebastian Kaebisch, Sebastian Steinhorst. **"RobWot: Generating Real-Time Digital Twin Simulations for the Robotic Web of Things"**. In: *2023 IEEE 9th World Forum on Internet of Things (WF-IoT). Aveiro, Portugal.*

Fady Salama, Anatolii Tsirkunenko, Ege Korkan, Sebastian Kaebisch, Sebastian Steinhorst. **"WoT-Phyng-Sim: Integrating Physics Simulations with IoT Digital Twins using the Web of Things"**. In: *2023 IEEE International Conference on Omni-layer Intelligent Systems (COINS). Berlin, Germany.*
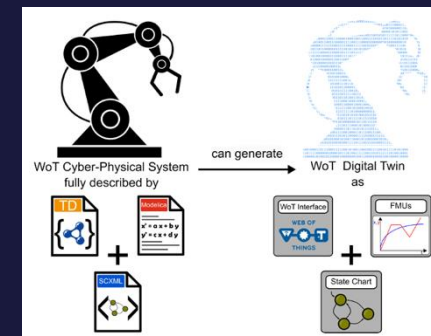
*TUM = Technical University of Munich

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Examples from TUM* – Siemens Research Cooperation
## Mixed-Reality for Web of Things
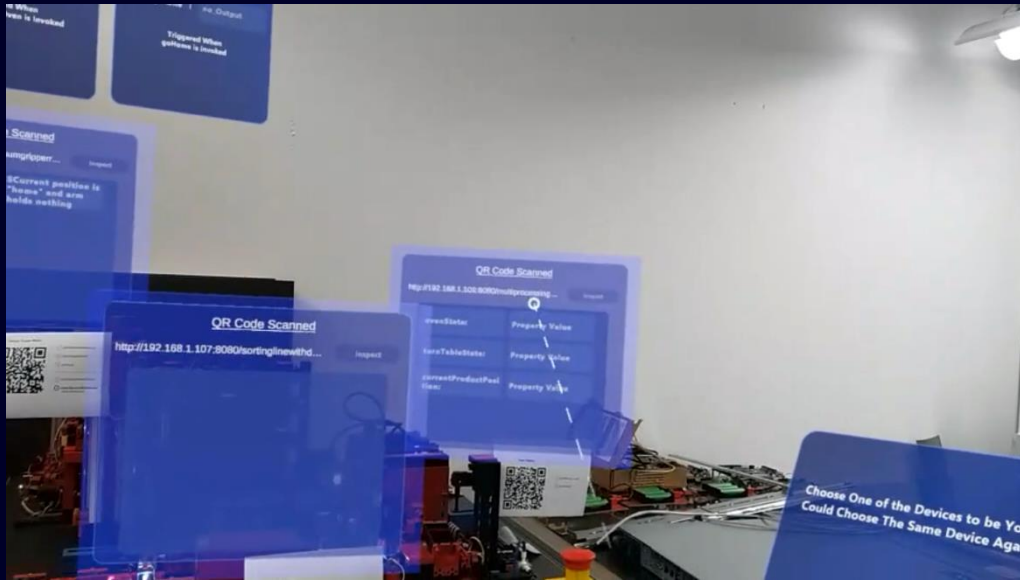
Video

Video

Fady Salama, Idil Sezgin, Ege Korkan, Sebastian Käbisch, and Sebastian Steinhorst. **HoloWoT: A First Step Towards Mixed Reality Digital Twins for the Industrial Internet of Things.** *In: Proceedings of the ACM/IEEE 27th International Conference on Model Driven Engineering Languages and Systems (MODELS Companion '24).* 2024. *Linz Austria.*

*TUM = Technical University of Munich

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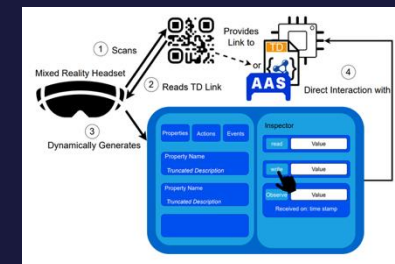
Summary

- Open standards such as WASM and WoT are a perfect vehicle for bridging both worlds, the real and the digital

- Be part of the discussion:
  - WASM embedded special interest group
  - WoT community group, discord channel, webpage

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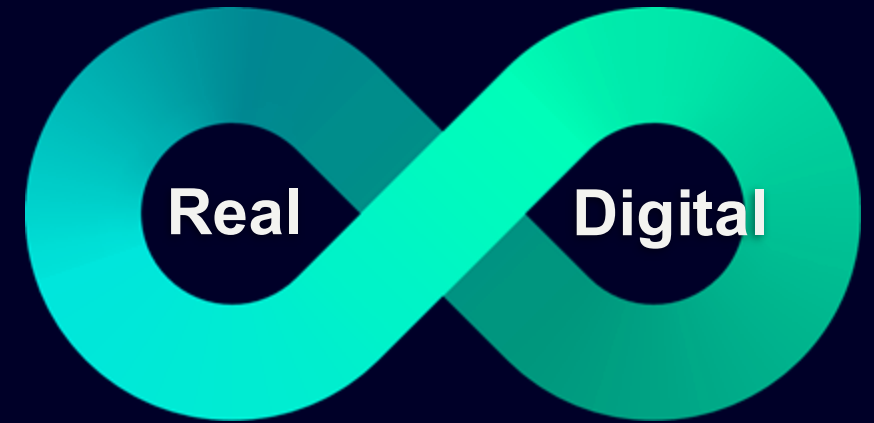
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Discussion

Q&A
Please also post your questions in the chat

- Future RD&I demand
- Topics for future webinars

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