Dipl.-Ing. Benjamin Beck
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Availability, security and interoperability of machine data in the connected construction site

Bauma Forum // 27.10.2022

Main challenges concerning digitalization

Lack of mobile coverage
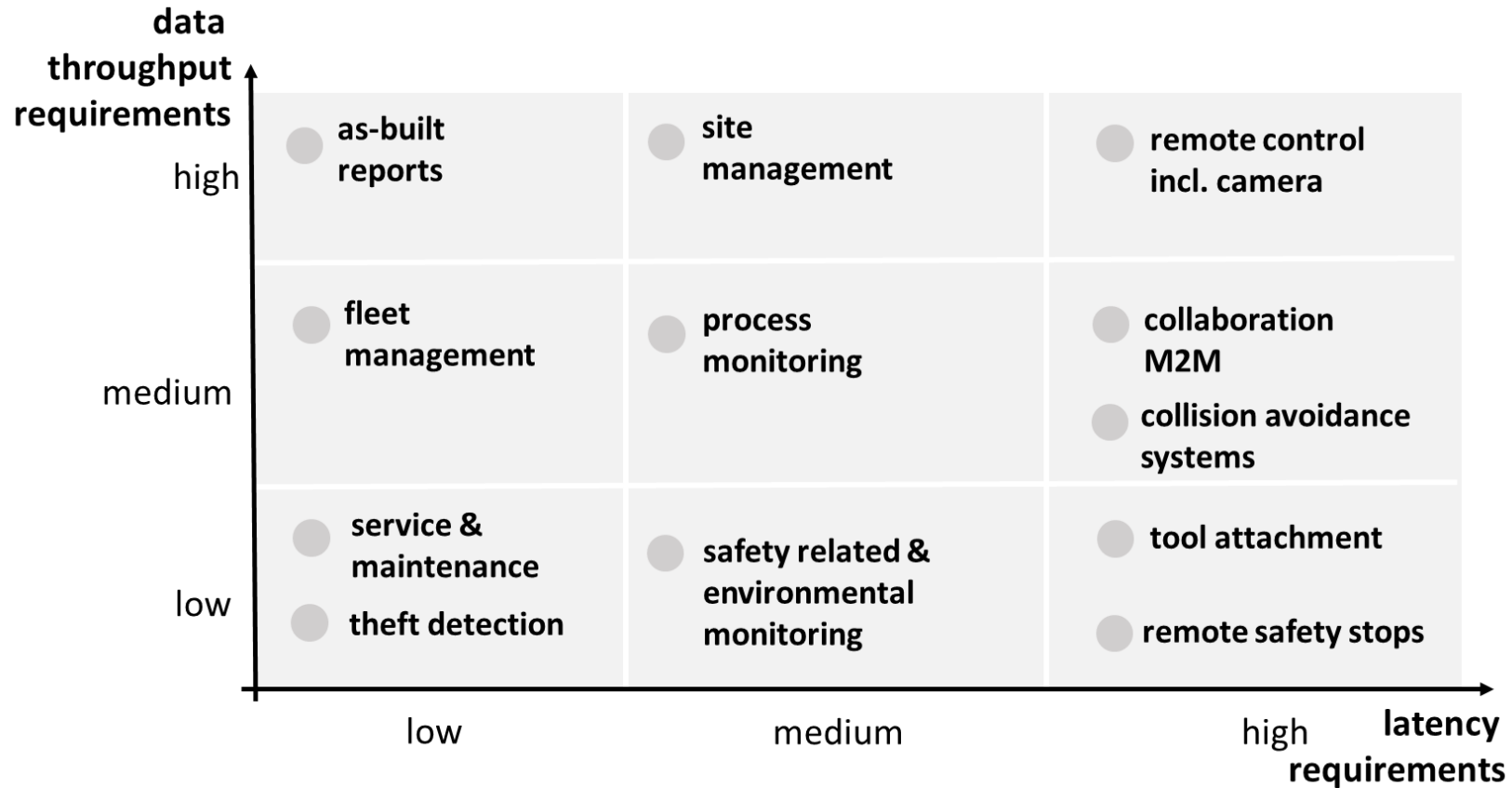
(rather no mobile internet)

Mixed Fleets
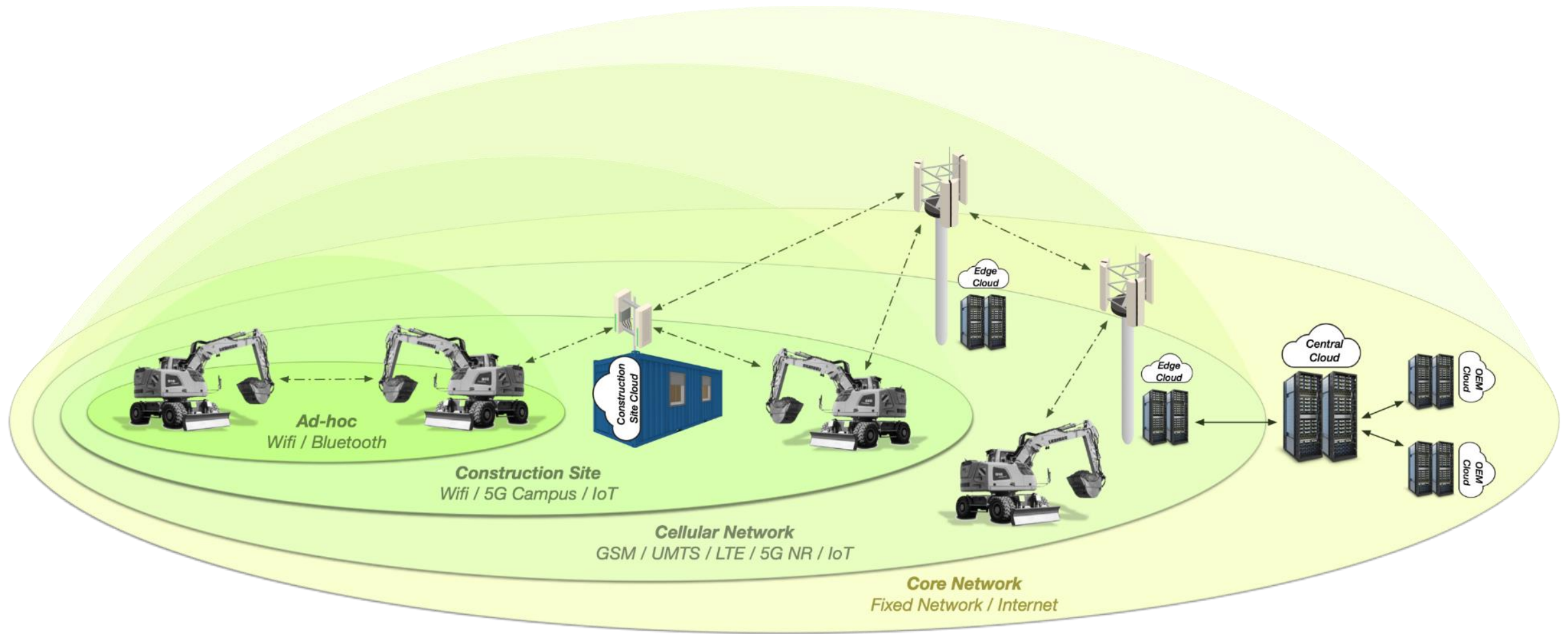
(mixed and fragmented technologies)

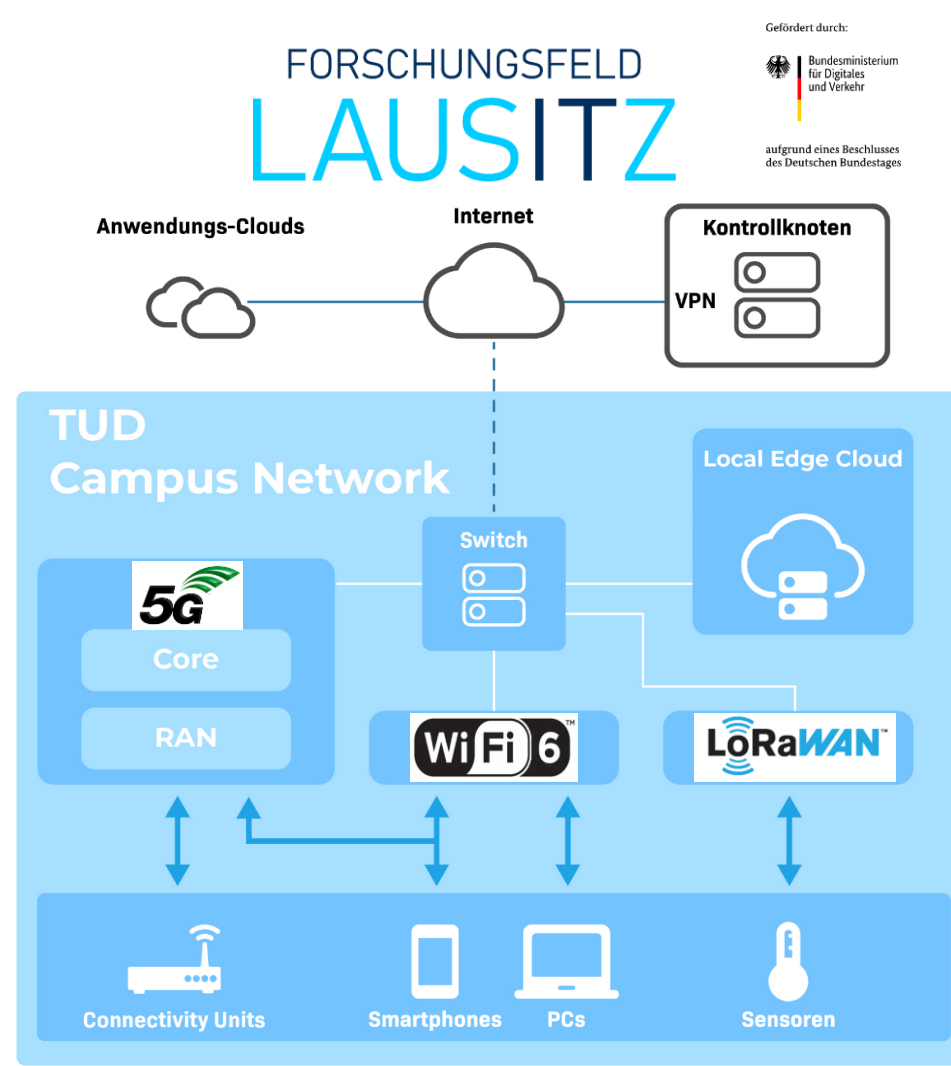**No interfaces / no standards**

(no worksite data flow)

Institut für Mechatronischen Maschinenbau
IMD

buildingSMART Deutschland
Wir sind Mitglied

B AUEN

Connectivity Use Cases

Various latency and data rate requirements

Bauen 4.0 Connectivity Architecture

Construction site: 5G Campus network

FORSCHUNGSFELD LAUSITZ

Gefördert durch: Bundesministerium für Digitales und Verkehr aufgrund eines Beschlusses des Deutschen Bundestages

Anwendungs-Clouds — Internet — Kontrollknoten / VPN

TUD Campus Network
- Local Edge Cloud
- 5G Core / RAN
- Switch
- WiFi 6
- LoRaWAN
- Connectivity Units
- Smartphones
- PCs
- Sensoren

Institut für Mechatronischen Maschinenbau IMD

buildingSMART Deutschland — Wir sind Mitglied

B:AUEN

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Data exchange on site – Middleware Approach

OPC UA
- SOA with semantic data model

ROS
- Middleware + Robotic Framework

MQTT
- lightweight publish/subscribe protocol

DDS
- throughput and latency optimized publish/subscribe protocol

	OPC UA	ROS	DDS	MQTT
Communication	TCP, UDP	TCP, UDP	TCP, UDP, SHM	TCP
Patterns	RPC, Pub/Sub	RPC, Pub/Sub	RPC, Pub/Sub	Pub/Sub
QoS	No	No	Yes	Yes
Authentication	User, PKI	Mac	PKI	User, PKI
Encryption	Yes	No	Yes	Yes
Std. API	No	No	Yes	No
Semantic Data	Yes	No	No	No

S. Profanter, u.a., „OPC UA versus ROS, DDS, and MQTT: Performance Evaluation of Industry 4.0 Protocols"
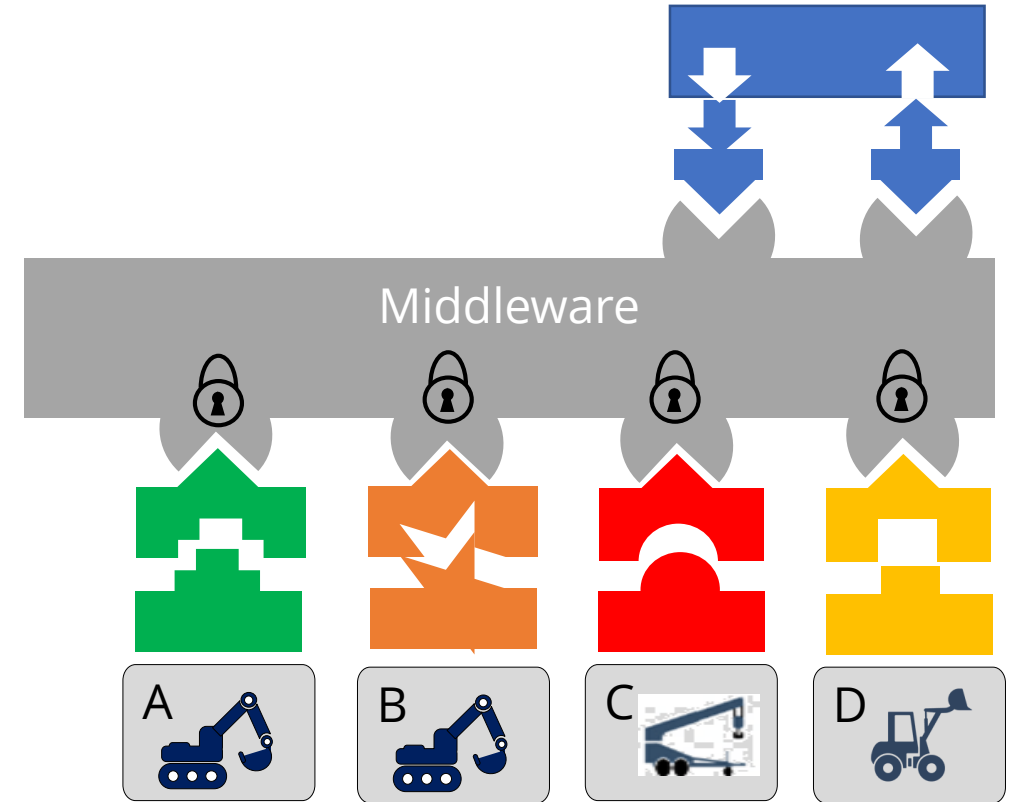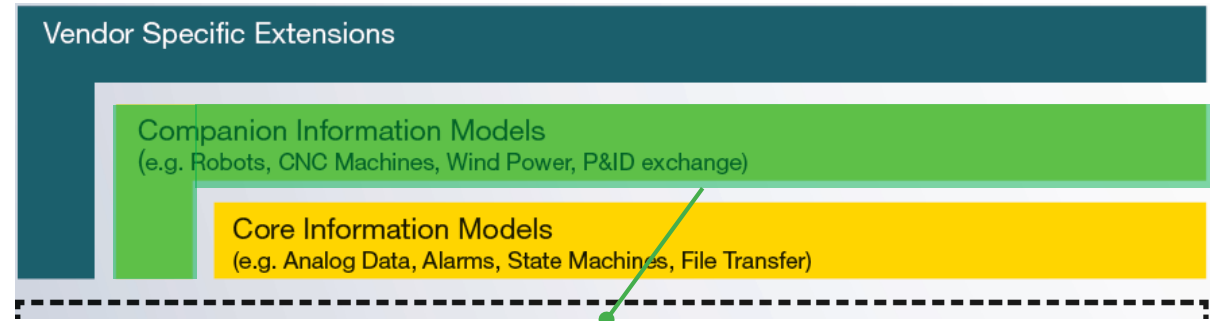
OPC UA / open62541 implementation

open62541

OPC Unified Architecture

➢ a communication protocol and a data model

➢ client-server or pub/sub

➢ service oriented architecture (client and server implement services to coordinate communication and data exchange e.g. browsing, discovery, subscription, method service, attribute, secureChannel)

➢ based on standard IP protocols (TCP/UDP, HTTP)

➢ an open standard, managed by the OPC Foundation

➢ secure (authentication, encryption, access rights per node, auditing)

➢ binary encoded

➢ is an efficient interface for the representation of complex data structures taking into account the requirements of production, automation, networking

Vendor Specific Extensions

Companion Information Models
(e.g. Robots, CNC Machines, Wind Power, P&ID exchange)

Core Information Models
(e.g. Analog Data, Alarms, State Machines, File Transfer)

Companion Specifications

▪ Information models for specific applications

▪ Examples: Robotics, machine tools, plastics and rubber machines, …

▪ Many others under development – see: https://www.vdma.org/viewer/-/v2article/render/1248676

Bauen 4.0 OPC UA data model

TECHNICAL SPECIFICATION ISO/TS 15143-3

Telematics according to "ISO 15143-3"

Earth-moving machinery and mobile road construction machinery — Worksite data exchange —

Part 3: Telematics data

VDMA Specification *Draft* November 2018

VDMA 40010-1

by 2018-12-31

Kinematic according to "OPC UA spec. Robotic"

OPC UA Companion Specification Robotics – Part 1: Condition monitoring, asset management, predictive maintenance, vertical integration

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VDMA Specification *Draft* June 2020

VDMA 40001-1

Comments by 2020-09-01

Identification according to "OPC UA spec. Machinery"

OPC UA for Machinery – Part 1: Basic Building Blocks

OPC UA for Machinery – Teil 1: Basic Building Blocks

OPC UA data model for construction machines

Topographical Mission data according to "ISO draft 15143-4"

VDMA Specification *Draft* January 2021

VDMA 40223

ICS 23.080; 23.160; 35.240.50

Hydraulics according to "OPC UA spec. Pumps"

OPC UA for pumps and vacuum pumps

OPC UA für Pumpen und Vakuumpumpen

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mic 4.0

standards from Working group "machine data"

Implementation with open62541 – view from UA expert client

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OPC UA-based Bauen 4.0 overall architecture

off-site

Local data server- construction site control system

OPC UA AGGREGATING SERVER

Storage

Simulation

OPC UA CLIENT

C/UI

Tracing

Uplink public Network (www)
S2C = Server to Cloud
M2C = Machine to Cloud

M2S

M2M

M2M

M2C

excavator - Information source on site

OPC UA SERVER
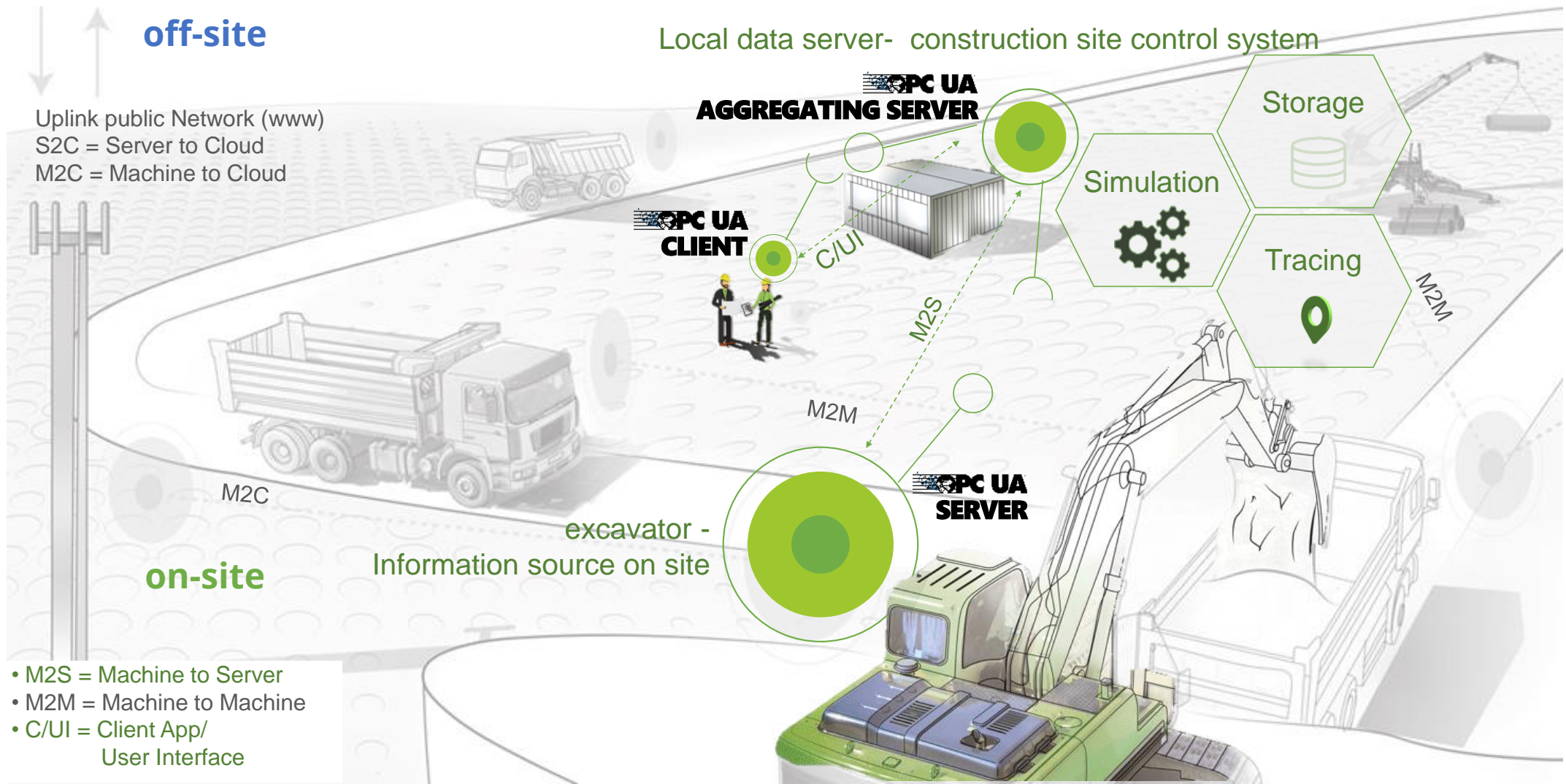
on-site

• M2S = Machine to Server
• M2M = Machine to Machine
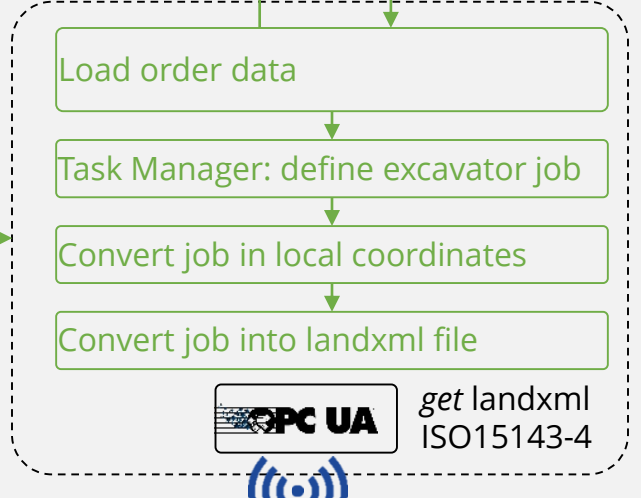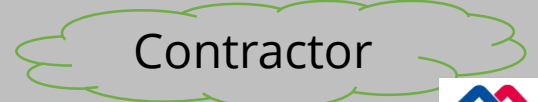• C/UI = Client App/
        User Interface

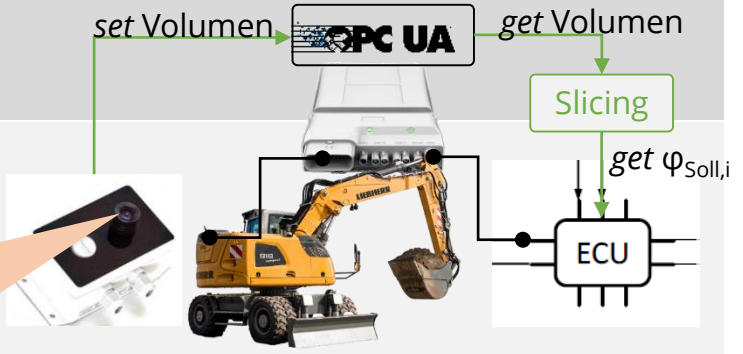# Signal flow within the Bauen 4.0 architecture

Off-site
Public Network

On-site
Private Campus Network

connectivity module

machine

Contractor

HTTP *request*   *get* *.ifc5xml

IFC

Load order data

Task Manager: define excavator job

Convert job in local coordinates

Convert job into landxml file

OPC UA   *get* landxml ISO15143-4

Site staff

UI

User Interface

Construction Site Control System

set Volumen   OPC UA   *get* Volumen

Slicing

get $\varphi_{Soll,i}$

ECU

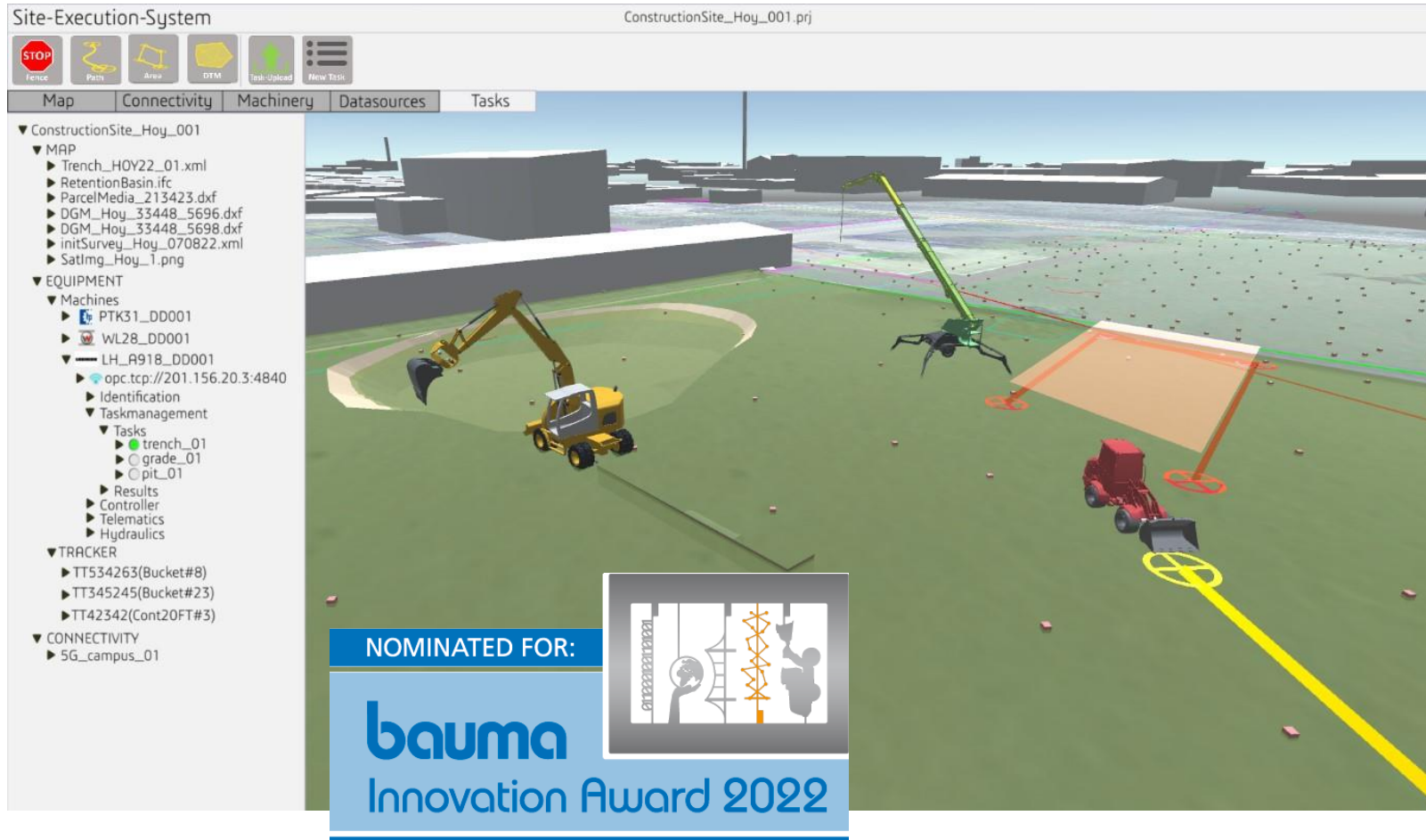Mission Data

AS-Built Data
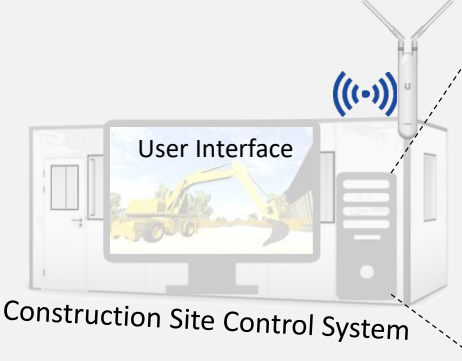
Site Execution System

> **Availability**
  - Local network,
  - Technology diversity
  - Reliable networks

> **Security**
  - 5G Campusnetwork with need special SIM cards
  - Authentication and Encryption

> **Interoperability**
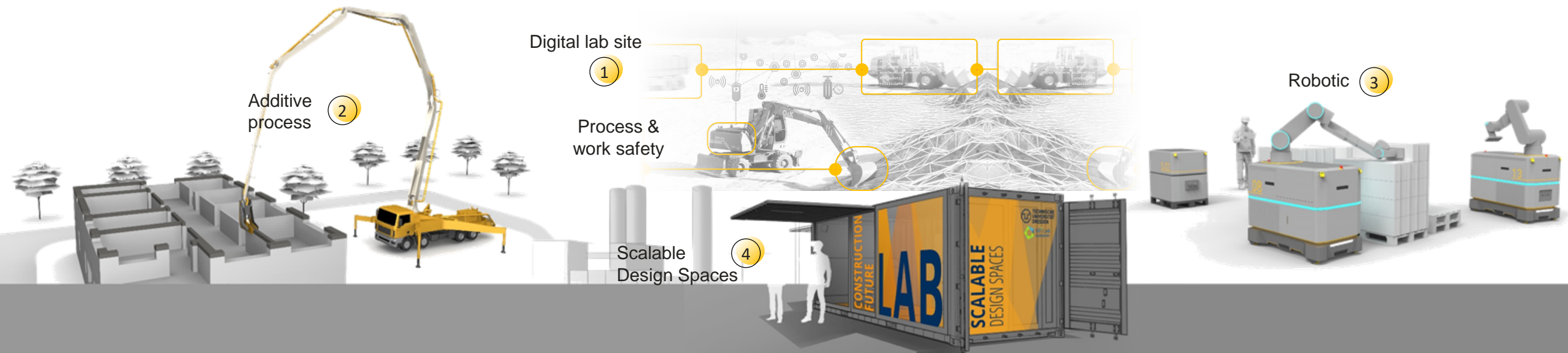 - OPC UA Middleware

> **Functionality**
  - Realtime data exchange

https://www.youtube.com/watch?v=WYHYys_944I&ab_channel=VDMAonline

Construction Future Lab gGmbH

Application research for future, digital, sustainable construction

- **Transdisciplinary,** holistic approach to technology development for complex construction R&D topics

- **Human-centered** research approach

- Development and **testing ecosystem** for the entire process chain

- Open (**neutral**) "test and trial" environment

- "Real" exchange & **collaboration** platform

Digital lab site
1

Additive process
2

Process & work safety

Scalable Design Spaces
4

Robotic
3

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contact

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Contact us at Science Hub Booth SH10

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Folie 16