Digitalization of Tunnels

Current Developments

ITA COSUF Workshop, Hamburg

06.12.2023 | Univ.-Prof. Dipl.-Ing. Dr. Matthias Flora

» "You can have data without information, but you cannot have information without data."
Daniel Keys Moran

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Operational Safety of
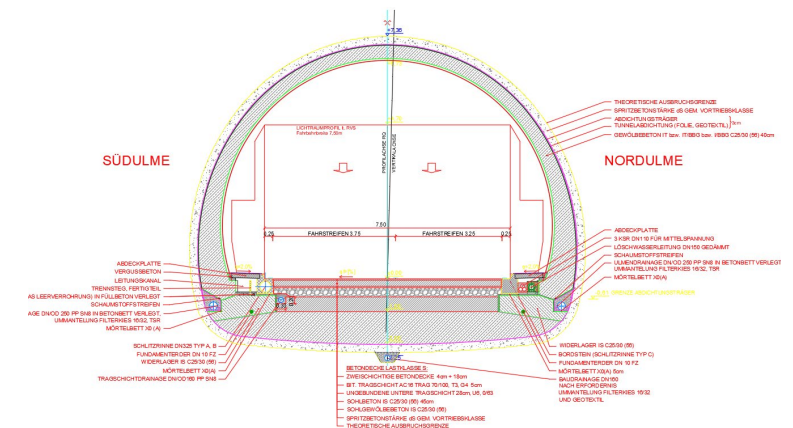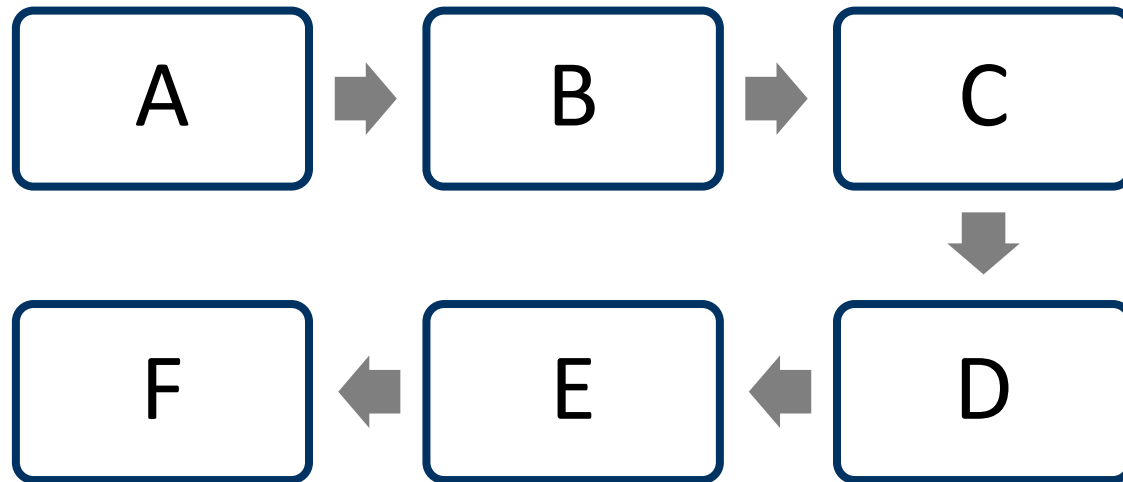Underground Facilities

1 Starting point

sequential   singular   2D-world

A → B → C

F ← E ← D
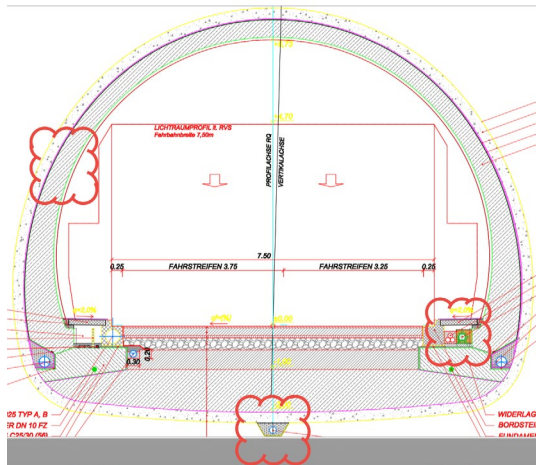
1 Beginning of Digitalization

- Digital data capture on site (e.g. laser scans)

- Management software (e.g. plan-management)
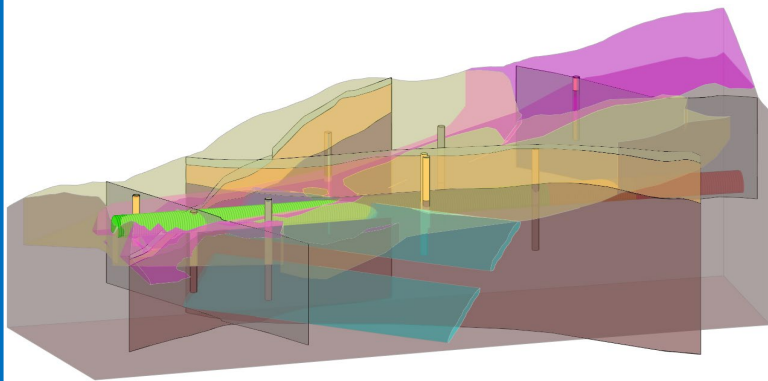
- Digital tools (e.g. digital markup)
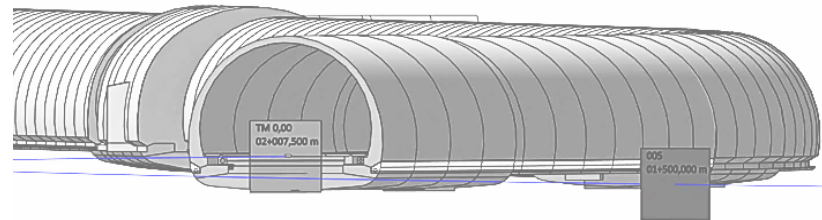
1 Limitations

2 Tunnel Information Modeling (TIM)

Ground Model

Structure Model

Construction Site Model
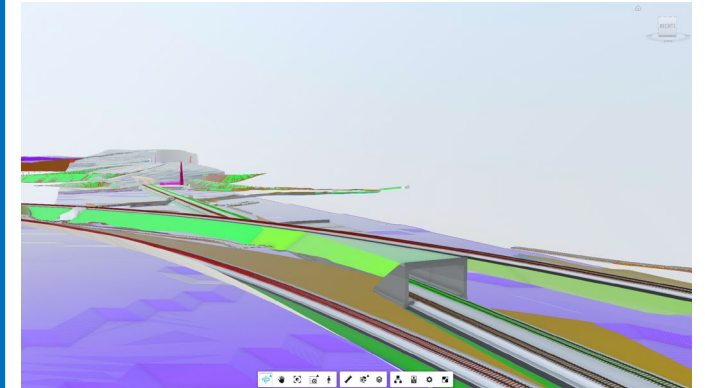
current developments iBT UIBK

2 Ground Model
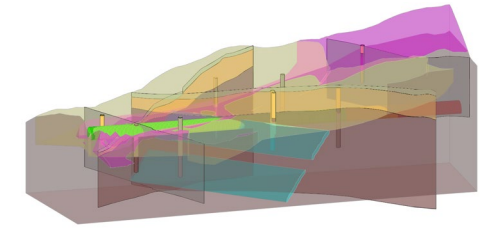
- **GeoDocu Model**
  - Ground investigation
  - Factual data (boreholes, seismik, …)
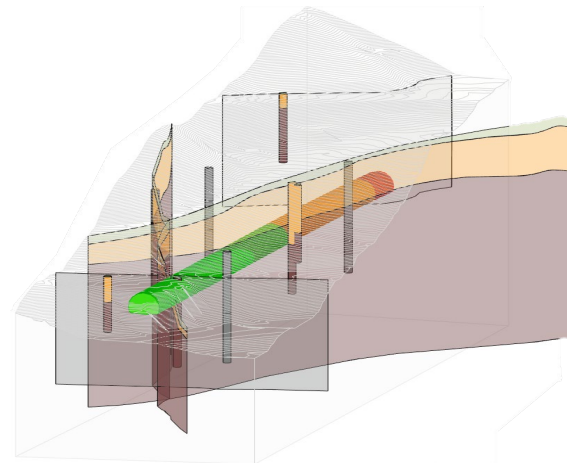
- **Interpreted Model**
  - Prognosis of ground
  - Reliability of prognosis
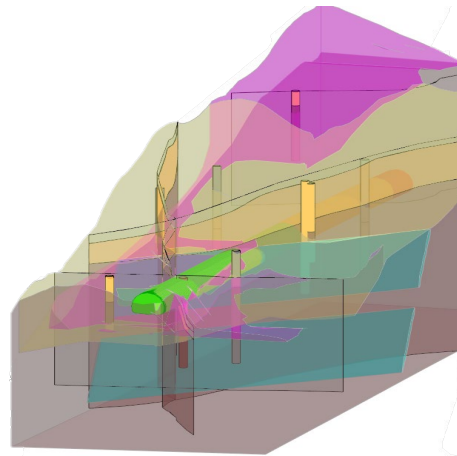
- **Synthesis Model**
  - Geological/Geotechnical Properties
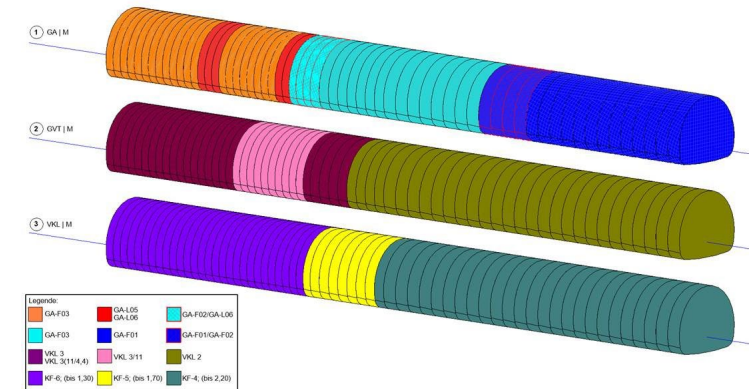
2 Structure Model

- Structured preparation of data basis

- Component library

- Semi-automated modelling

- Semi-automated attribute integration
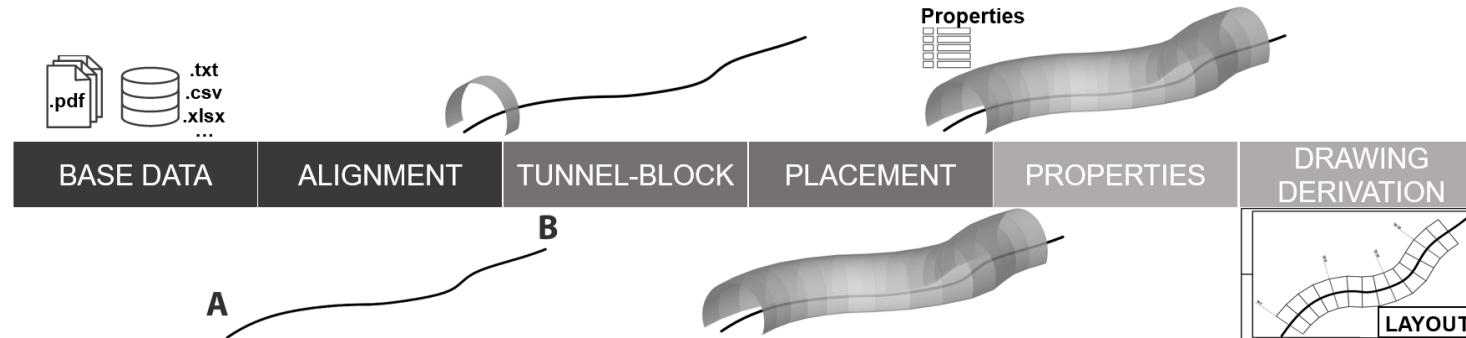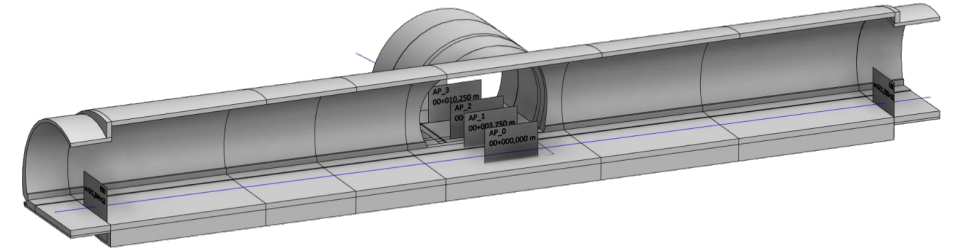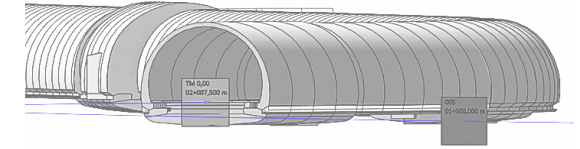
2 Limitations

- Interconnection with database → ever higher data creation

- Simulations (i.e. construction site, structural analysis)

- Operation of tunnel → far longer period than the construction

- Contract model – billing, as-built, current project status, prognosis
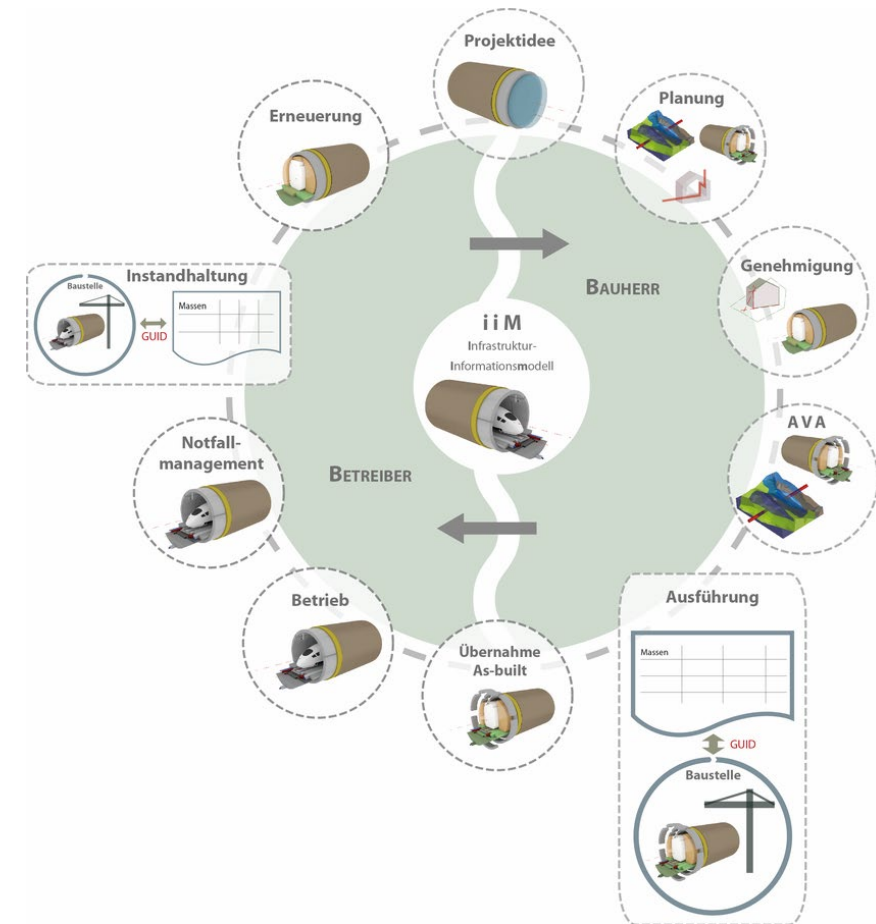
3 Digital Twin

Definition and development of digital twins further advanced in other sectors → utilise knowledge

Generation of Digital twins not limited to operation phase, but also during excavation

Potentials

- More efficient operation
- Early detection of problems
- Optimisation of construction site logistics
- Optimisation of sustainability

Digital Model

Physical Object

Virtual Object

Digital Shadow

Physical Object

Virtual Object

Digital Twin

Physical Object

Virtual Object

- - - → Manual Data Flow ——→ Automatic Data Flow
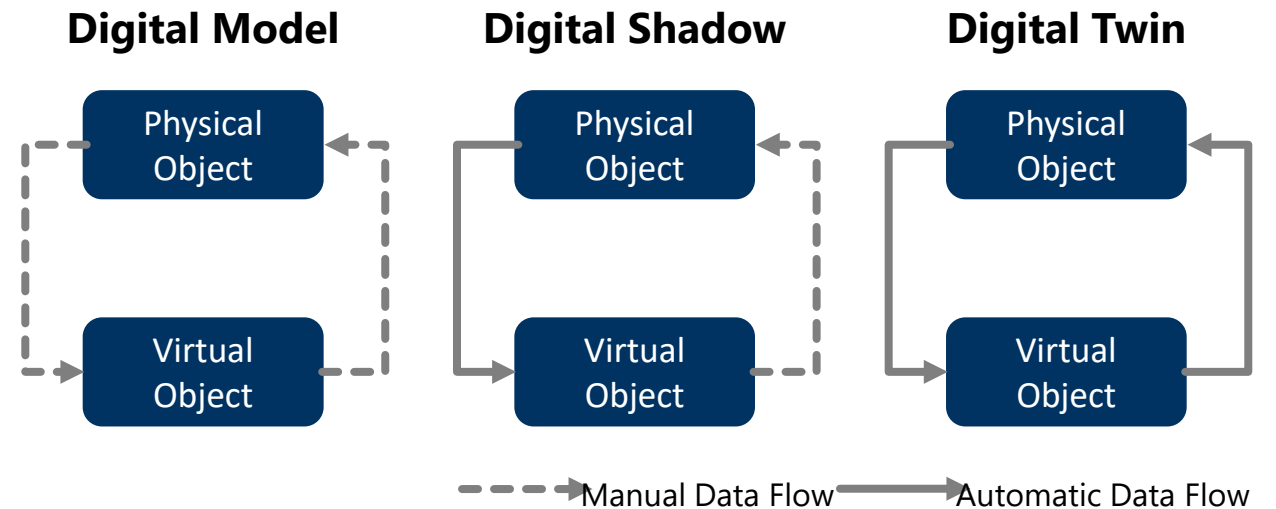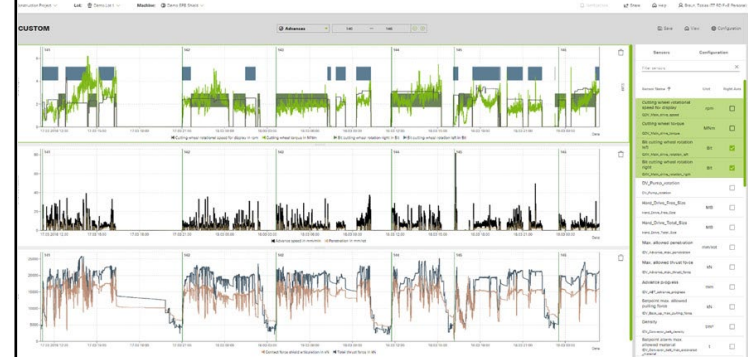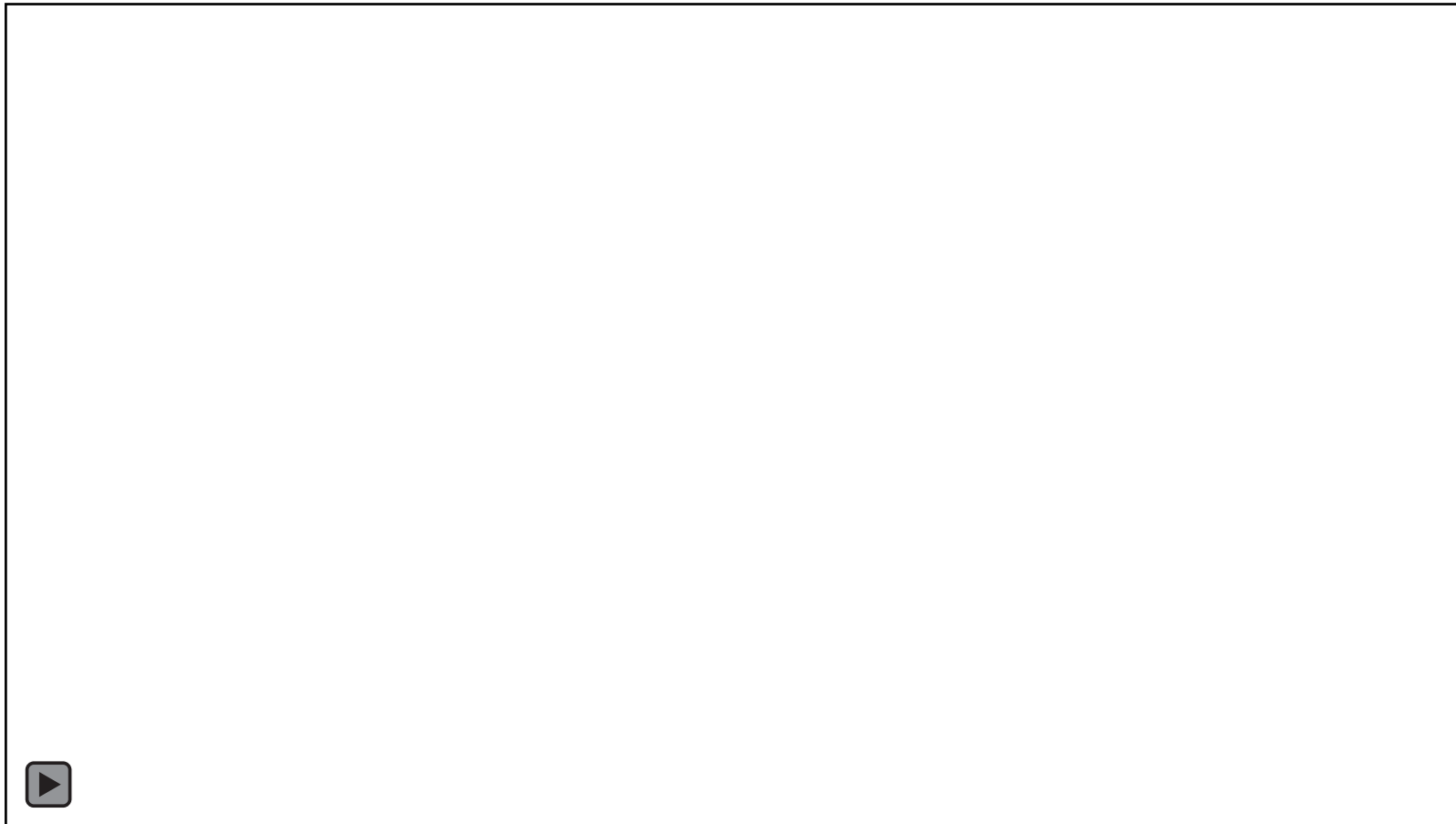
3 Digital Shadow

→ **Digital shadows particularly for monitoring purposes**

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3 Digital Twin - Structure

Systems

ERP FM EMS

TIM

Information

Dynamic Data

Documents

Physical object

Sensor Data

Actuator Data

Data processing and analysis

e.g. simulation, control, machine learning, AI, ...

Digital Model

Digital Shadow

Digital Twin

3D Models
from TBMs, tunnelling equipments, etc.

sensor data
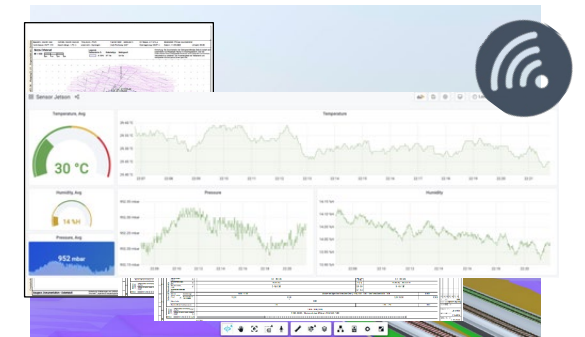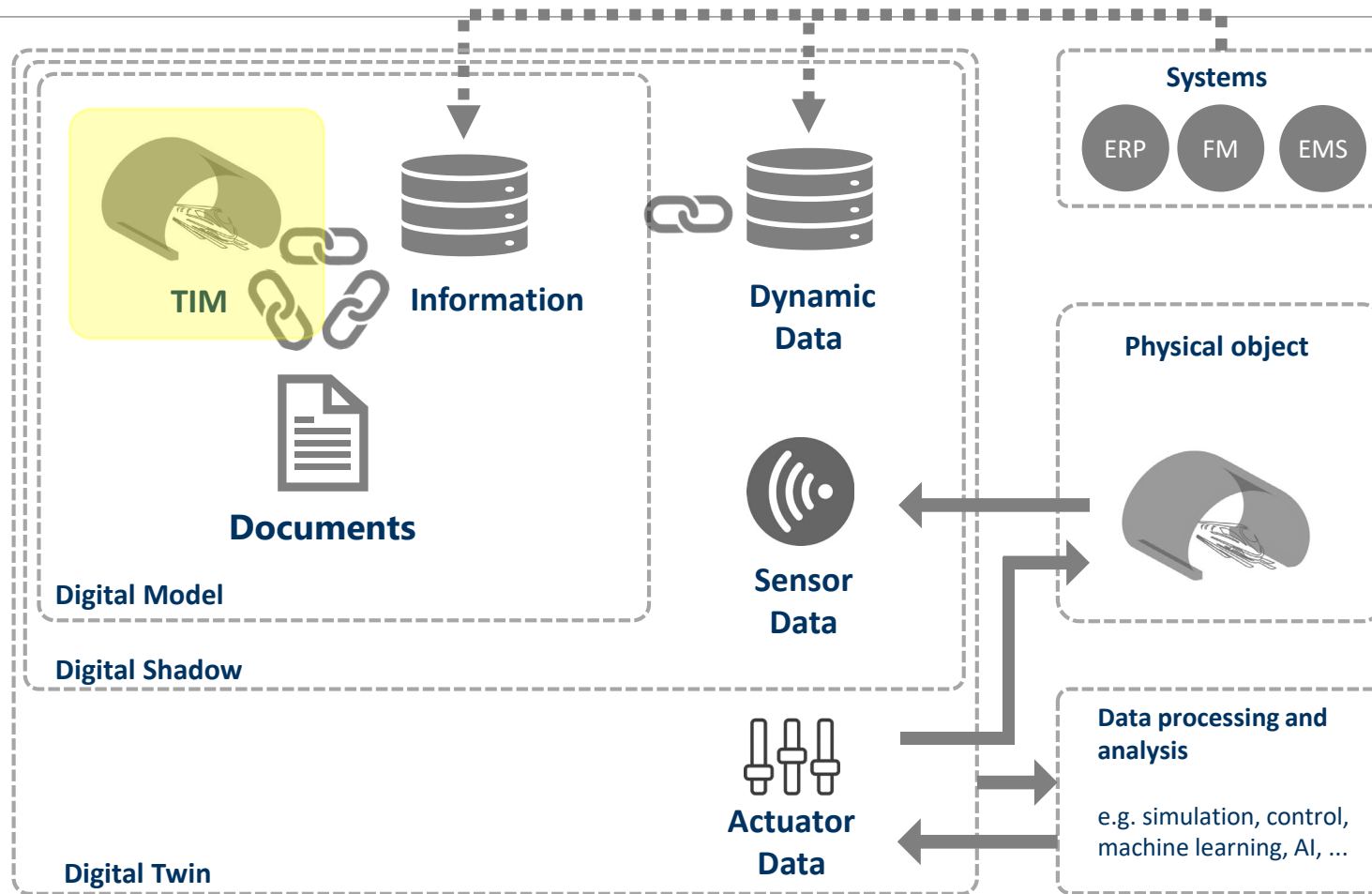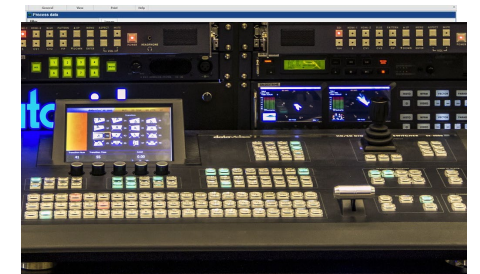
dynamic system data
e.g. machine data, process data, load data, weather data, data ...

Actuator data
e.g. maintenance instructions, traffic controls, operating parameters, alarms

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4 Future – System of Systems

Tunnel	Smart Tunnel	Connected Tunnel Systems	System of Tunnel Systems	System-of-Systems (Smart City)

Tunnel

Tunnel + Regulation System

Tunnel + Ventilation System + TBM ... = Digital Shadow Tunnel

Digital Shadow Tunnel + Traffic System + Ventilation System + Segment production + TBM = Digital Twin Tunnel

Digital Twin Tunnel + Smart Energy + Smart Transportation + Smart Administration + Smart Buildings

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Beginning of Digitalization

PATH OF DIGITALIZATION

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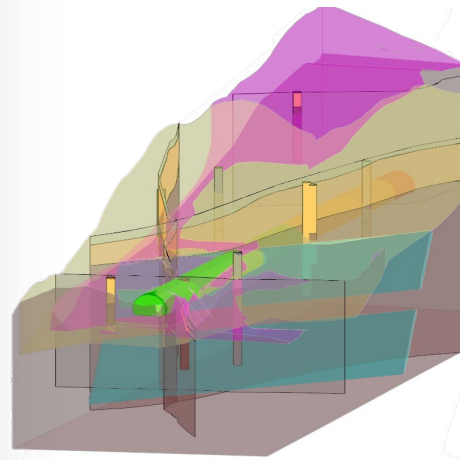
PATH OF DIGITALIZATION

1

Beginning of Digitalization

2

Tunnel Information Modeling

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1

2

3

Beginning of Digitalization

Tunnel Information Modeling

Digital Twin

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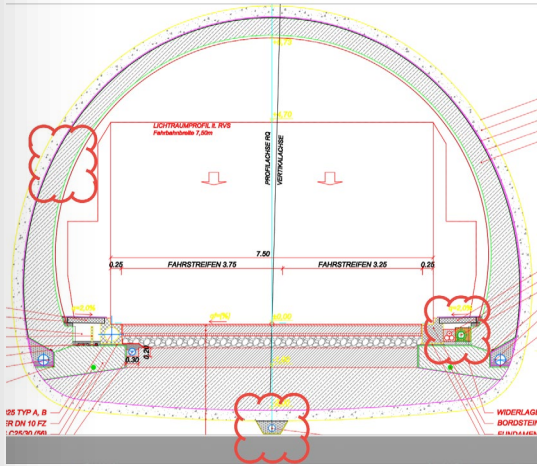Operational Safety of Underground Facilities

1 2 3 4

PATH OF DIGITALIZATION

Beginning of Digitalization

Tunnel Information Modeling

Digital Twin

Future

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Let's discuss