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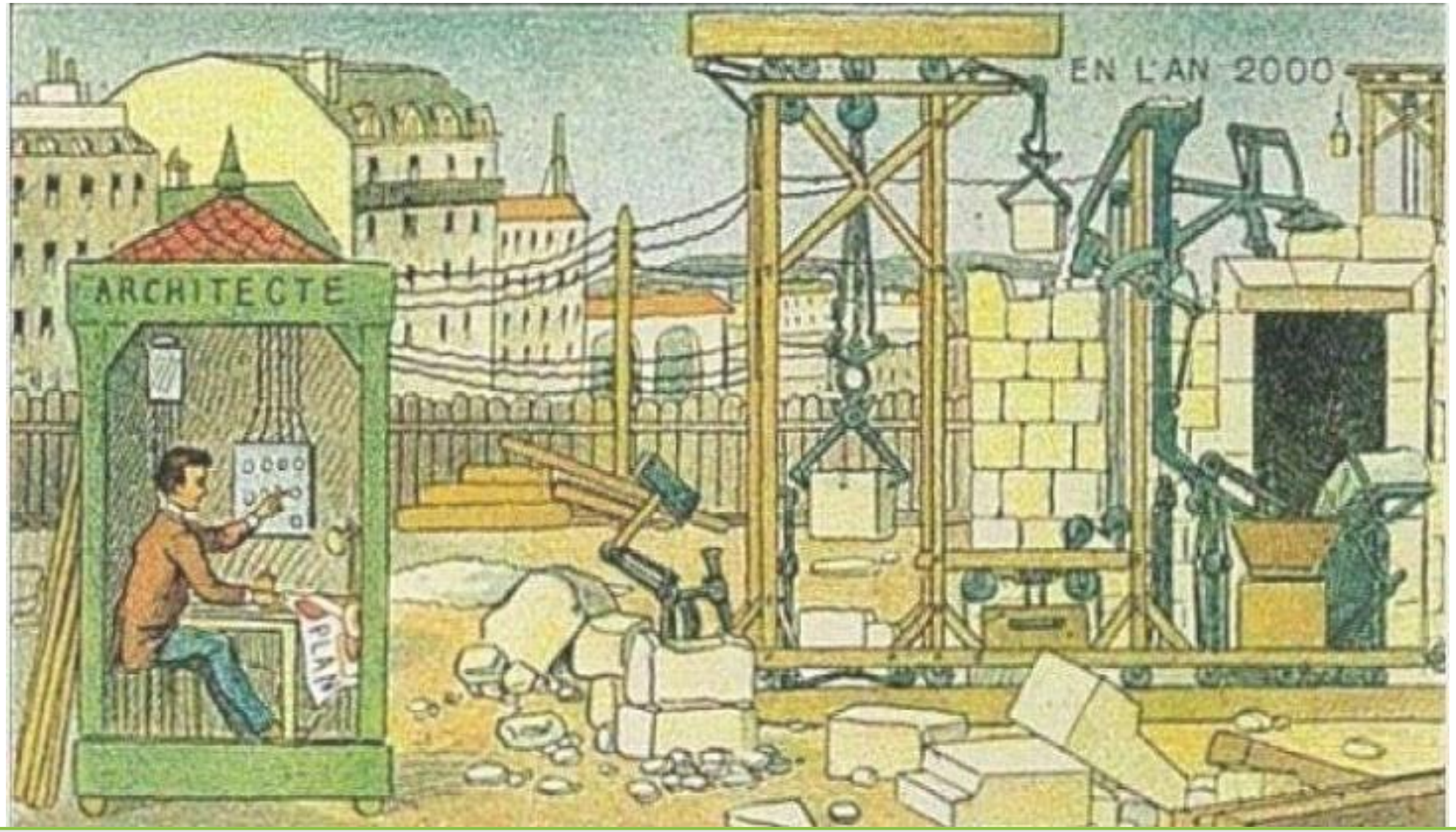
Bauen 4.0 – Communicating Construction Machines as Prerequisite for Digital Construction Processes

Maha Fluid Power Conference Purdue University // May 17th - 19th , 2022

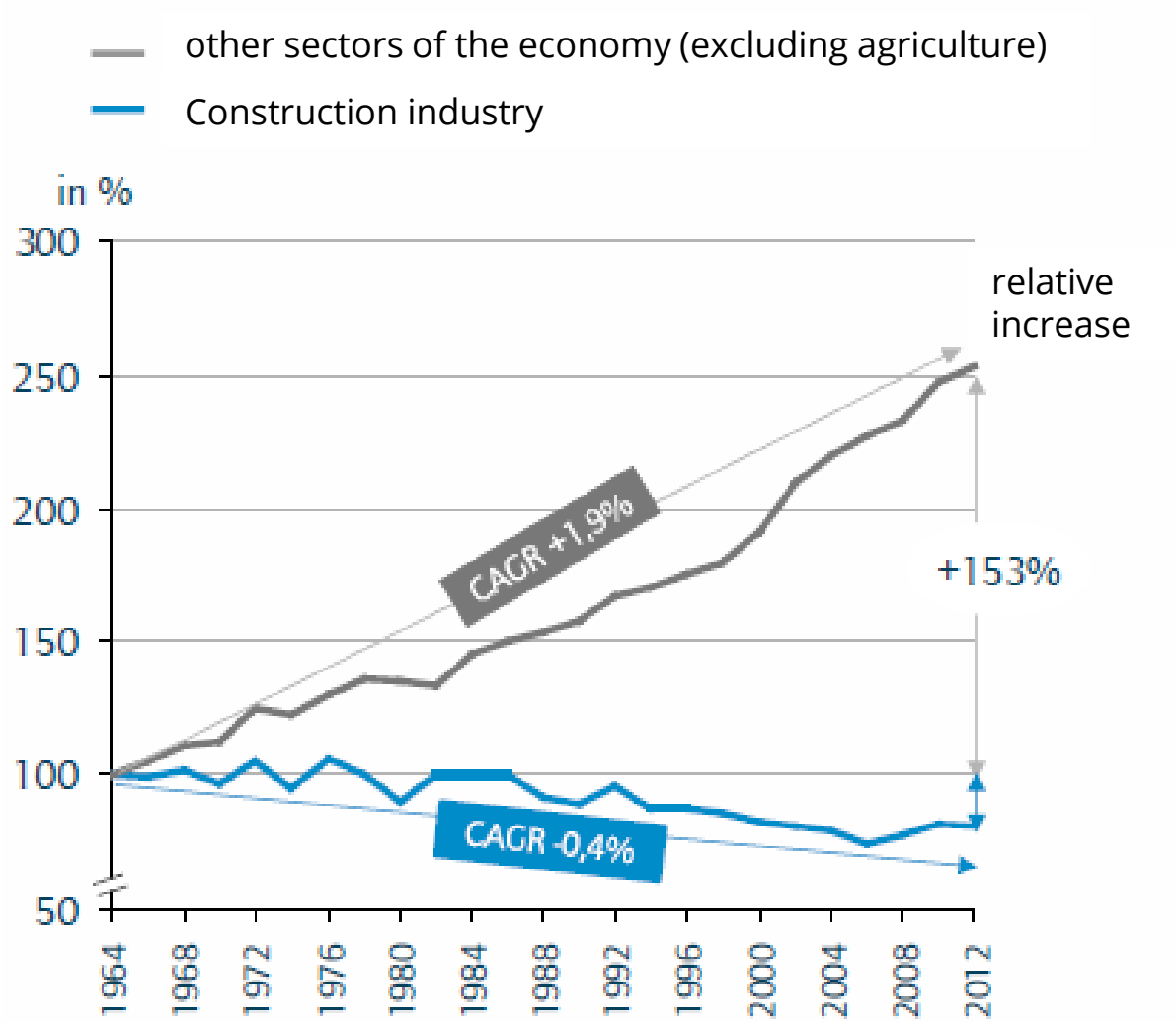
Outline

1. Overview
2. “Bauen 4.0” solutions
3. Demos
4. Outlook

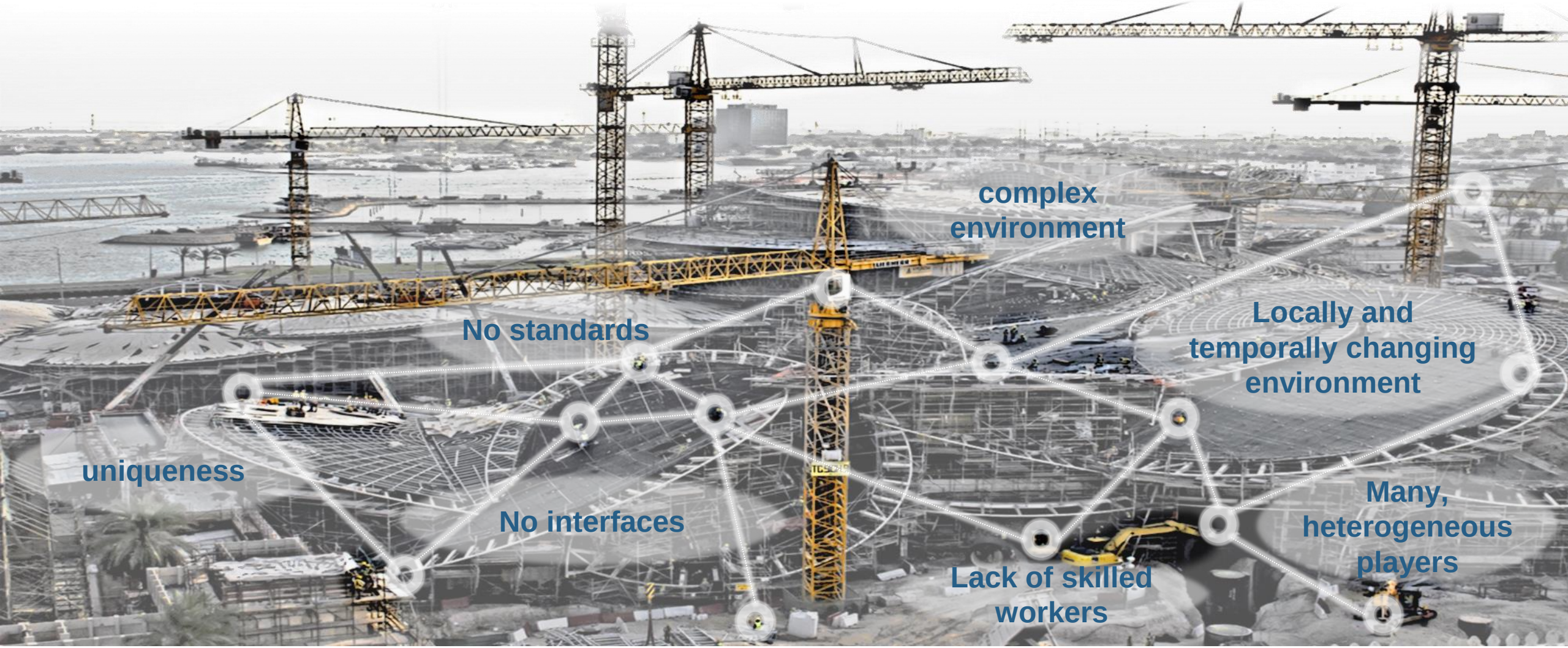
1910 – Vision of a construction site in 2000



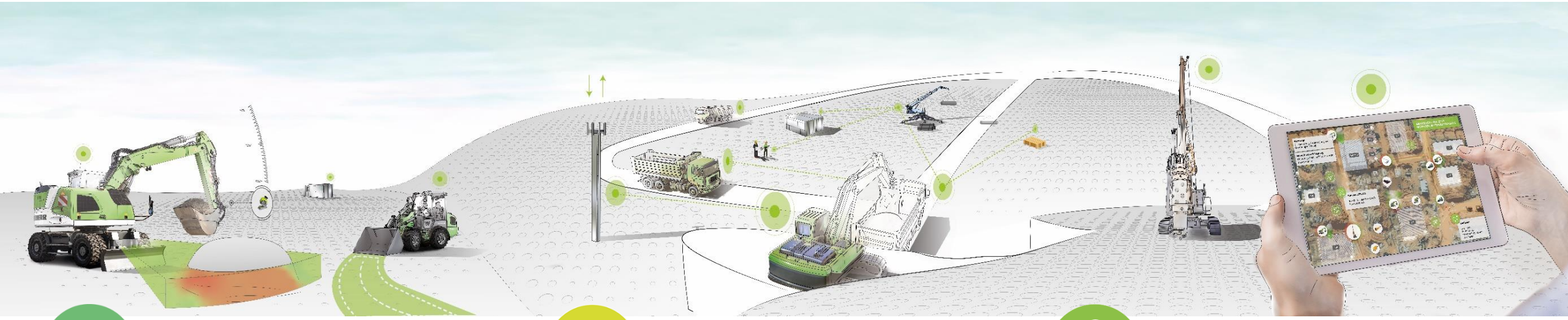
Comparison of Productivity



Construction site challenges



The main topics



Automated, connected mobile machines

- **Automation**
- **Assistance functions**
- **Remote control**
- **Environment recognition**
- **Vertical Integration**

5G machine and construction site connectivity

- **Connectivity Solutions**
- **Cloud Technologies**
- **Reliable and secure data exchange**

Processes and solutions for the digital construction site

- **Tracking & Tracing**
- **Simulation of construction processes**
- **BIM to BIMsite**
- **Driver guidance system 4.0**

Integration of main topic solutions into a common construction demo scenario – end of project demonstration

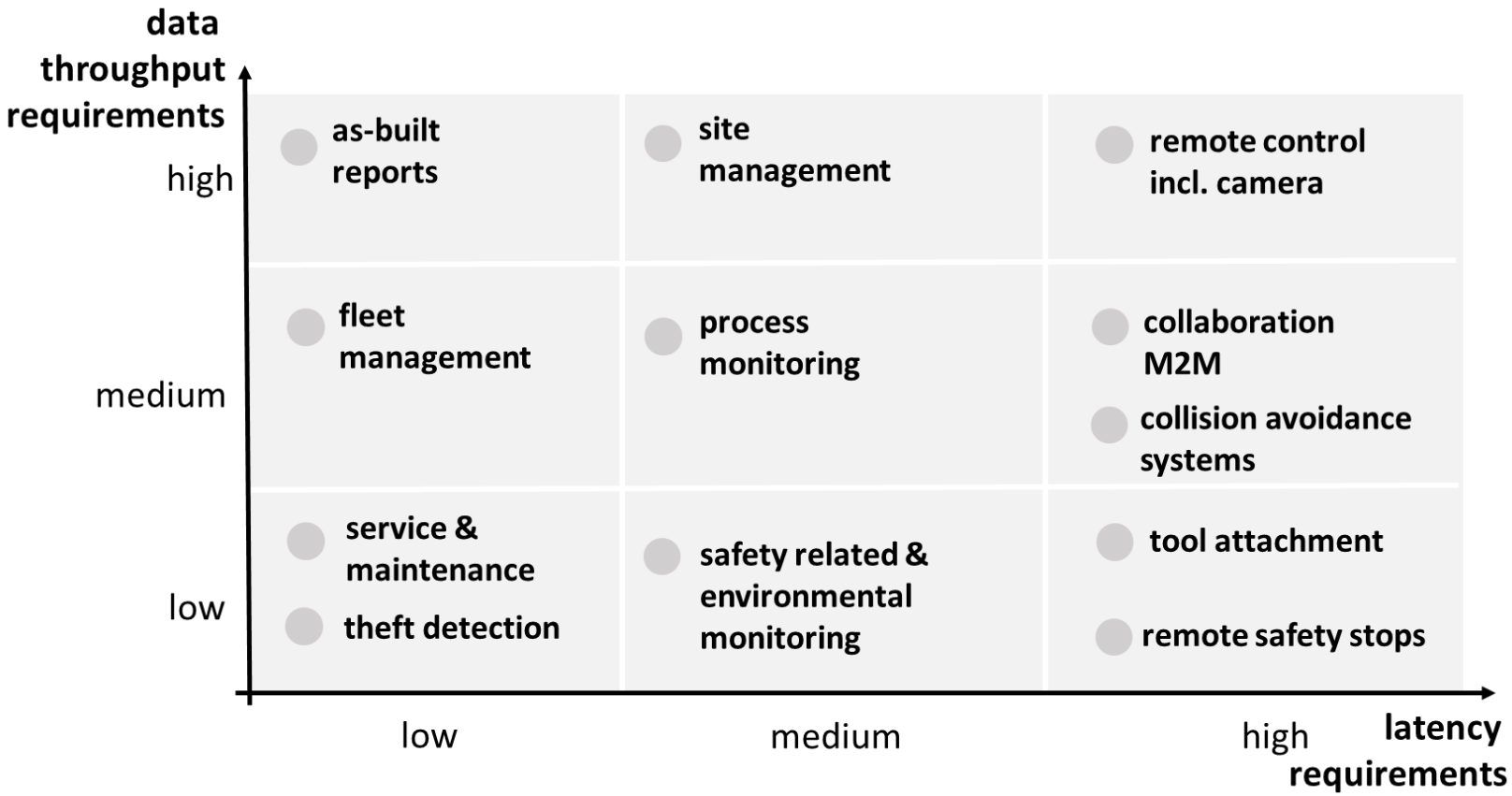
Project Partners and organizational framework

Facts and Figures:

- Funding BMBF – Project Management Agency Karlsruhe – INKOWE program
- Duration July 2019 – ~~July 2022~~ extended to December 2022
- 22 industrial partners, 2 universities
- Accompanied by various associations
- Total costs 10 Mio. € / 5 Mio. € funding

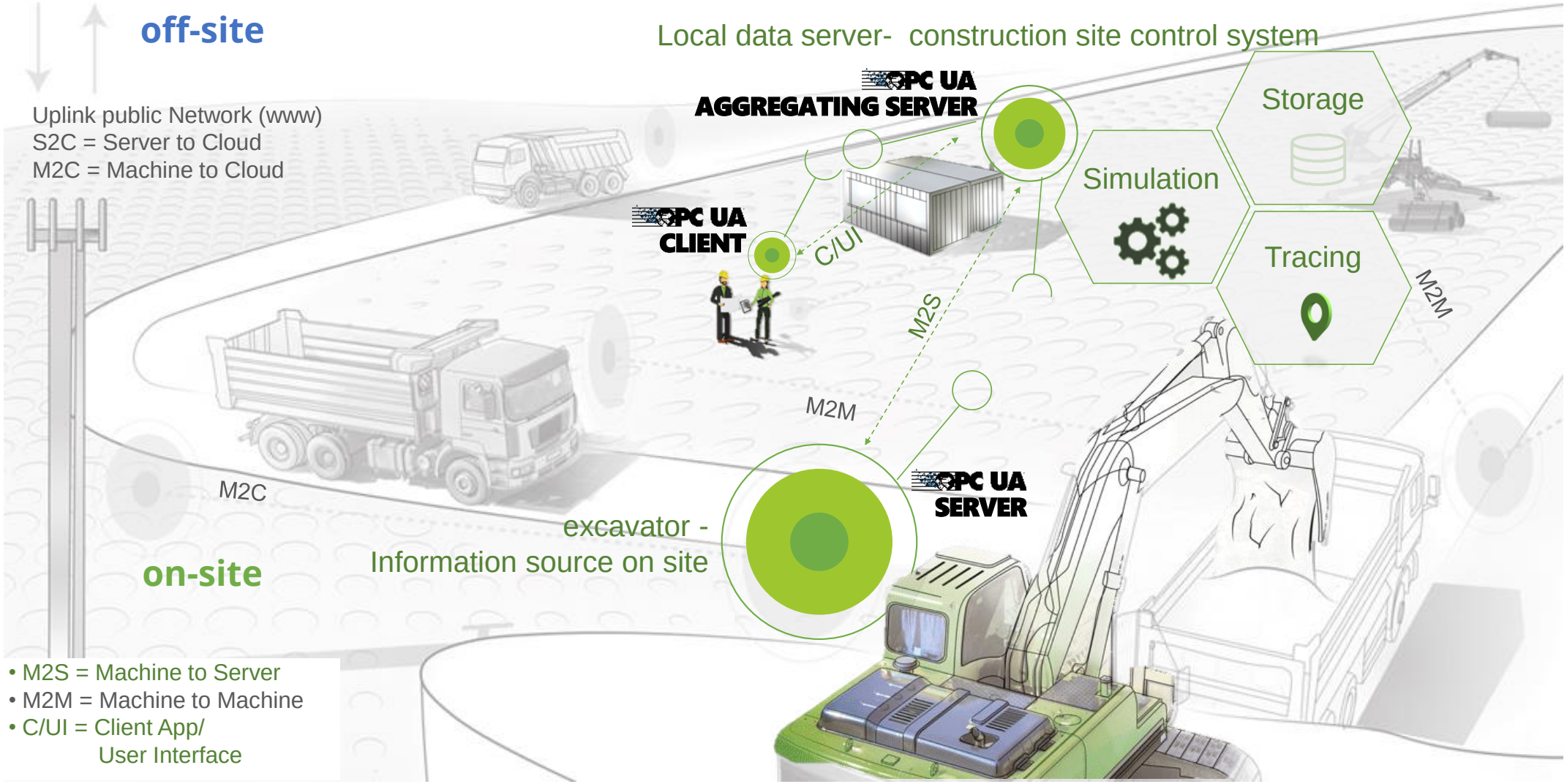
2 „Bauen 4.0“ solutions – overall

Requirements on construction sites



Various latency and data rate requirements and no mobile internet at every construction site

OPC UA-based Bauen 4.0 architecture



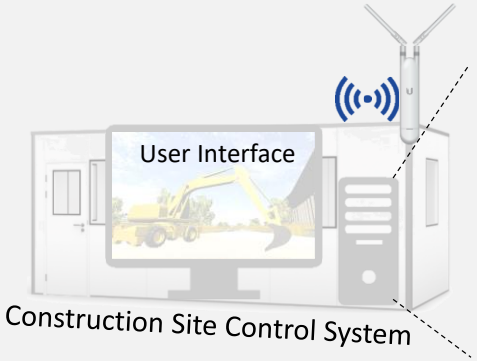
Signal flow within the Bauen 4.0 architecture

Off-site
Public Network“

On-site
Private Campus Network

connectivity module

machine



Site staff

UI

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

set Volumen

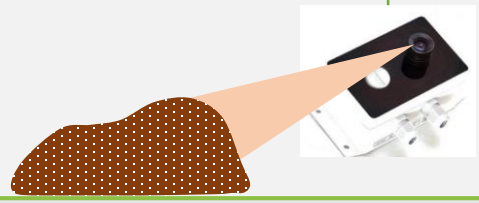
OPC UA

get Volumen

Slicing

get $\varphi_{Soll,i}$

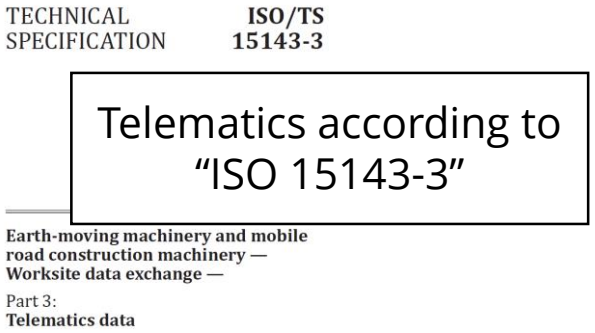
ECU



Mission Data

AS-Built Data

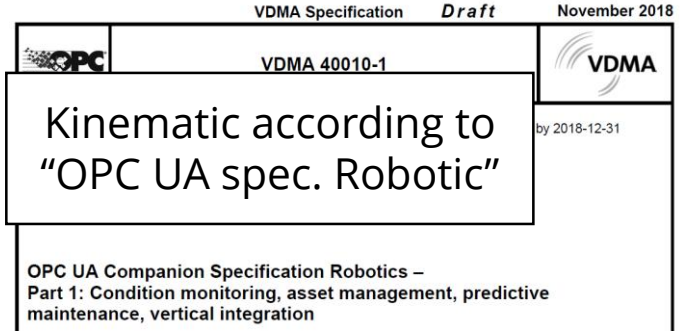
Bauen 4.0 OPC UA data model


TECHNICAL SPECIFICATION ISO/TS 15143-3

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

Part 3: Telematics data

Telematics according to “ISO 15143-3”

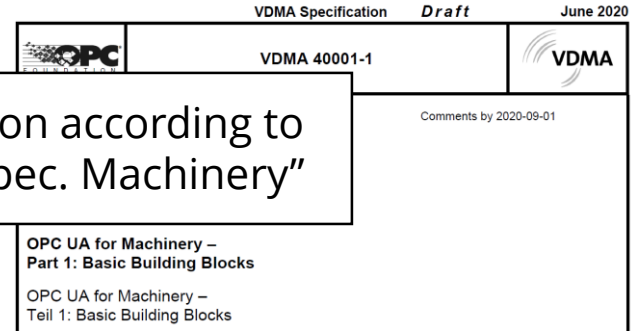

VDMA Specification Draft November 2018

VDMA 40010-1

by 2018-12-31

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

Kinematic according to “OPC UA spec. Robotic”


VDMA Specification Draft June 2020

VDMA 40001-1

Comments by 2020-09-01

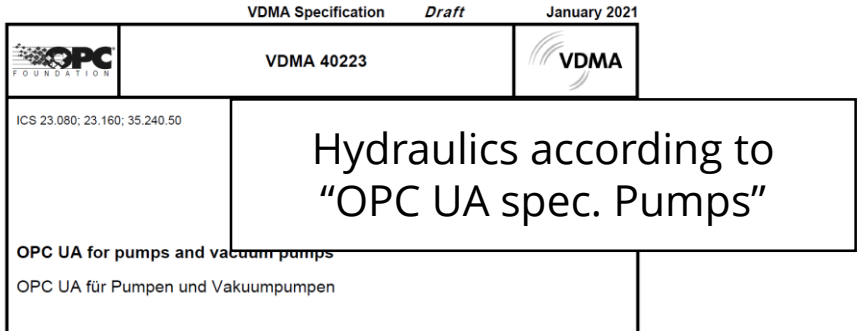
OPC UA for Machinery – Part 1: Basic Building Blocks

OPC UA for Machinery – Teil 1: Basic Building Blocks

Identification according to “OPC UA spec. Machinery”

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

OPC UA for pumps and vacuum pumps

OPC UA für Pumpen und Vakuumpumpen

Hydraulics according to “OPC UA spec. Pumps”

mic 4.0

standards from Working group “machine data”

2 „Bauen 4.0“ solutions – main topics

Main topic “machines”: Level of automation

Complexity of Operation

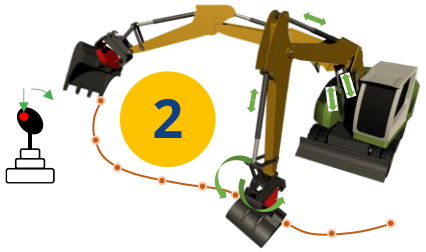
Level of Automation

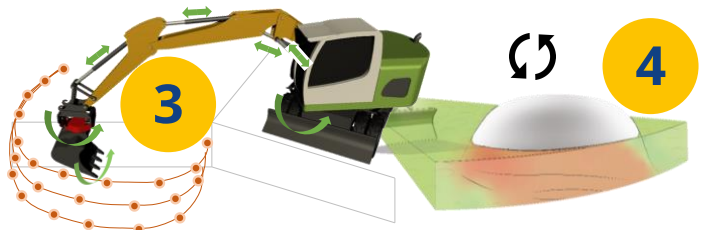
0	1	2	3	4	5
no	**assistance**	**partly**	**conditional**	**high**	**full**

State of the art

Focus in „Bauen 4.0“

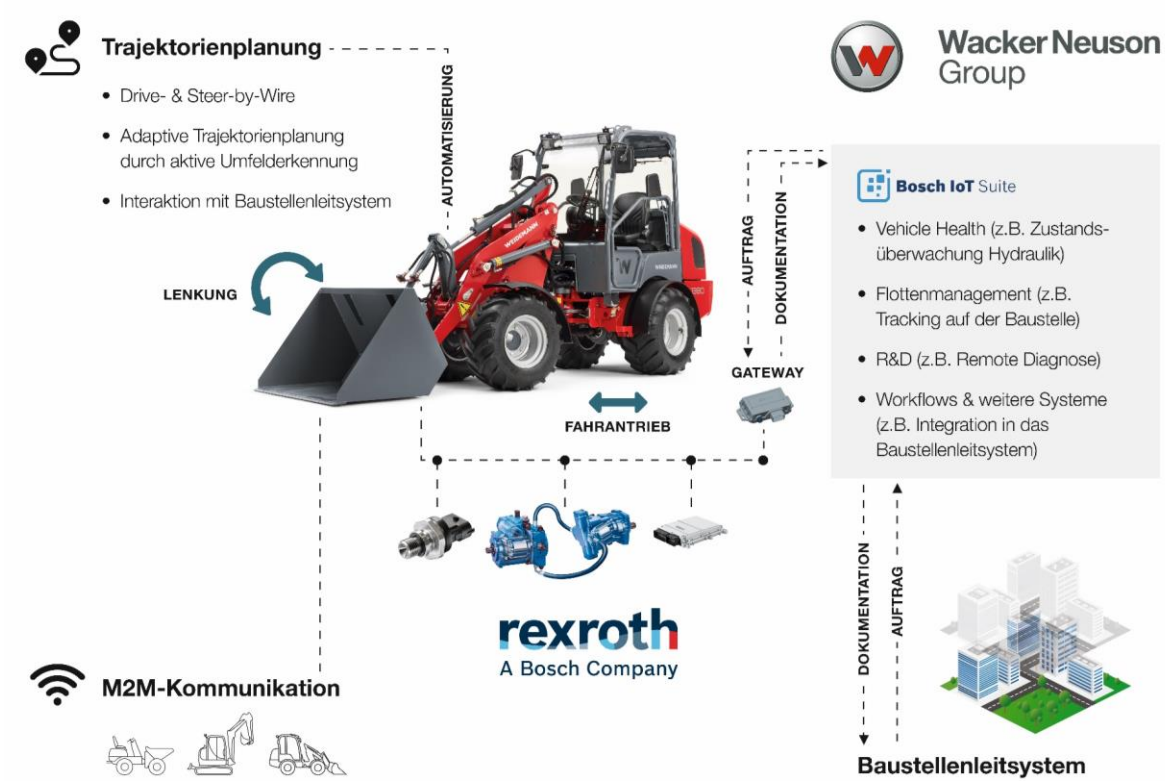
A few examples in mining and agriculture

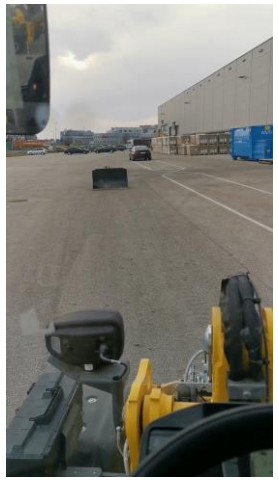




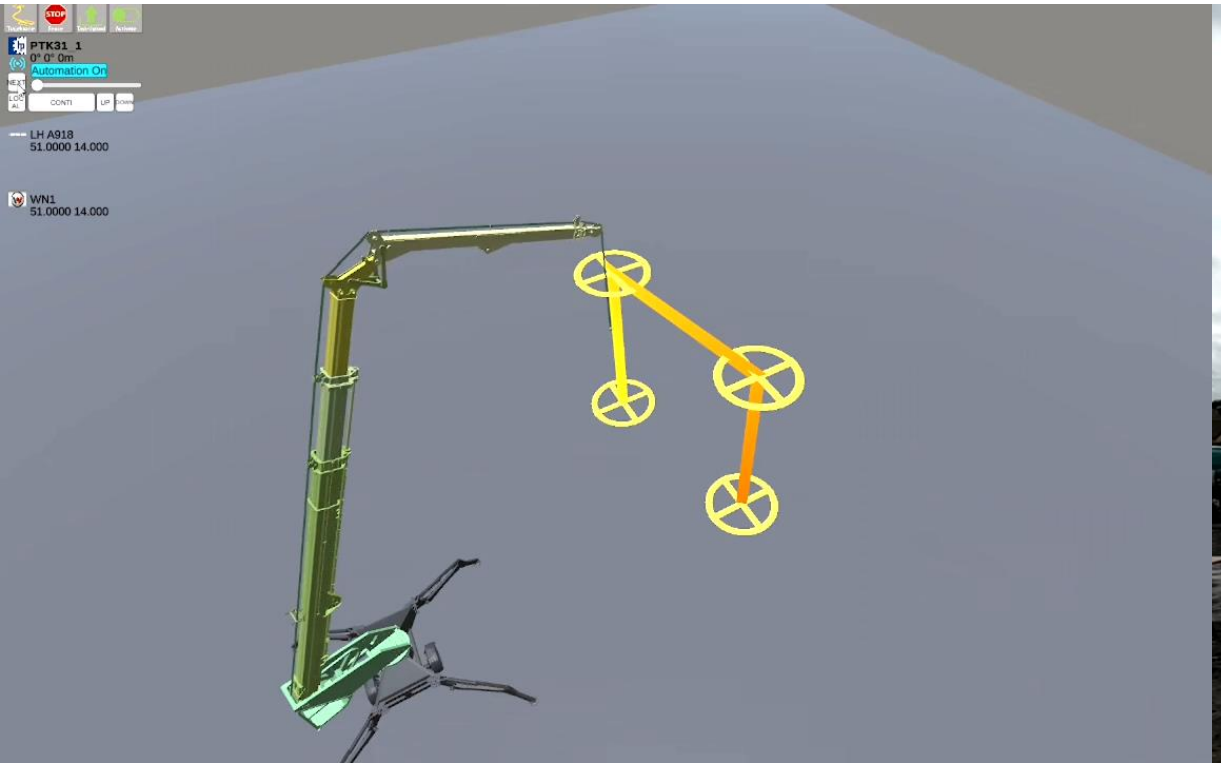
Main topic “machines”: Excavator remote control via 5G campus net

Main topic “machines“: Wheel Loader automation



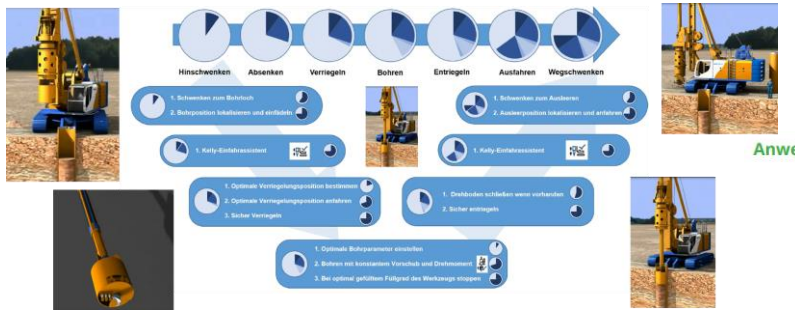


Main topic “machines”: loading crane automation



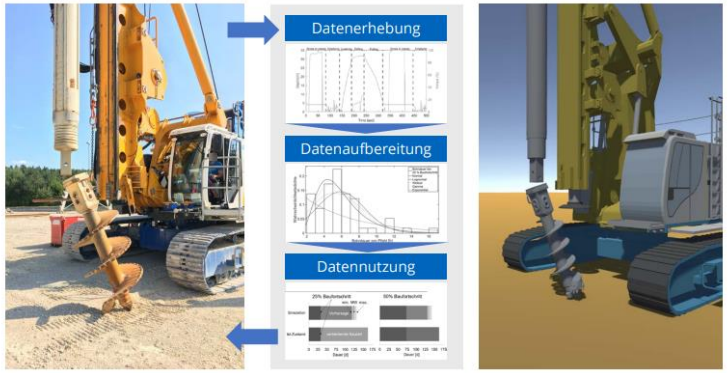
Main topic “machines”: drilling rig activities

Smart tools / equipment management

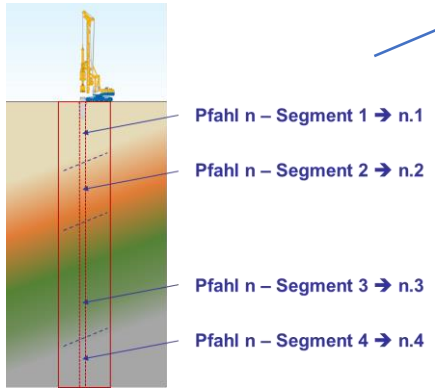


Autonomous working

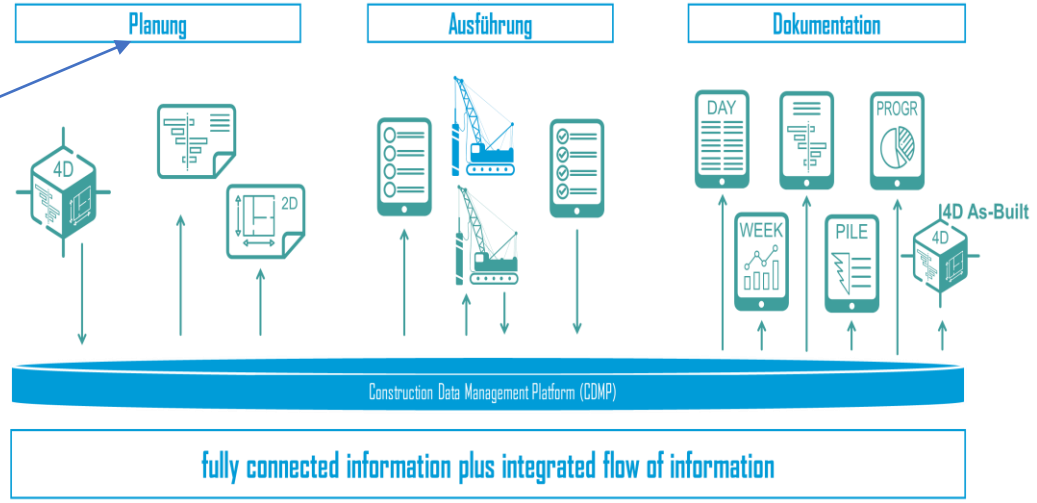
Anwendung der Simulation (AP 3.2.4) – Der Demonstrators mit Bauer



Process identification
Process simulation



Contract award

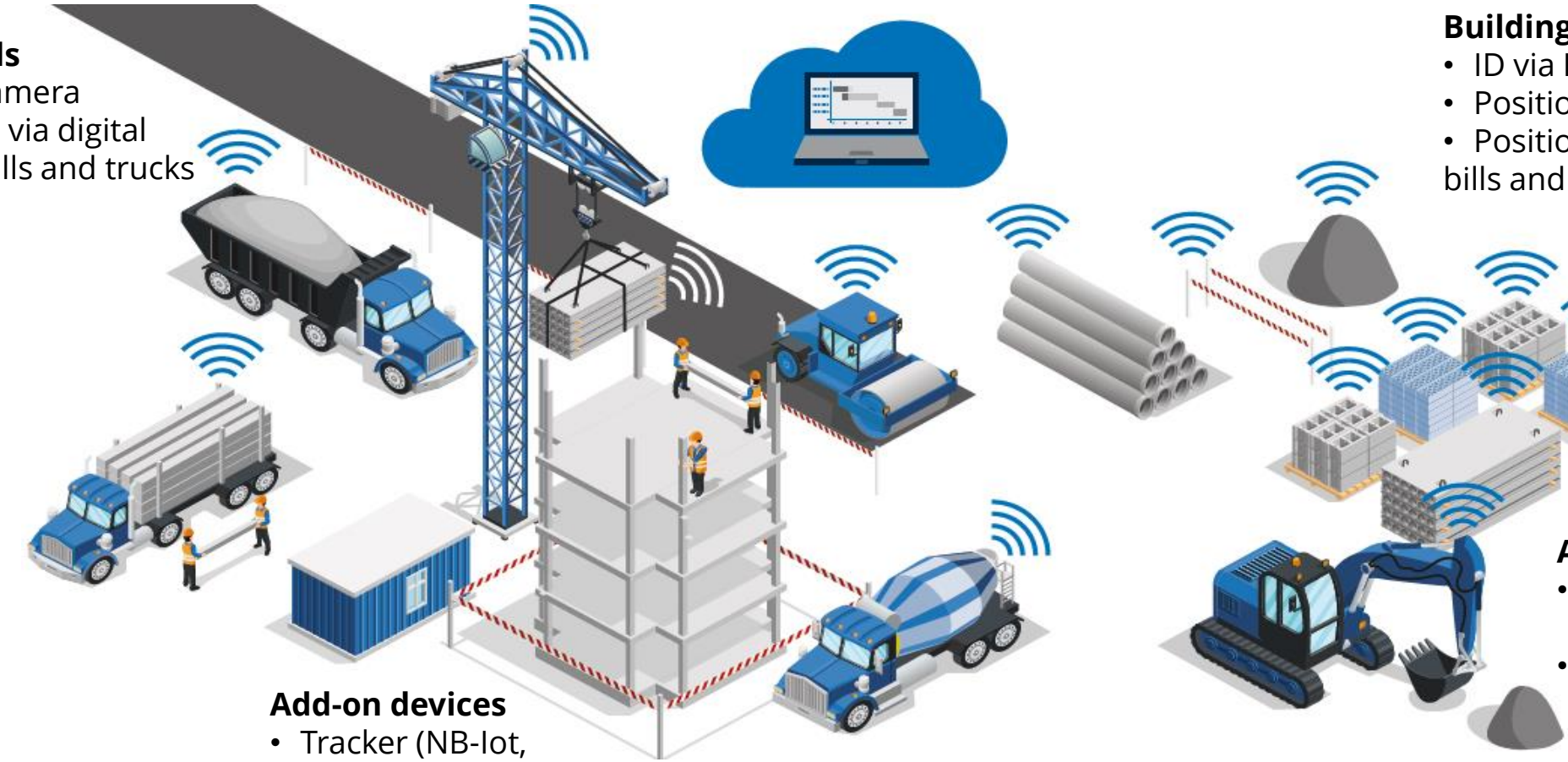


Main topic “processes”: Tracking & Tracing

Consistent information flows

Bulk solids
- ID via camera
- Position via digital delivery bills and trucks

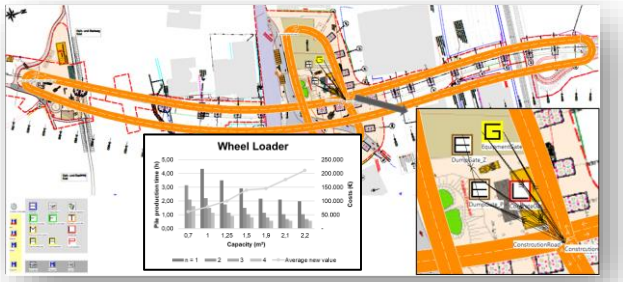
Building materials
- ID via RFID Tag / QR Code
- Position via Reader
- Position via digital delivery bills and trucks



Add-on devices
- Tracker (NB-Iot, Bluetooth Beacon, BLE…)

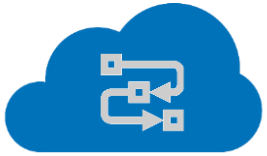
Attachments
- Active trackers with sensors
- Advanced GNSS Modules with high accuracy
- Fleet management system

Main topic “processes”: Simulation



Micro-/Meso-Simulation

Macro-Simulation



disturbances

boundaries

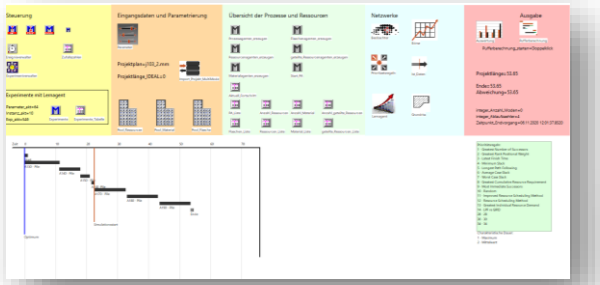
Working calculation

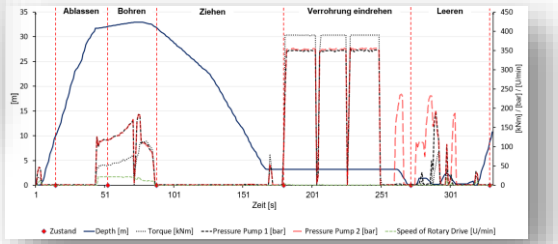
Detailed plan

variants

Execu-tion

Provided performance





Target-actual comparision

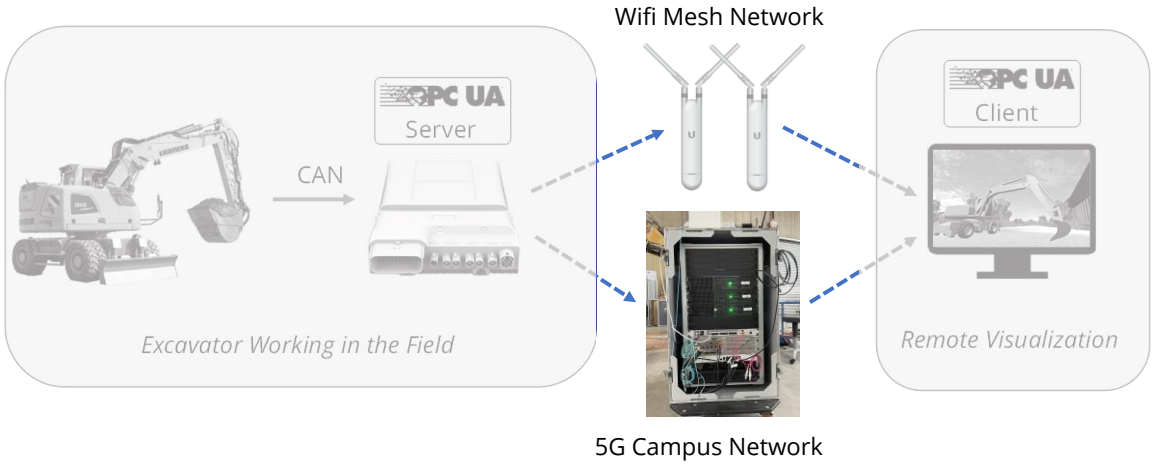
Activity recognition

i. A. [Fis-2021b]

Main topic “processes”: BIMsite

Main topic “Connectivity”: 5G Connectivity module

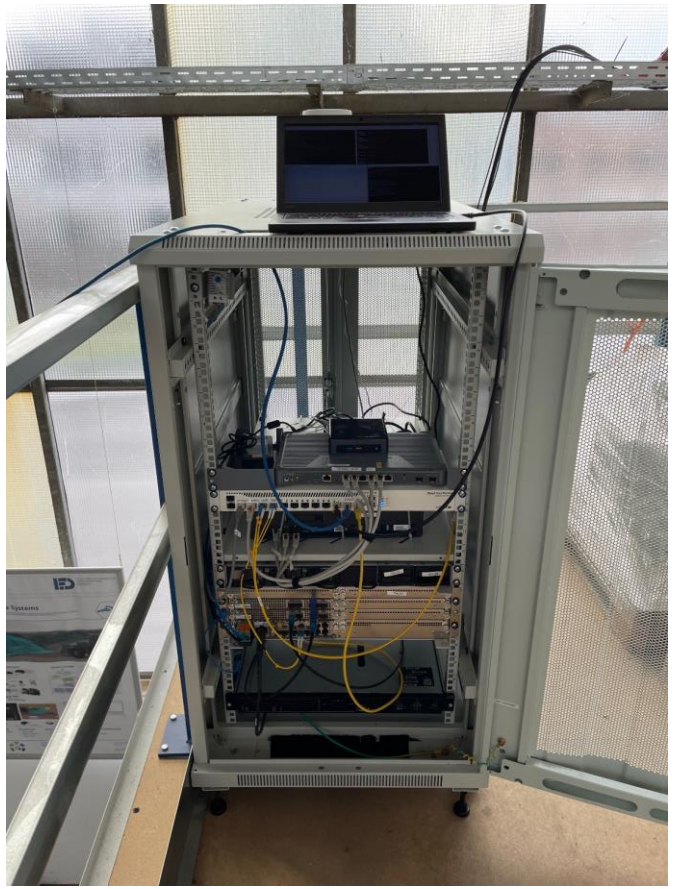
5G Campus and multi-connectivity



Special 5G connectivity module

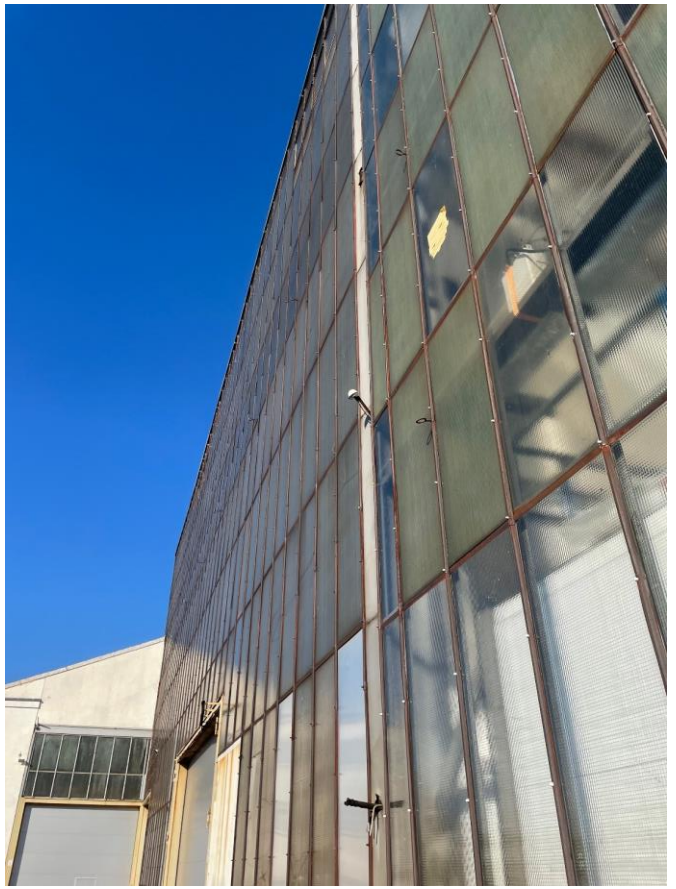
Main topic connectivity: 5G Campus components

5G Core, Baseband, Backhaul, MEC



Radio Unit

GPS



Overall solution: site control system

- **Mission data is submitted via OPC-UA interface**
- **Topografic mission data in annotated LandXML in accordance with ISO 15143-4**
- **Automation specific annotations**
  - geofences
  - trajectories
  - tracks
  - dump areas
  - target geometry

2 Demos

Demos within the main topics

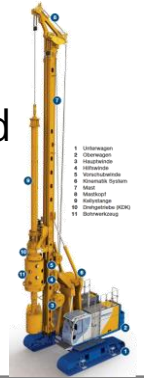
Automated, connected mobile machines

Vertical Integration via OPC UA

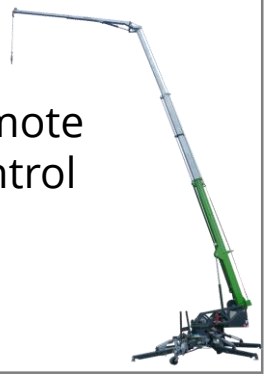
- Automated digging
- Automated tool change
- Detection “as built” condition

- Automated driving
- Environment recognition

- Automated processes



- Remote Control

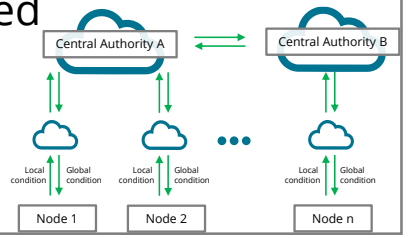


5G machine and construction site connectivity

- Mulit-Connectivity modul: WiFi, 5G, 4G, BLE…

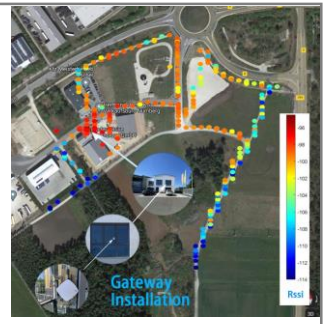
- Construction Site Networks: WiFi, 5G Campus

- Distributed Cloud Services



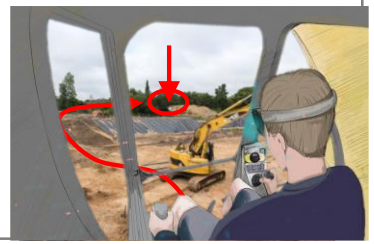
Processes and solutions for the digital construction site

- Tracking & Tracing of Material via LPWAN

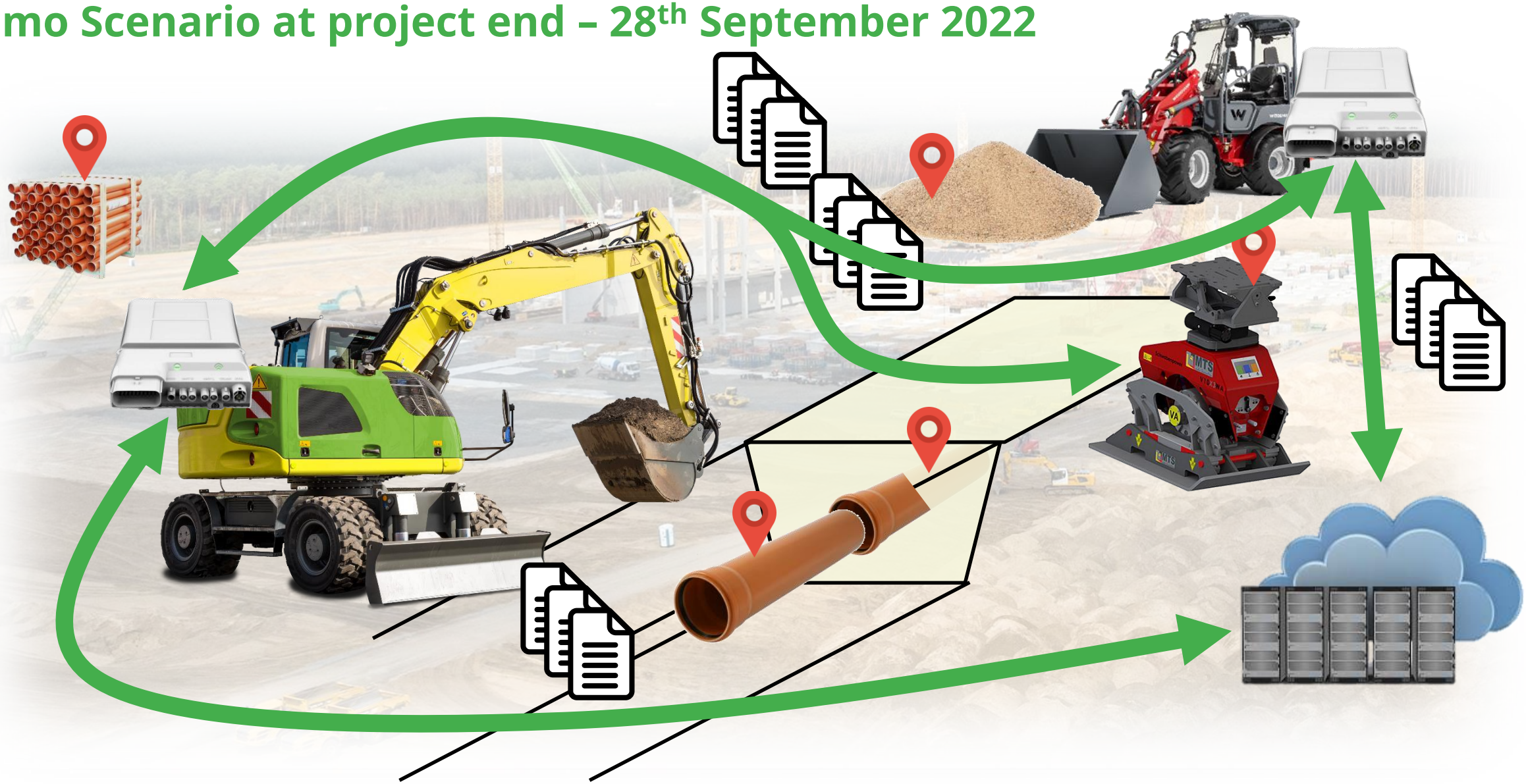


- Process optimization and progress prediction using simulation and machine data (e.g. with ISO 15143-3 data via OPC UA)

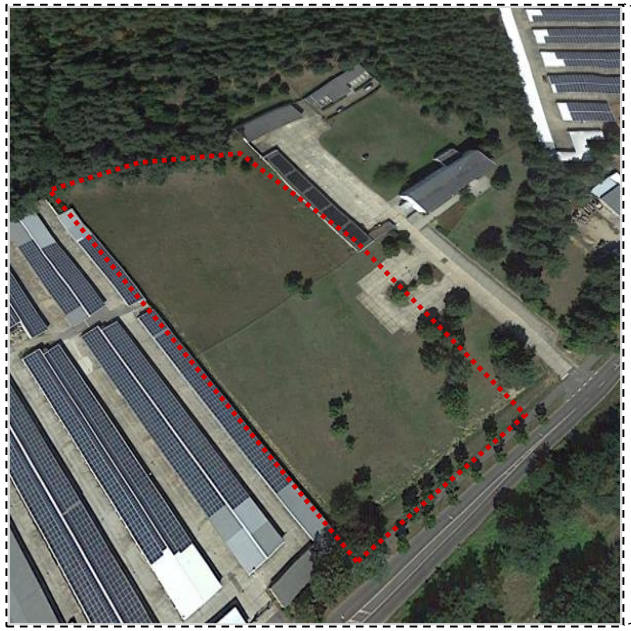
- AR-based driver assistance: Visualization via HoloLens

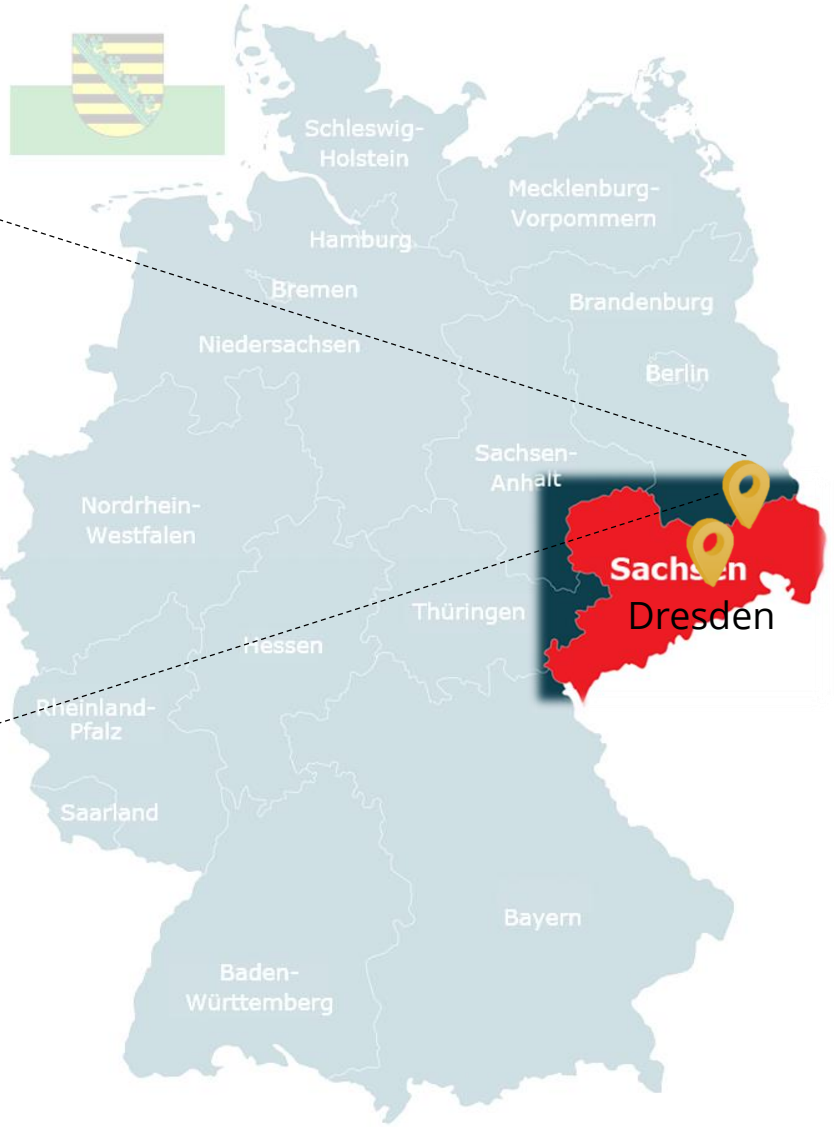


Demo Scenario at project end – 28th September 2022



Testing fields



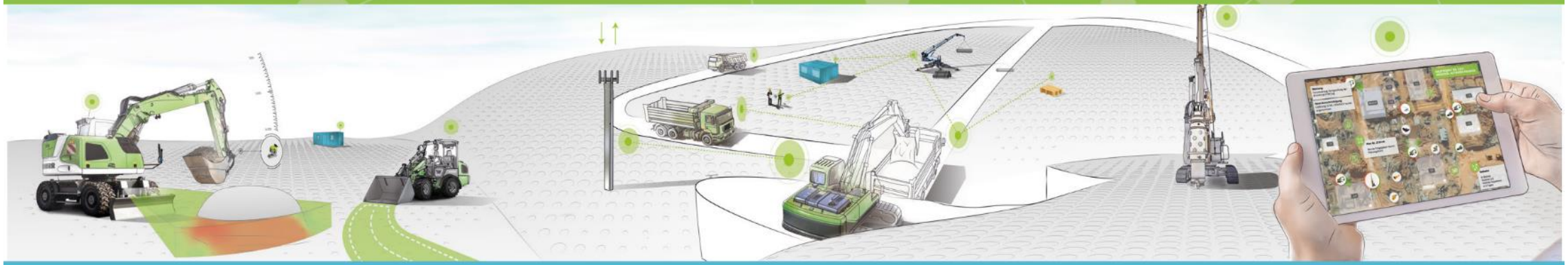


Industrial area Zeißig, Hoyerswerda

Save The Date

28. September 2022

Bauen-4.0-Abschlussveranstaltung
in Kooperation mit dem 5G Lab Germany
Forschungsfeld Lausitz



Bauen 4.0

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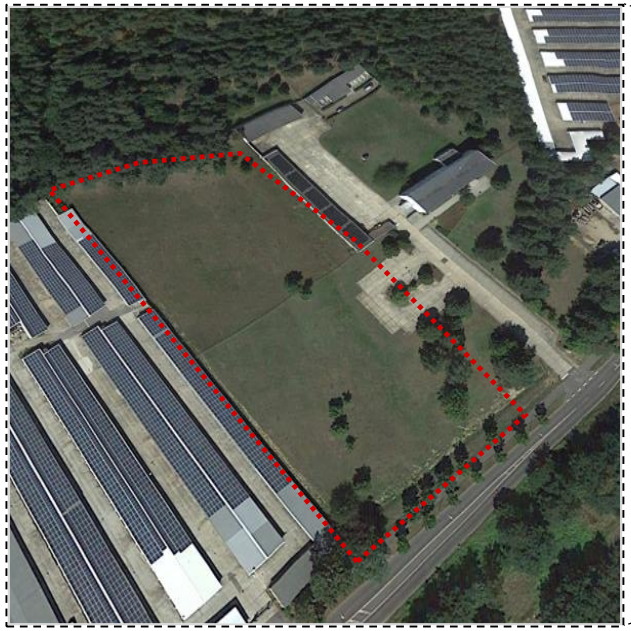
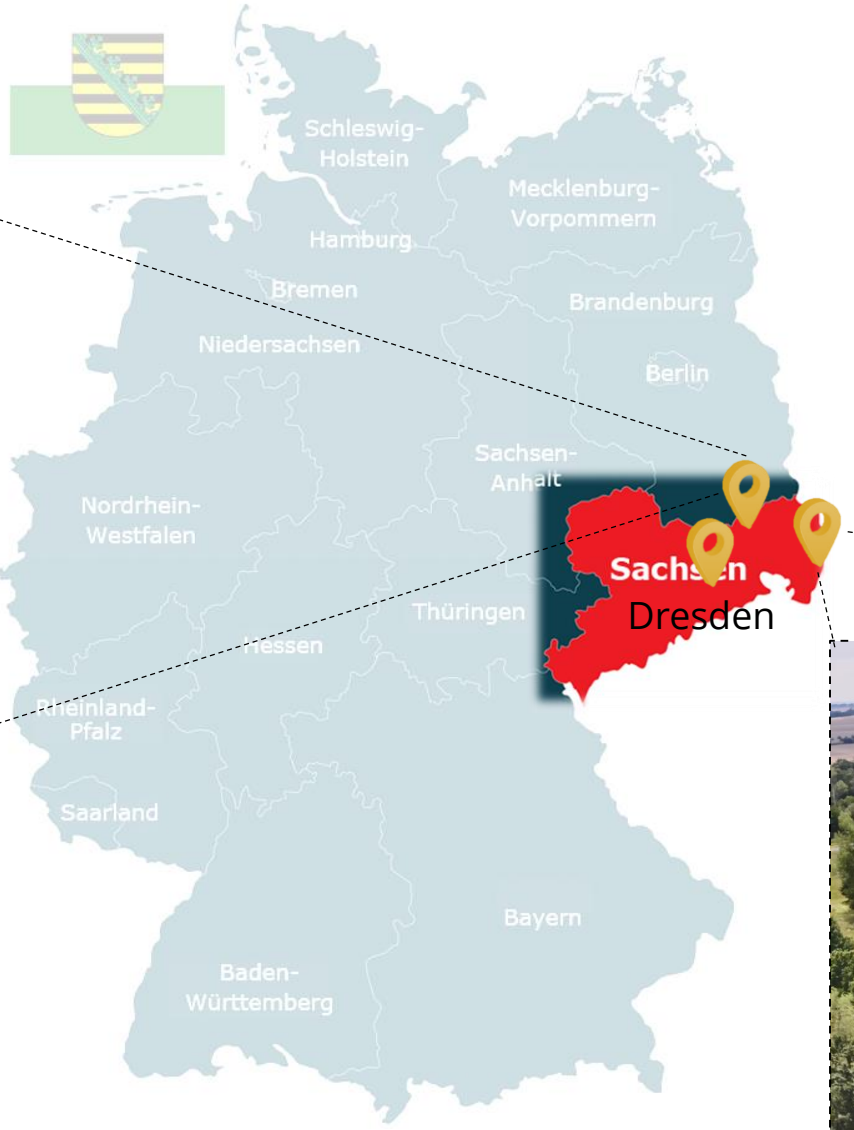
https://www.vdma.org/kalender/-/event/view/71487

4 Outlook

Testing fields



Industrial area Zeißig, Hoyerswerda

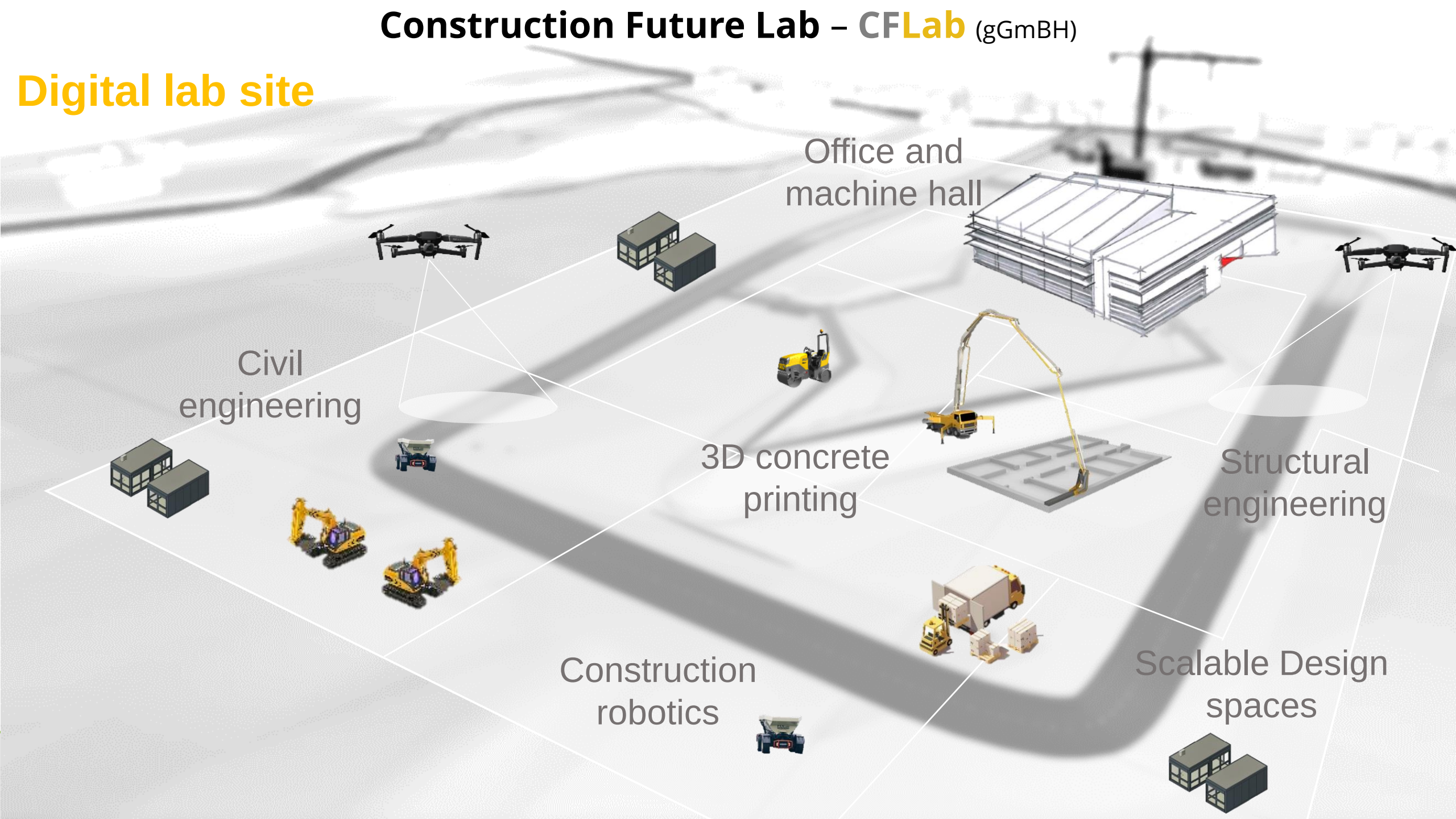


Industrial area Görlitz

https://youtu.be/zSP7ZykJe_U

Construction Future Lab – CFLab (gGmBH)

Digital lab site



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Institute of Mechatronic Engineering

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Imagefilm_EN

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