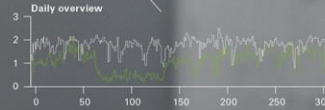
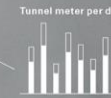
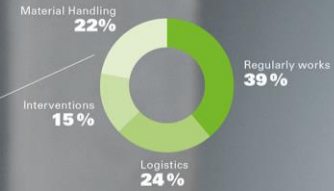
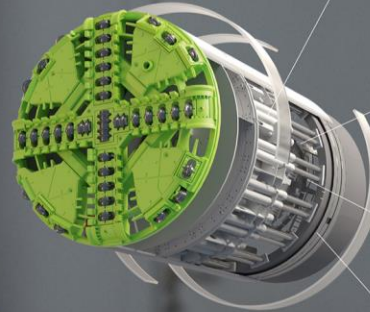


**VISUALIZATION
REPORTS DATA**

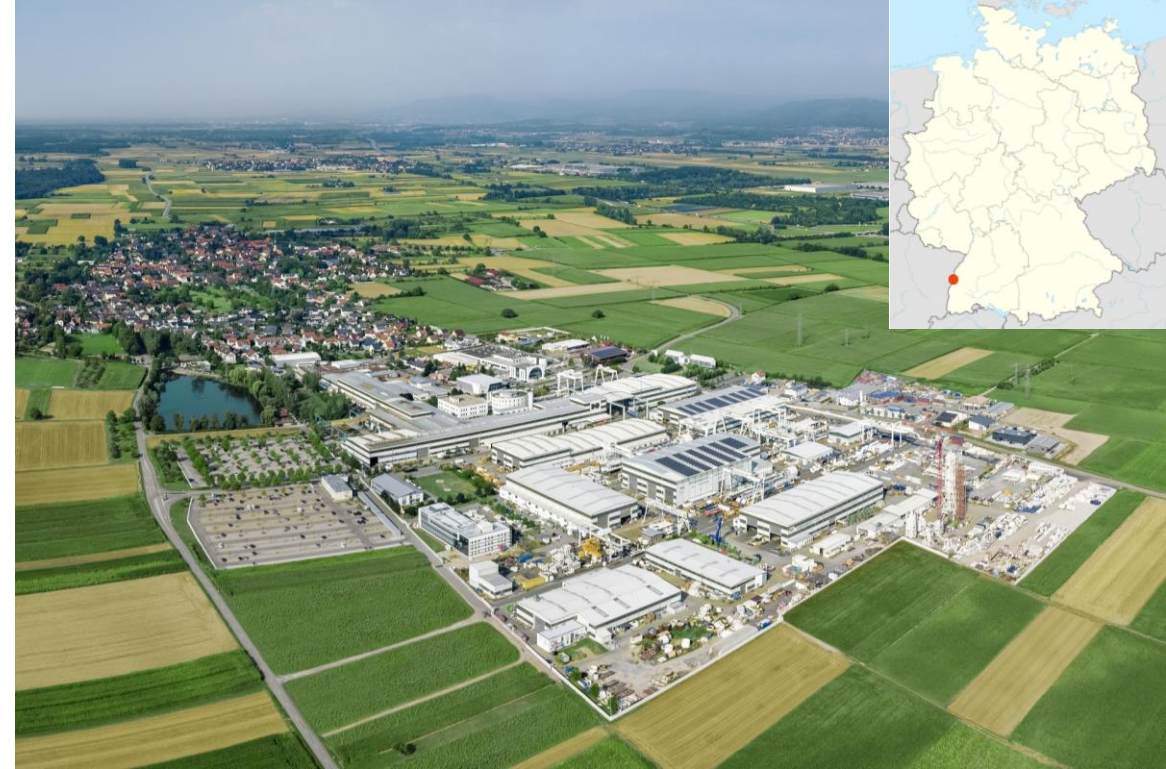


HERRENKNECHT.CONNECTED

**YOUR EXCLUSIVE CUSTOMER
LINK TO THE DIGITAL WORLD
OF TUNNELLING**

HERRENKNECHT IN ZAHLEN

- › gegründet 1974
- › Firmensitz in Schwanau
- › rund 5,000 Mitarbeiter weltweit
- › Ca. 200 Auszubildende & Studenten
- › Weltmarktführer

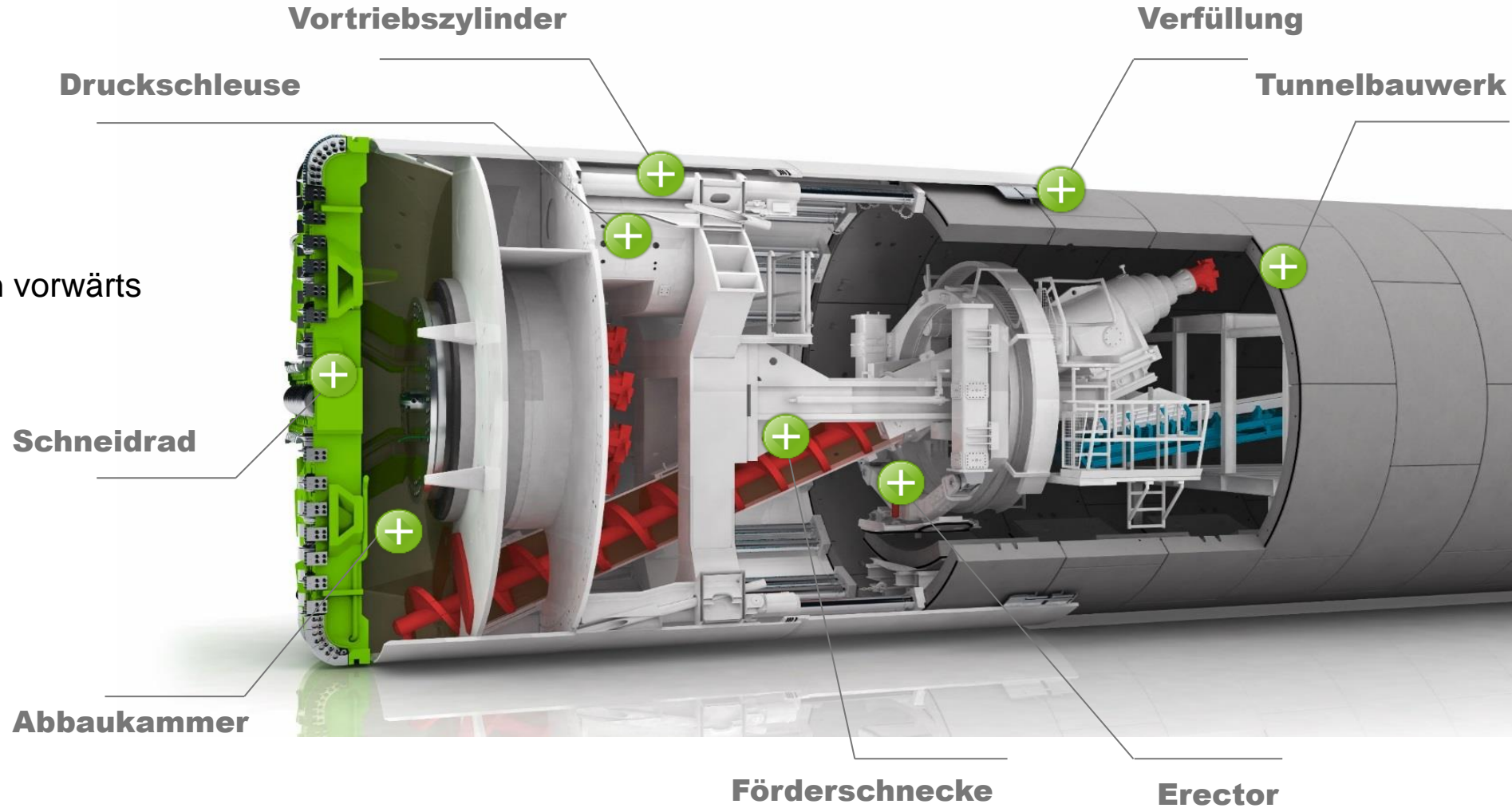


- › weltweit 70 Standorte
- › Durchmesser von 30 cm bis zu 19 m
- › mehr als 5.300 Referenzen
- › 2 Durchbrüche pro Woche
- › Rund 1 Mrd. Umsatz im Jahr

MASCHINELLER TUNNELBAU

Individuell für jedes Tunnel-Projekt

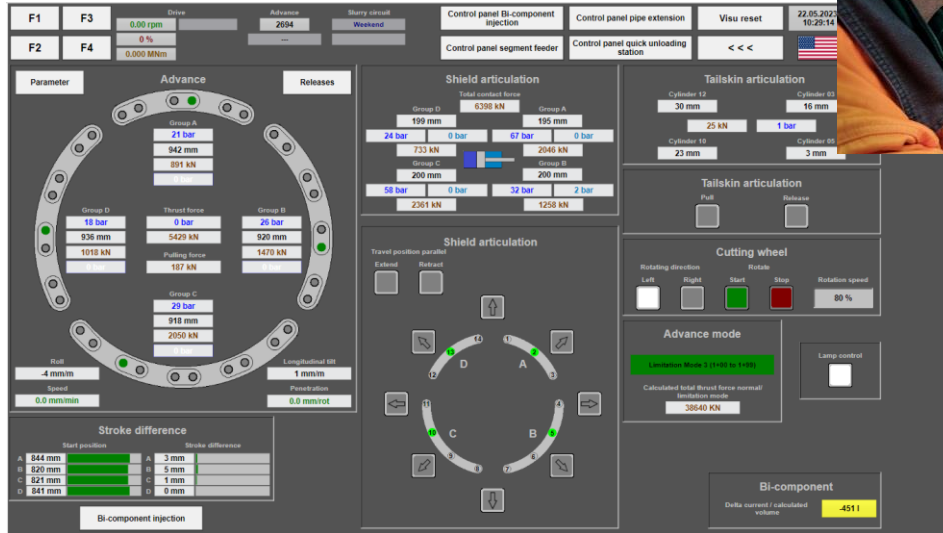
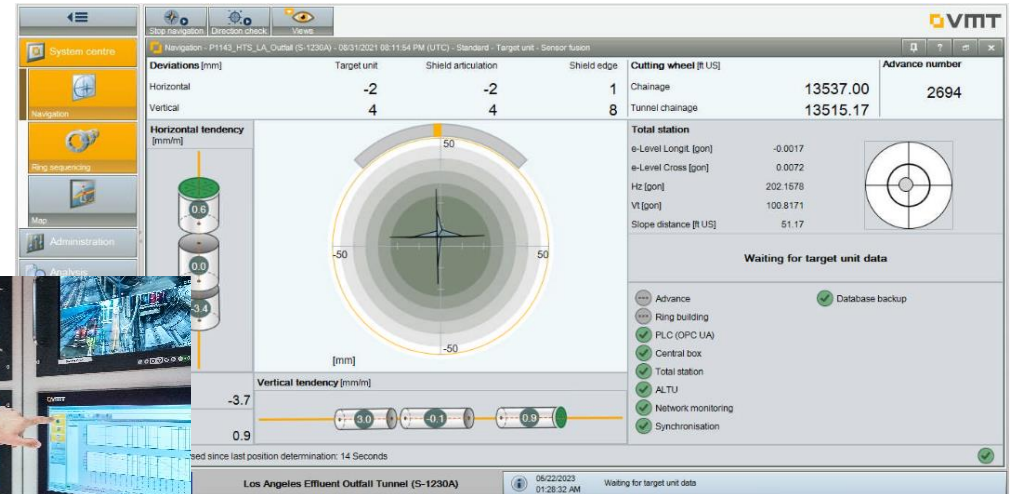
- › Material ausheben
- › Tunnelbauwerk errichten
- › Hydraulikzylinder drücken vorwärts
- › Geplanter Trasse folgen



UNSERE VISION

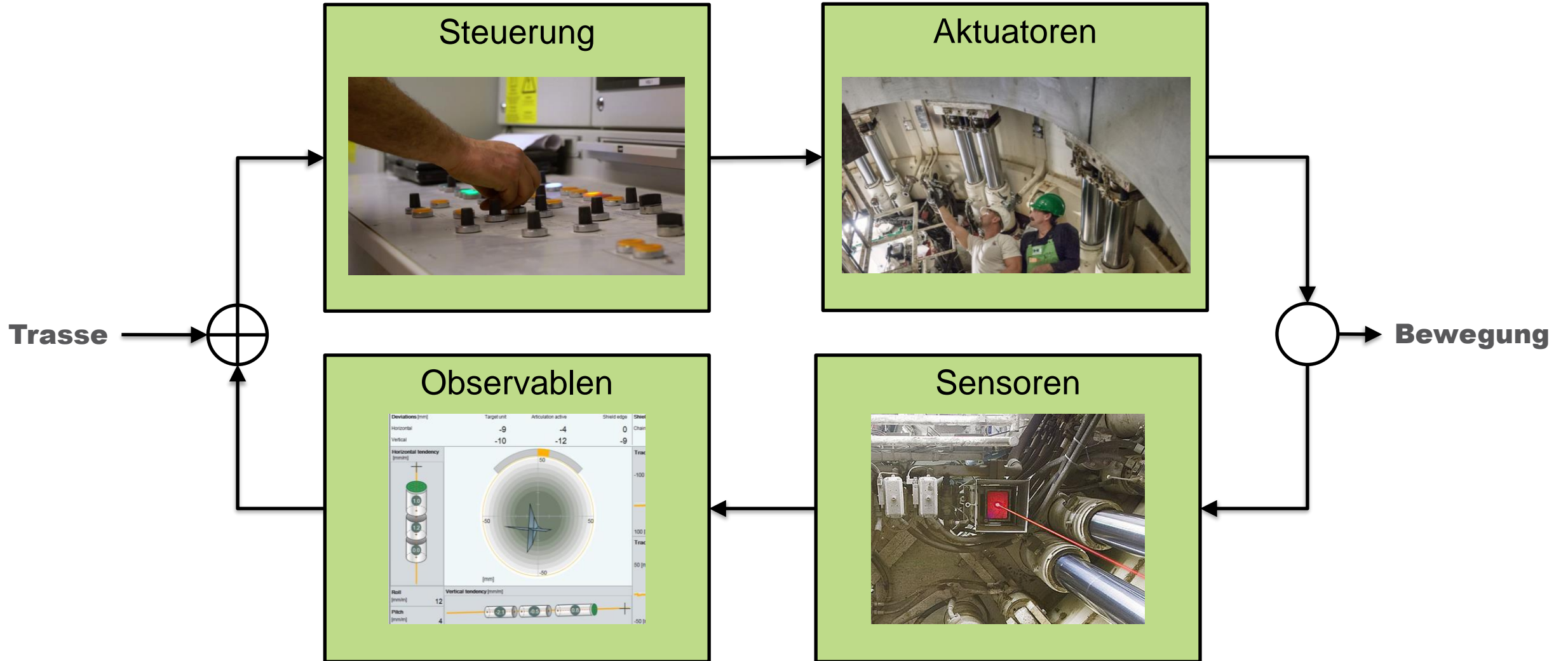
Die Autonome Tunnelbohrmaschine

- › Zahlreiche Prozesse
 - › Beispiel: Richtungssteuerung
- › Von Menschen überwacht und geregelt
- › Reales Experiment
 - › Große Risiken und Gefahren
- › Virtuelle Testumgebung



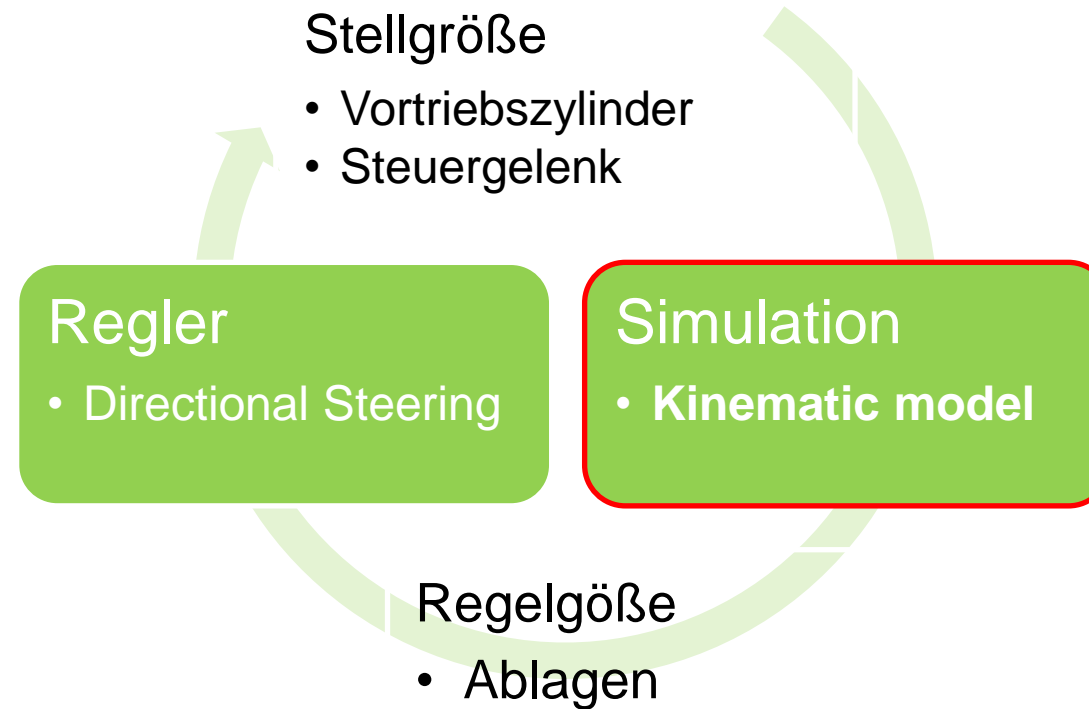
RICHTUNGSSTEUERUNG

Manuell gesteuerter Regelkreis



AUTOMATISIERUNG DER RICHTUNGSSTEUERUNG

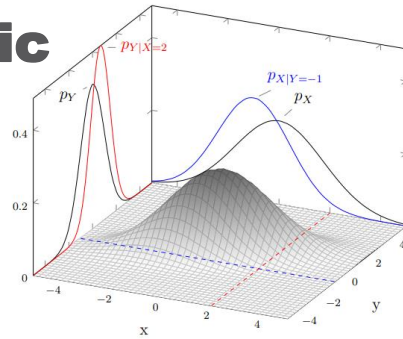
Entwicklung einer virtuellen Testumgebung



KINEMATISCHES MODELL

Simulation der TBM Bewegung

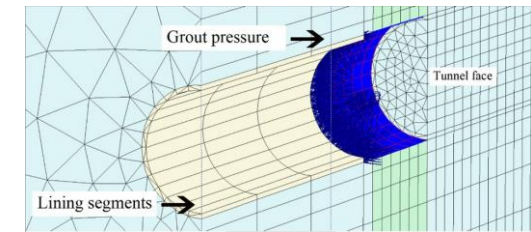
Stochastic



S. Mauerberger, 2022

- ▶ Data Intense
- ▶ Observational errors
- ▶ Unique projects

Deterministic



M. Forsat, 2021

- ▶ Compute intense
- ▶ Precise physics
- ▶ Unknown subsurface

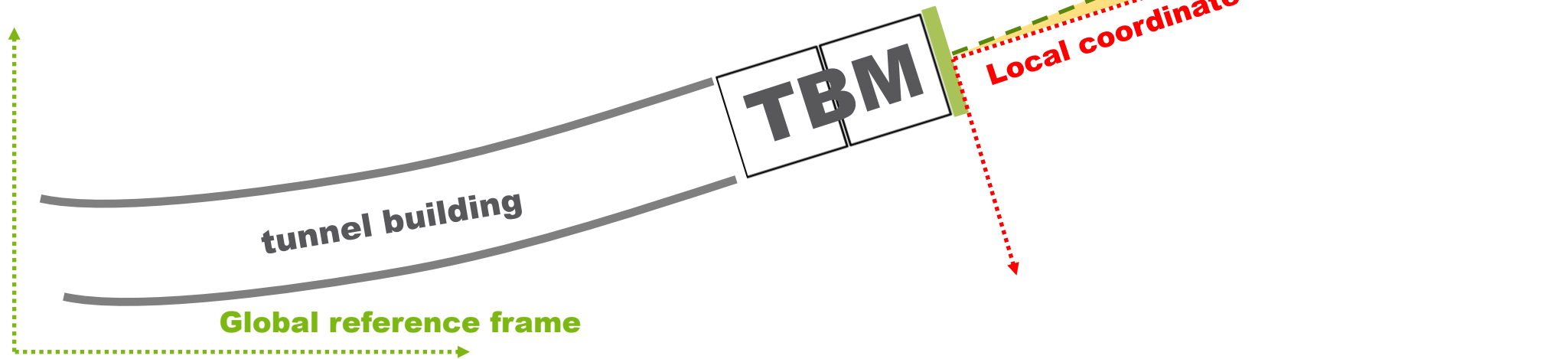
Hybrid

- ▶ Coarse physical principles
- ▶ Transfer of historic data

KINEMATISCHES MODELL

Annahmen und Datenmodell

- › An articulation of the shield introduces changes in direction
- › Resulting radii of the track are related to that articulation
- › Geology is not considered
- › Spatial orientation has no influence on the direction control
- › Change in direction is quantified by the curvature of the track



1st pitch: Estimate a linear relation between change in direction and shield articulation.

PROTOTYPE TEST

Vorhersage der Bewegungsrichtung

- Relevante Umgebung
- Experimentelles Setup
- Produktiver Einsatz



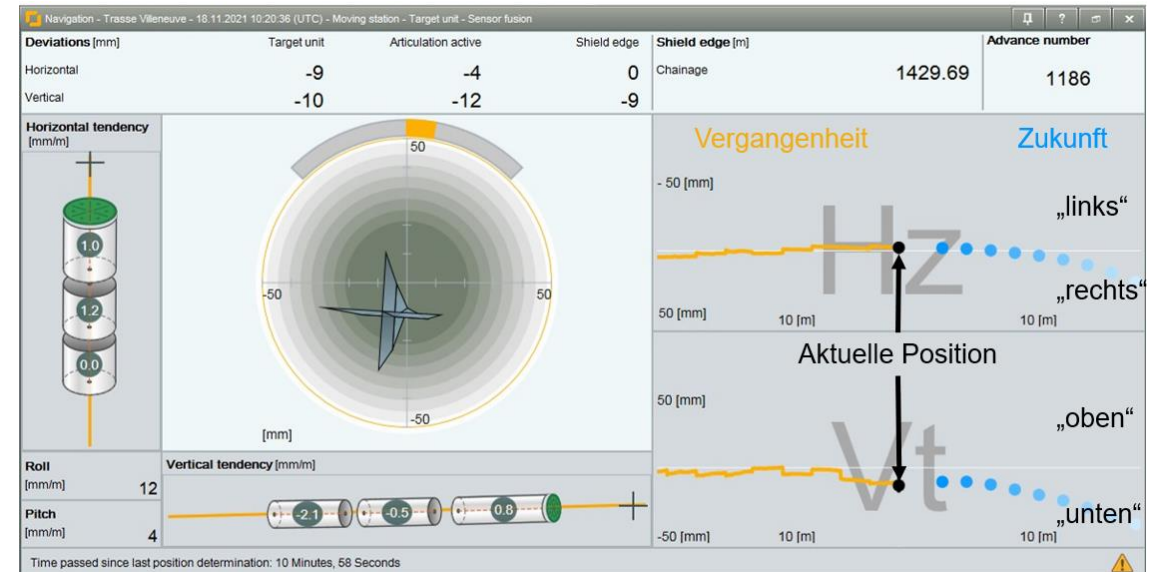
Inside the TBMs control cabin



On site

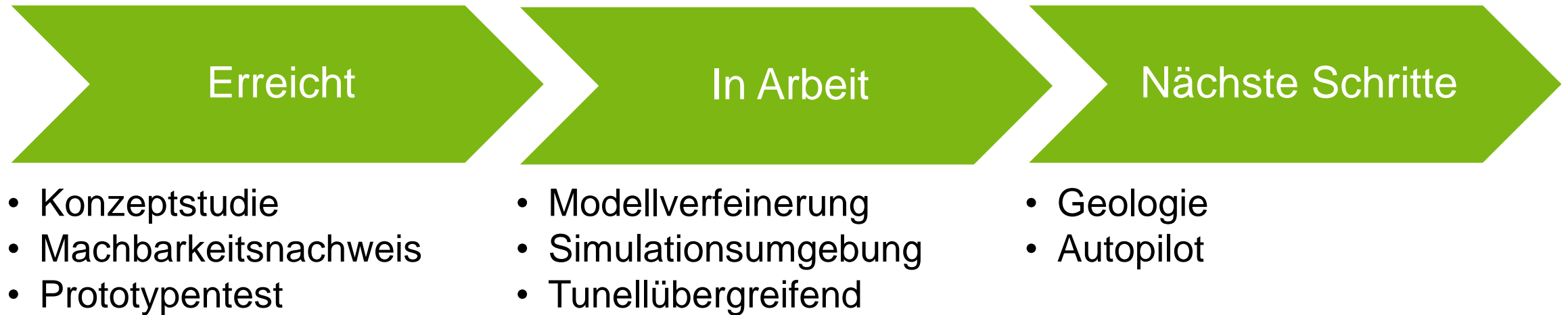


Edge device



Extended GUI visualizing the predictions

PROJEKTSTATUS



AKTUELLE MATERARBEITEN

Modell-Generalisierung

Rehnuma Ananya

Uni Magdeburg

Knowledge Management & Discovery Lab

Prof. Myra Spiliopoulou



Predicting the Movement of Tunnel Boring Machines with ARIMAX and Transfer Learning

Simulation & Regelung

Fabian Müller

HS Offenburg

Machine Learning and Analytics

Prof. Janis Keuper



Entwicklung und Validierung eines Machine Learning Algorithmus zur Automatisierung des Schildsteuergelenks von AVN-Maschinen im maschinellen Tunnelvortrieb

Modell-Entwicklung

Shreyas Dattashivarama

TU Hamburg

Digitales und Automates Bauen

Prof. Kay Smarsly



Investigation of data-based regression methods for modeling the movement of tunnel boring machines