

HERRENKNECHT

ULTRA-LONG TUNNEL DRIVE

for the construction of the mineral transport for the Woodsmith Project
Polyhalite Mine

Mine Safe 2025, November 2025

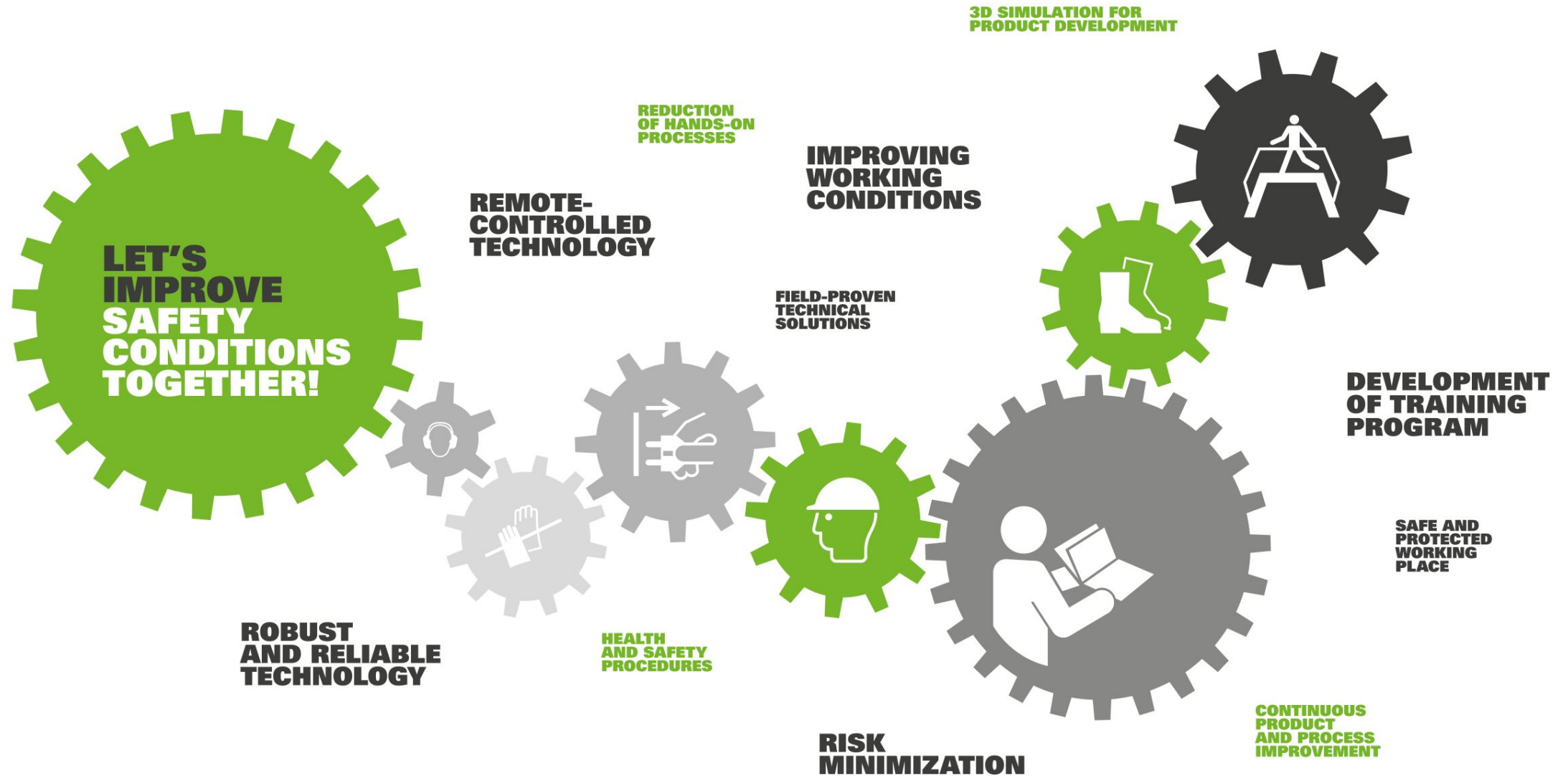
Dr. Karin Böppler

Presenter: Danie Roos



Safety First

SAFETY SHARE



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INTRODUCTION

HERRENKNECHT IN GERMANY

Strongly rooted in the location of
Schwanau and the surrounding region

Around 2,400 employees work in
Schwanau and Kehl

Our long-term and sustainable thinking is
reflected in our support of education,
environment and society



Key figures

HERRENKNECHT GROUP

1,394

Total output
2024 in million euros

1,288

Revenue
2024 in million euros

1,473

Incoming orders
2024 in million euros

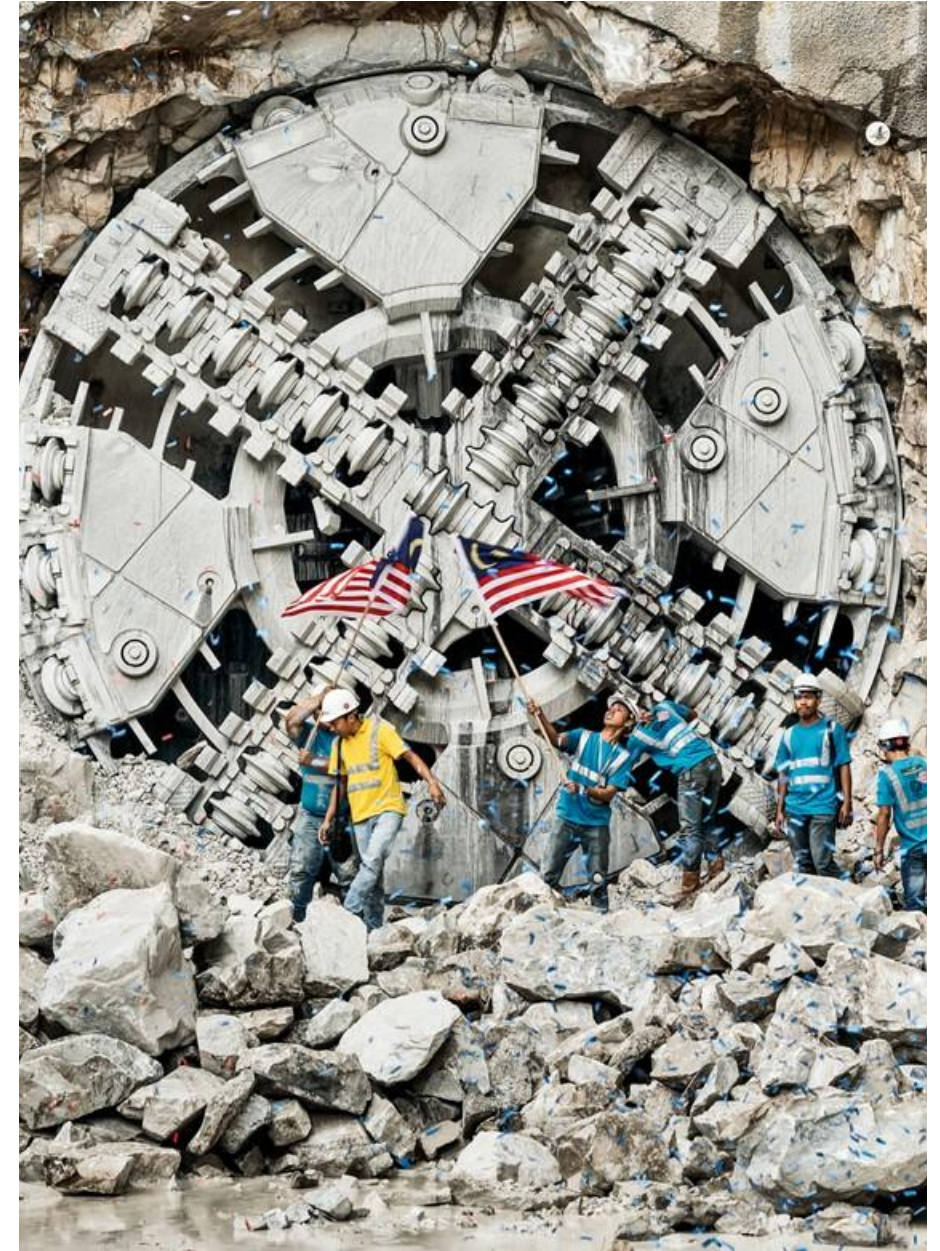
EMPLOYEES WORLDWIDE

5,490

Employees
at the end of 2024

215

Trainees
at the end of 2024



Key figures

A UNIQUE LEGACY WORLDWIDE

6,200

Projects
completed

> 1,300

Metro projects
with > 3.000 km length

850

Utility machines
in operation

> 800 km

Railway tunnel

> 375 km

Road tunnel



Kai Tak Development Trunk Road T2, Hongkong

TUNNELLING

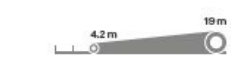


EPB Shield



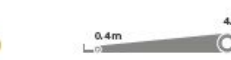


Mixshield





AVN Machine





Multi-mode TBM





Single Shield TBM





Gripper TBM





Double Shield TBM





Vertical Shaft Sinking Machine VSM





Direct Pipe®



MINING



Pipe Express®





HDD Rig





SDD Rig





Partial-face Excavation Machine





Auger Boring Machine





Shaft Boring Roadheader SBR





Shaft Boring Machine SBM





Shaft Boring Cutterhead SBC





Extension Shaft Boring Machine SBE



EXPLORATION



Shaft Drilling Jumbo SDJ





Raise Boring Rig RBR





Boxhole Boring Machine BBM





Boxhole Back Reaming BBM





Reef Boring Machine RBM





Terra Invader Slingshot Rig





Terra Invader Rack & Pinion Rig





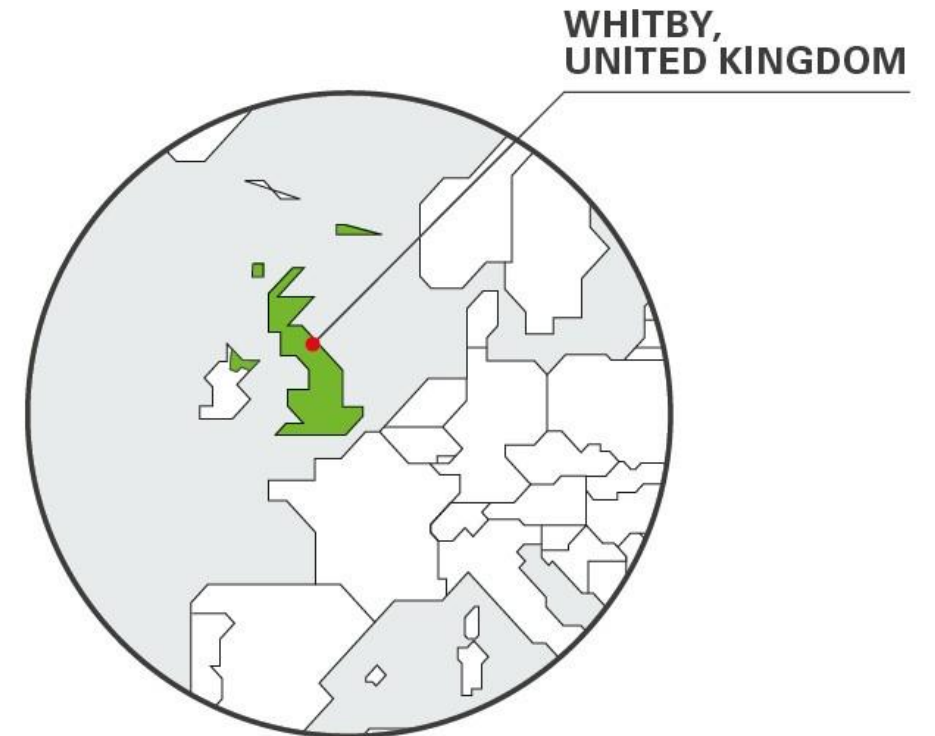
Terra Invader Cantilever Rig



Ultra-Long Tunnel Drive

INTRODUCTION

- Mining project located in Western Europe
- Sensitive landscape in the north-east of England
- Project contains the largest and highest-grade resource of polyhalite worldwide



Ultra-Long Tunnel Drive

INTRODUCTION

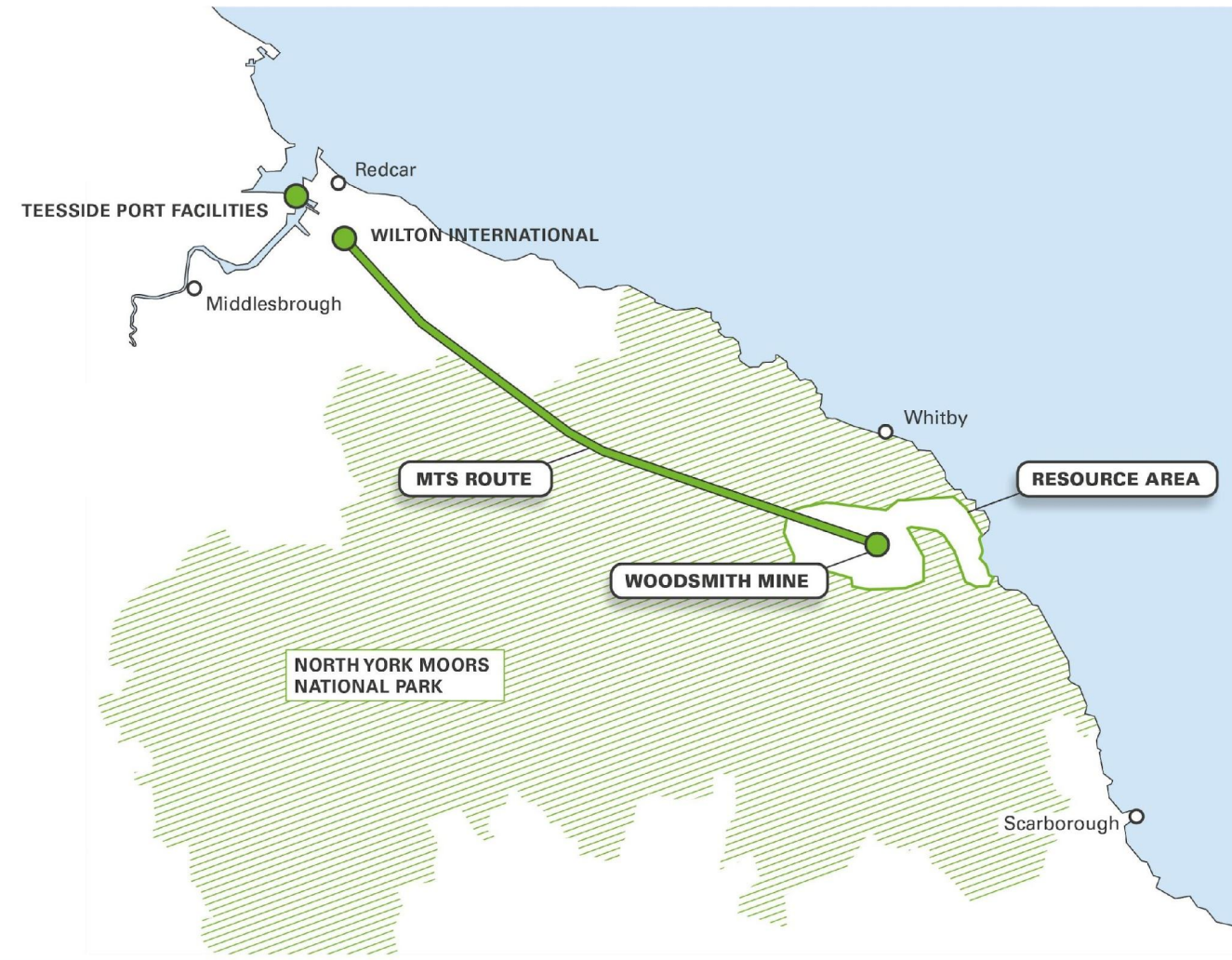
- Mineral from a deep polyhalite seam will be extracted from reserves beneath the North York Moors National Park extending eastward underneath the North Sea
- The dry mineral will be raised at a production shaft and to be transported via a Mineral Transportation System (MTS) to a processing site
- Ultra-long mechanized tunnel drive of 37km using a Ø5.94m Single Shield TBM
- Once in full operation, the Woodsmith Mine is planned to produce up to 20 million tons per annum



Ultra-Long Tunnel Drive

GENERAL PROJECT OVERVIEW

- Project: Woodsmith Mine
- Owner: Anglo American Crop Nutrients
- Underground Mineral Transport from Woodsmith Mine production shaft to Mineral Handling Facility (MHF) on Wilton processing site
- Mineral Transport System (MTS):
 - 37km long MTS tunnel with a diameter of 4.9m
 - Average depth of 250m below ground
 - 1x Single Shield TBM Ø5.94m
- MTS tunnel with a high-capacity conveyor belt system capable of transporting 20 million tons per annum of polyhalite at 7.5m/s



Ultra-Long Tunnel Drive

PREDICTED GEOLOGICAL CONDITIONS

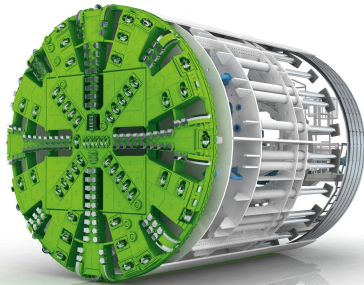
- TBM drive entirely in the Redcar Mudstone
 - Grey, fossiliferous, fissile mudstones & siltstones with occasionally thin limestone beds & argillaceous limestone
 - Weak to moderately strong rocks
 - UCS values from 14.5 MPa to 180.6 MPa for ironstone nodules or bands with Ø 69.6 MPa
- Tunnel crosses frequent faults and fault zones with the possibility of potentially higher water inflows although no water pressure is expected.
- Rock mass permeability is dependent of the fault extensions, fractured rock, and connection between faults and joint sets.



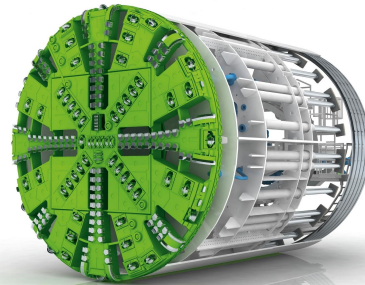
Ultra-Long Tunnel Drive

PREDICTED GEOLOGICAL CONDITIONS

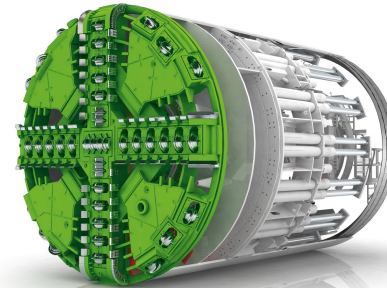
TBM SELECTION



Mixshield

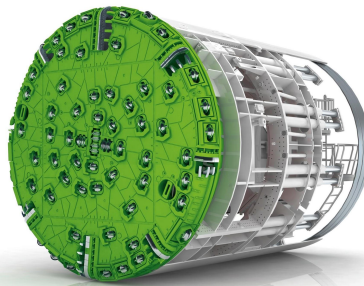


Multi-mode TBM

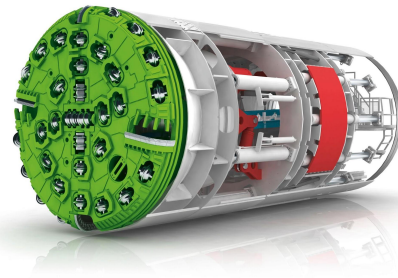


EPB Shield

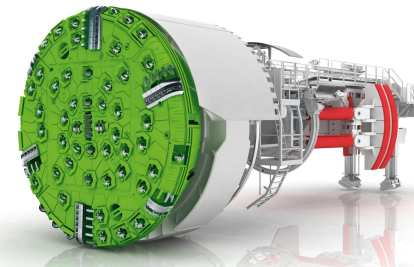
Soft Rock TBMs



Single Shield TBM



Double Shield TBM



Gripper TBM

Hard Rock TBMs

Ultra-Long Tunnel Drive

TBM DESIGN FOR HIGH-CAPACITY UNDERGROUND MTS

- Single Shield TBM   5.94m
- Length of TBM incl. back-up gantries is about 252m
- Drum-type cutterhead  6m for unidirectional hard rock excavation
 - 4x 17inch center disc cutters (2-ring disc cutters)
 - 26x single disc cutters (18x face, 8x gauge cutters and 8x buckets)
 - All excavation tools are back-loaded
- Nominal thrust force of 62,068 KN
- Total power of 2,100 KW by six electric motors   350 KW
- Nominal torque of 3,281 KNm
- Contractor: Strabag AG



Ultra-Long Tunnel Drive

TBM DESIGN FOR HIGH-CAPACITY UNDERGROUND MTS

- Single Shield TBM Ø 5.94m
- 37km long MTS tunnel, segmentally lined
- Tunnel lining composed of reinforced concrete segments:
 - ID 4.9m, OD= 5.6m,
 - Ring length 1,500mm
 - Ring Distribution 6+0
- Two-component grout annular gap backfill material



Ultra-Long Tunnel Drive

TBM DESIGN: PROBE DRILLS

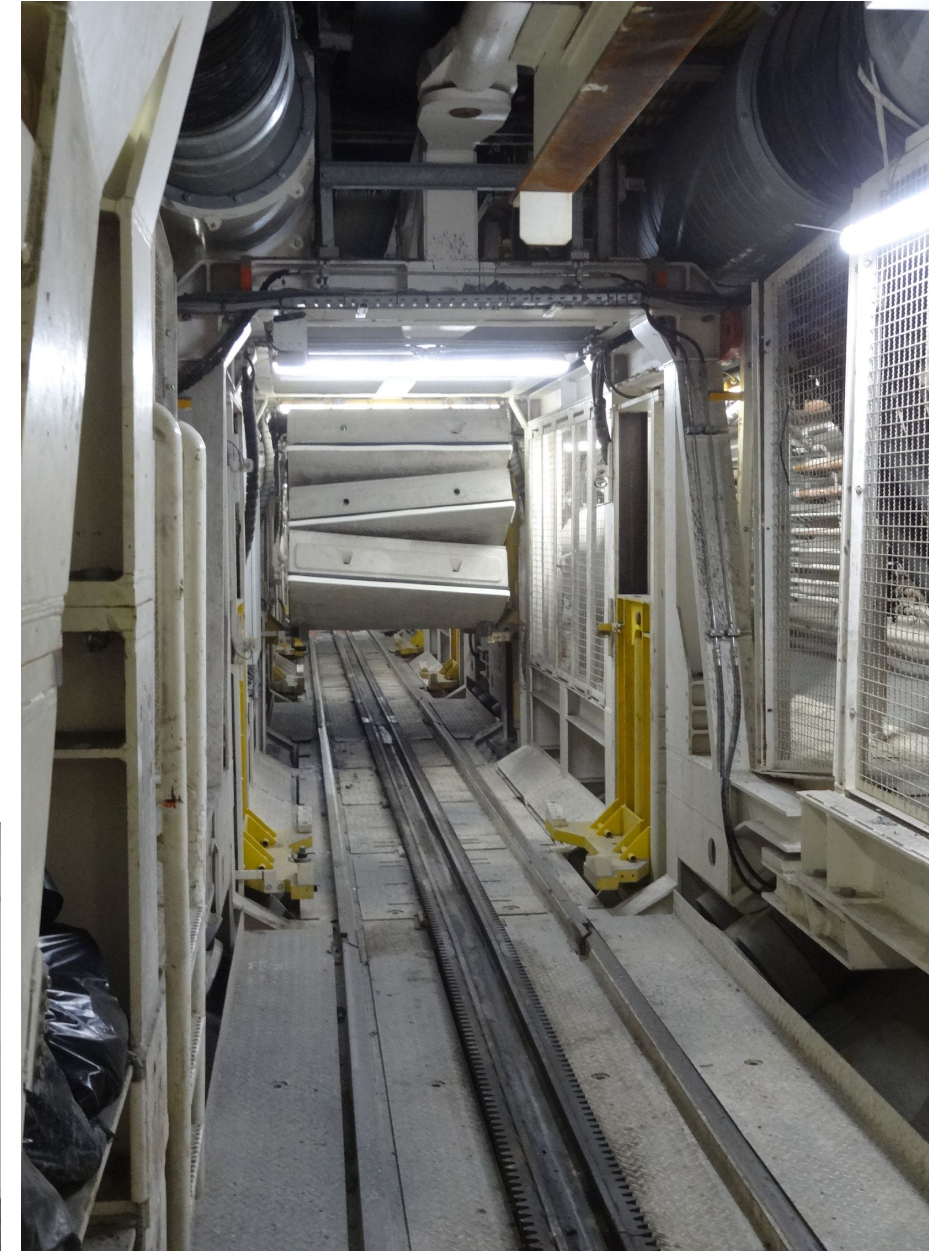
- Probe drills:
 - 6x probe drill ports DN 100 through the shield, inclination 10°
 - 1x horizontal probe drill position DN 100 through shield & cutterhead
 - 2x flexible probe drill with a bore diameter DN 100; can be mounted on the erector for probe or injection drilling.



Ultra-Long Tunnel Drive

TBM DESIGN: LOGISTICS

- TBM supply by train
- Muck transport by conveyor belt
 - Machine belt width of 800mm; capacity (conveyance rate) of 740t/p/h
 - Tunnel belt width of 800mm; muck transport towards the portal at Wilton
- Quick unloading devices for segment handling:
 - Semi-automatic process for the three-ring logistics
- Conveyor extension area to install the structure for conveyor belt extension, fiber optical cable boxes & services extension material
- Pipe handling area for pipes stored



Ultra-Long Tunnel Drive

TBM DESIGN AND MANUFACTURING

- TBM designed & manufactured by Herrenknecht AG in Germany
- April 2018, TBM order for Herrenknecht
- January 2019, Factory acceptance test in Schwanau, Germany
- February 2019, TBM Ø5.94m arrival on Teesside at AV Dawson's port facility
- April 2019, TBM assembly
- June 2019, TBM Ready to Bore



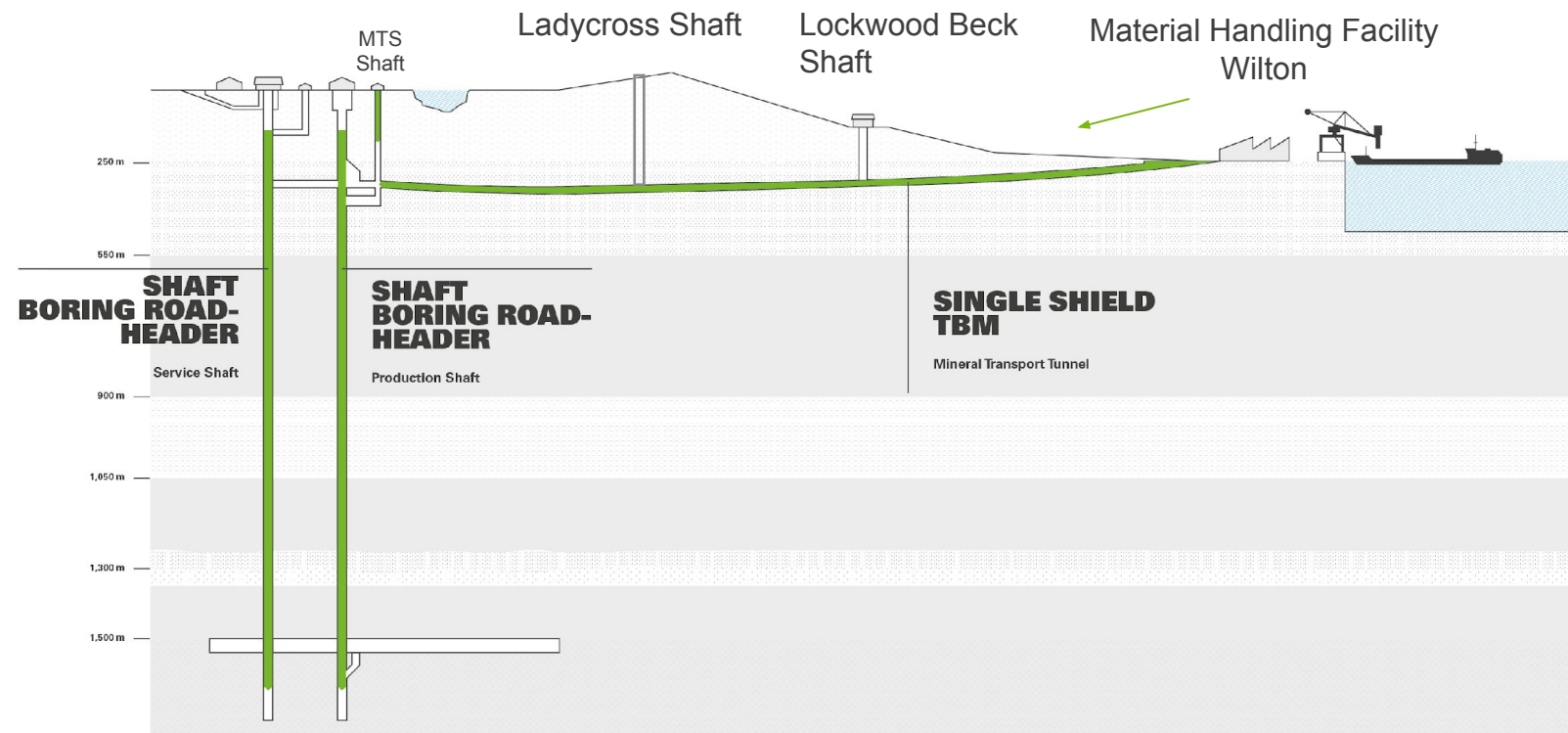
Beginning of Feb. 2019, Loading of a barge at Kehl port facility on the Rhine river for shipment

Ultra-Long Tunnel Drive

EXPERIENCES DURING TUNNELLING

- Original plan: Excavation of a 13.5km long tunnel section with one TBM toward Lockwood Beck with a TBM operation based on six days a week, 24 hours per day.
- End of March 2021: Completion of 1st drive of 13.5km
 - Five months earlier than scheduled.
 - Best daily performances of 52.65m
- After completion of the 1st tunnel drive, it was decided to continue TBM operation for the remaining sections (drives 2 & 3), so that the TBM finally has to excavate an overall distance of almost 37km.

**OCTOBER 2023: TBM REACHED 26KM!
NEW WORLD RECORD FOR THE
LONGEST SINGLE TBM DRIVE!**

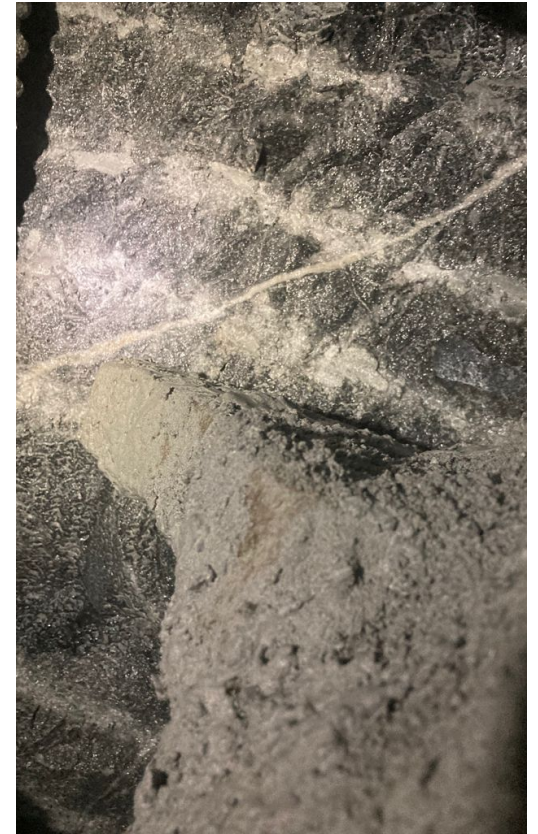


Ultra-Long Tunnel Drive

EXPERIENCES DURING TUNNELLING

Faced tunnelling conditions

- Entire length of ultra-long drive through Redcar Mudstone Formation.
- First tunnel sections: cohesive & sticky mudstone that caused clogging of the cutterhead.
- First long tunnel drive of about 13.5km in favorable rock mass with little wear (disc cutter lifetime of $> 4000\text{m}^3/\text{c}$).



Ultra-Long Tunnel Drive

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Grillbar as build at the HK factory

Countermeasures

- Installation of Teflon plates in the cutterhead to reduce clogging.
- After approx. 13.5km of tunnelling, the opportunity was taken for machine maintenance & refurbishment.
- **Cutterhead inspection** (visual checks for abrasion or cracks & dye penetration tests) & **refurbishment** (grill bars, renewal of wear protection, replacement of hardox welding on grizzly bars size limiters, restructuring of gauge cutters) **before TBM continued for another 23.5km**. Refurbishment works took about 2-3 weeks.

Ultra-Long Tunnel Drive

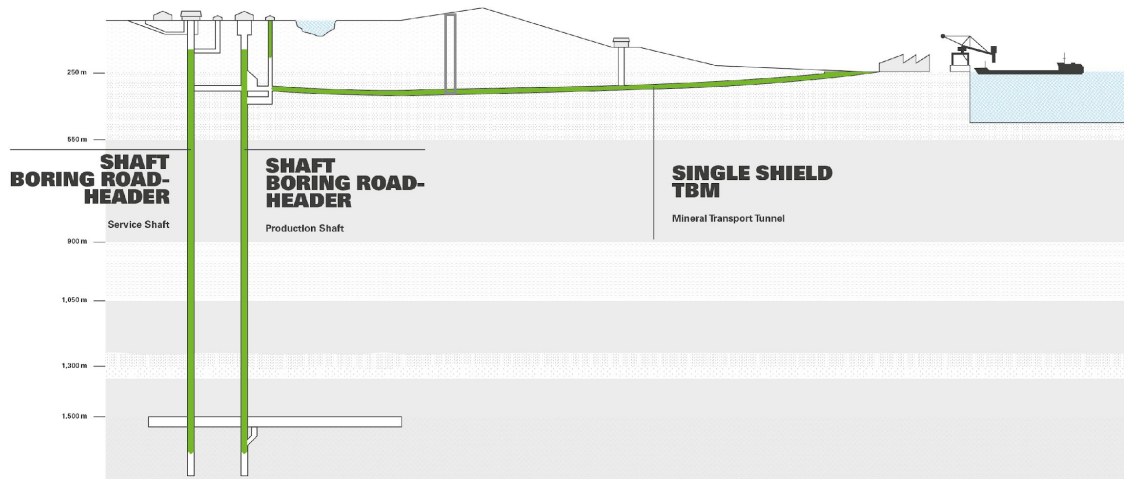
EXPERIENCES DURING TUNNELLING

Demand on tunnelling efficiency

- Guaranteeing a continuing efficient TBM operation for the remaining 23.5km with the same TBM

Countermeasures

- Diversion of some logistics from the tunnel portal at Wilton to the Lockwood Beck Shaft to reduce the travelling distance and time
- (e.g. logistics for backfill grouting with bi-components, ventilation, cooling water but also personnel transport using an Alimak hoist).



Ultra-Long Tunnel Drive

SHAFT CONSTRUCTION

Shaft Construction

- For the shaft located at Woodsmith Mine a Vertical Shaft Sinking Machine (VSM) from Herrenknecht was used to construct the MTS shaft to a depth of 120m.
- The shaft at Lockwood Beck was drilled from the surface & a steel liner was installed.
- The other of the two shafts along the MTS tunnel section was constructed using similar techniques at Ladycross Plantation.
- The main mine shafts are constructed using Herrenknecht Shaft Boring Roadheaders (SBR).
- The VSM was designed to work beneath the groundwater table having a shaft lining being lowered above. This shaft will be sunk to the 360m level using traditional drill & blast techniques to connect to the Mineral Transport System.
- SBR delivers higher sinking rates compared to conventional drill & blast technology since the excavation and shaft lining can be carried out together. Mechanization plus automated excavation helps to achieve greater safety levels (no personnel required to work on the bench & mechanical excavation minimizes disturbance to surrounding geology compared with drill & blast methods).

Impressions

SHAFT BORING ROADHEADERS



Ultra-Long Tunnel Drive

LESSONS LEARNED FOR TBM DESIGN

- October 2023, the TBM reached the **26km milestone** □ **New record for the world's longest single TBM drive!**
- October 2025, the TBM has excavated around **30km** □ **Reduced excavation rates due to slowdown in project**
- Achieving the completion of the entire section of almost 37kms, the TBM has executed the longest TBM drive worldwide using a Herrenknecht TBM.
- **Advantageous for ultra-long tunnel drives** is the **provision of intermediate shafts** such as the Lockwood Beck shaft and Ladycross Shaft
 - to reduce the travel distance for some of the relevant logistics
 - to ensure efficient support for TBM supply of consumables & personnel transport.
- No problems associated with wear of cutterhead due to quite **favorable geology with low abrasivity**.
- **Semi-automatic process** between the quick unloading station and the segment crane **is a safe & efficient system** which worked well with the three-rings logistics (safe & efficient segment handling system that reduced the number of train movements needed in such a very long tunnel).

Ultra-Long Tunnel Drive

CONCLUSION

01

Proven TBM technology & durability of applied technology is the choice to construct remarkably projects safely, in time and in budget.

03

Particularly **unique project** due to construction of an **ultra-long tunnel drive of almost 37km with one TBM.**

05

Close & trusting **teamwork tunnelling & experienced** tunnelling **team** is fundamental & key for a project's success.

02

The Woodsmith Project is a **notable project in more unusual environment** of a National Park.

04

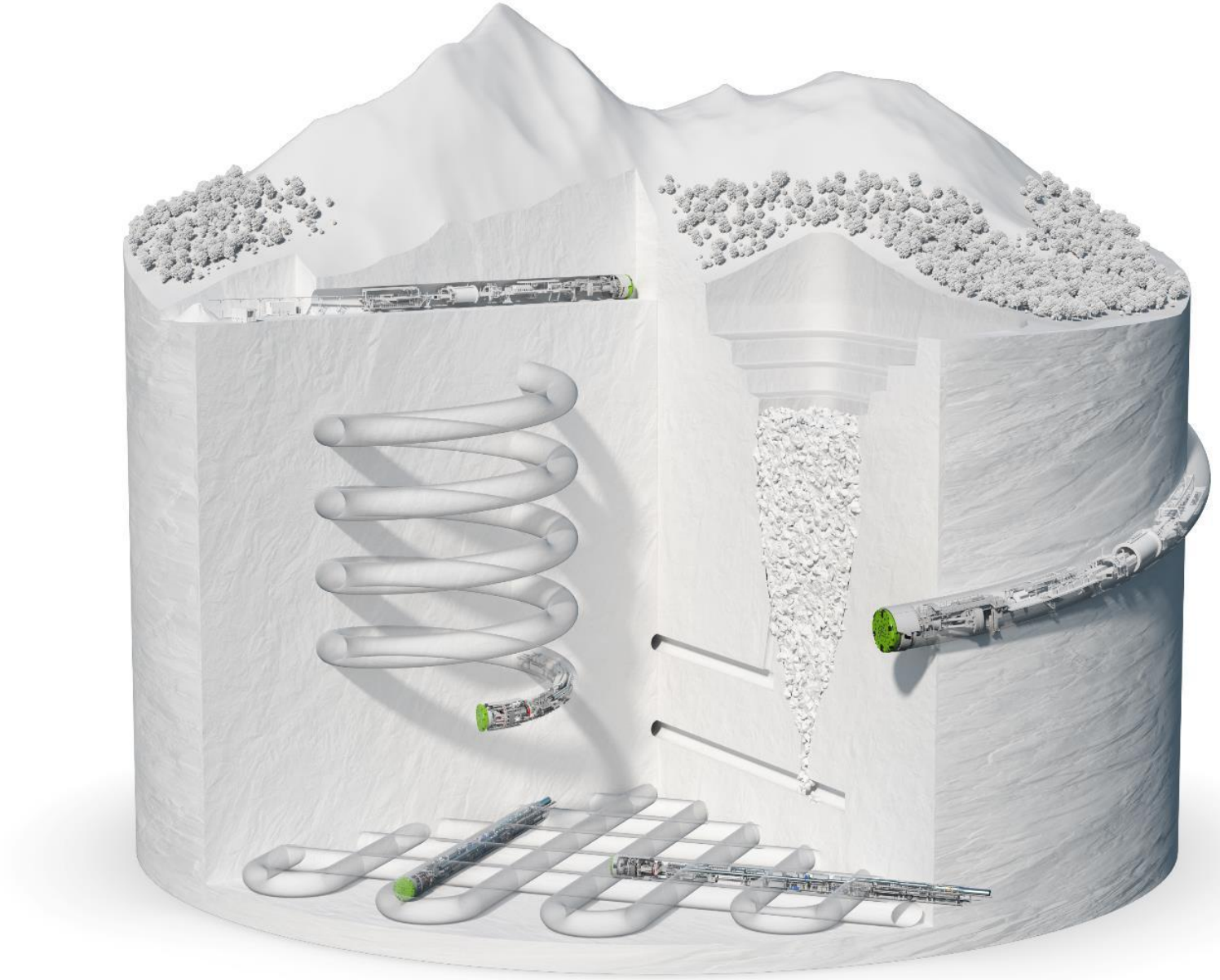
Underground conveyor belt running at average depths of **250m below ground**



Overview

TBM FOR UNDERGROUND MINE DEVELOPMENT

- Standard TBM
- Helix/ Ramp TBM
- Decline TBM
- Horizontal infrastructure



THANK YOU FOR YOUR ATTENTION.

