ITA TUNNELLING AWARDS 2019

Autonomous TBM (A-TBM)

MALAYSIA

Presented by:
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Acting General Manager - Tunnel

MMC-GAMUDA

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PROJECT STAKEHOLDERS

PROJECT	Klang Valley Mass Rapid Transit Line 2
PROJECT CLIENT	MRT Corp (Government of Malaysia)
MAIN CONTRACTOR	MMC-Gamuda KVMRT (T) Sdn Bhd
SCOPE	13.5km Twin Bored Tunnels 11 Underground Stations
A-TBM PROJECT TEAM	

Project Sponsor	Ng Hau Wei
Project Advisor	Gusztav Klados
Project Lead	Justin Chin Jing Ho
Technical Lead	Russell Jon Batty
Lead AI Developer	John Lim Ji Xiong
Lead PLC Developer	Sam Liew Kit Shen

MRT CORP

MMC-GAMUDA

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CONTENT

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INTRODUCTION

Autonomous TBM Control

Tunnelling 4.0

Artificial Intelligence
Algorithms

- Auto Steering
- Auto Advance
- Auto Excavation
- Auto Slurry

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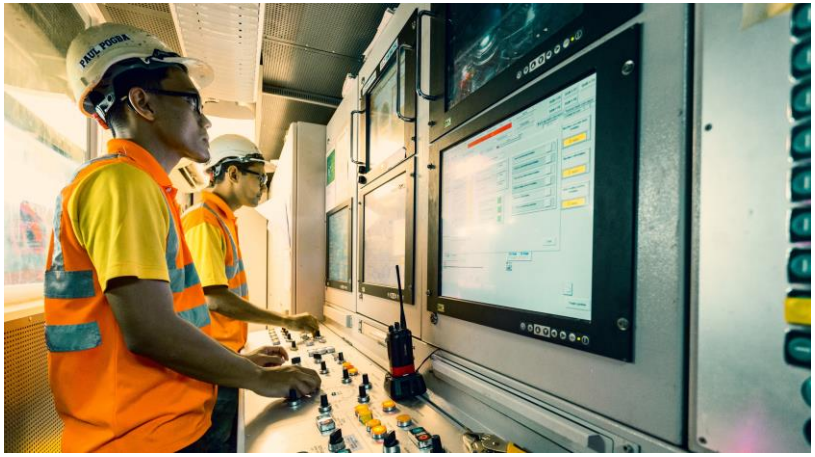
TBMs: Ready for a Digital Revolution

TBMs are fitted with hundreds of sensors connected to a logic controller which make them perfect for a **digital revolution**.

With all industries moving towards a digital future in **Industry 4.0**, we have taken a bold step to pioneer an **Autonomous Control System** for TBMs.



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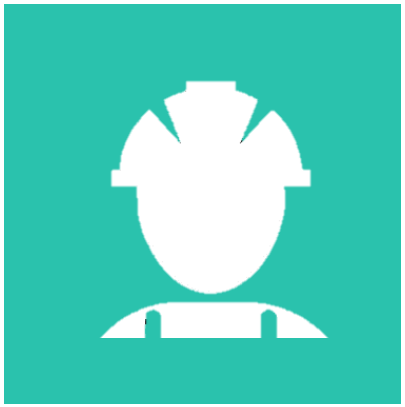
PROBLEM STATEMENT

Competency & Sustainability?

Reliance on Operators

Tunnelling has always been reliant on operators and their competency for safe delivery of projects.



Shortage of Operators

With a global tunnelling boom and the burgeoning of tunnel projects worldwide, there is an increasing demand for TBM operators.

Training is Costly

Training operators is a long and costly process which requires years of experience and mentorship.

Hard to Gauge Competency

Risk and consequences of making mistakes is high and there is no formal way to validate an operator's competency.

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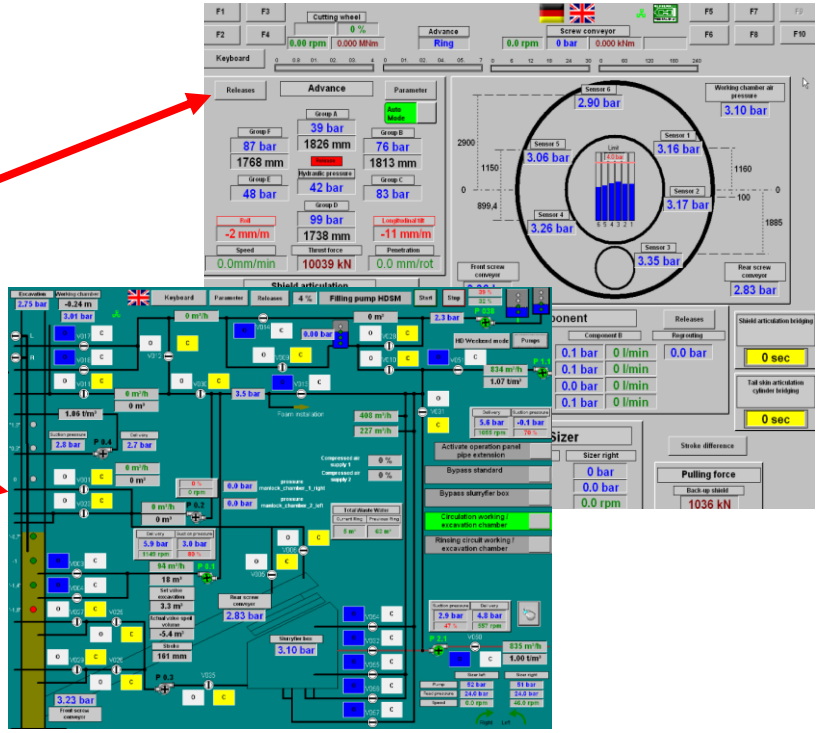
PROBLEM STATEMENT

Operators are Data Overloaded



TBM Operators monitor hundreds of parameters across 5 separate screens concurrently and operate the controls using many buttons and dials.

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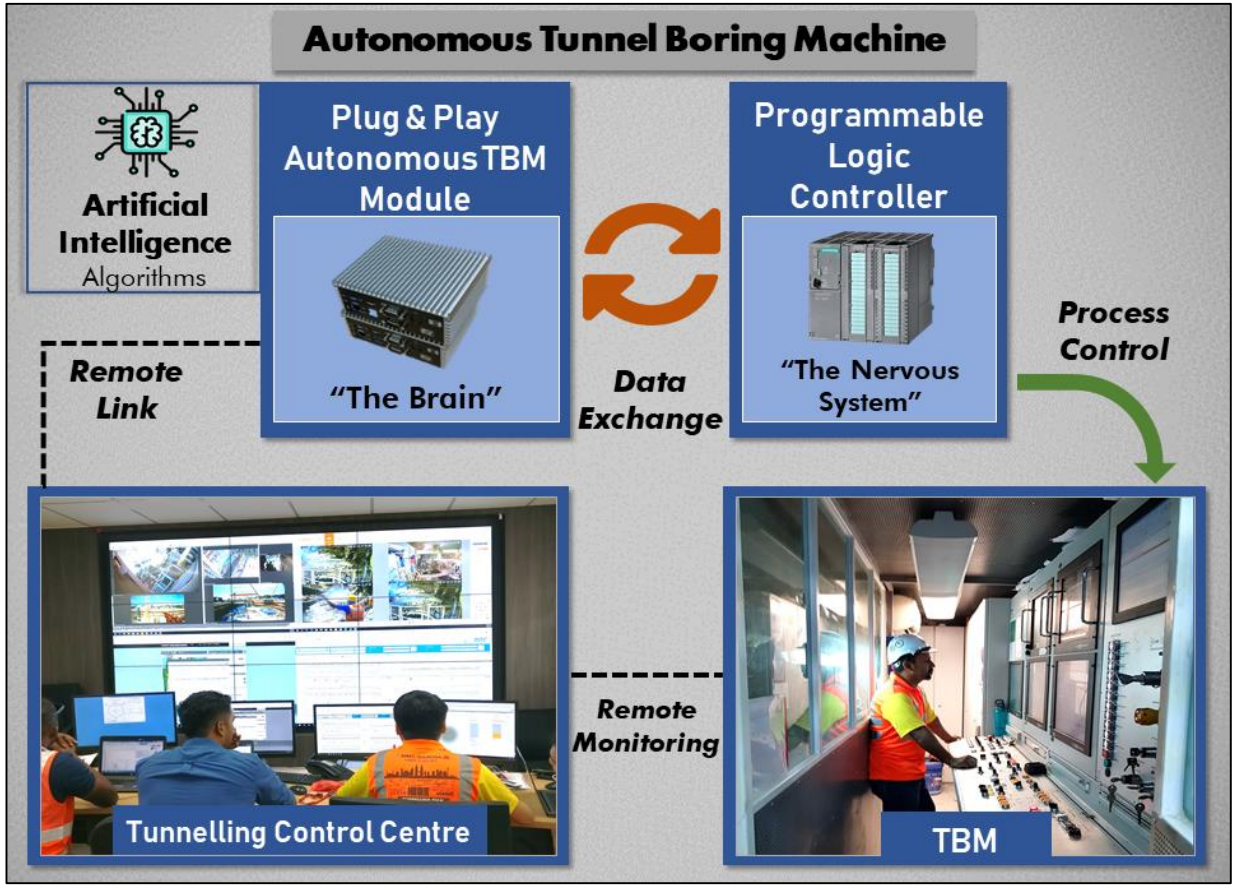
THE SOLUTION

Plug and Play AI Control System

The Autonomous TBM module is a **plug and play** system that fully controls the TBM operation using **artificial intelligence**.

Interfaces with existing hardware without hardware modification.

It **acts as the brain** and **interfaces with the nervous system (PLC)** to exchange data, process and decide on optimal parameters to control the process.



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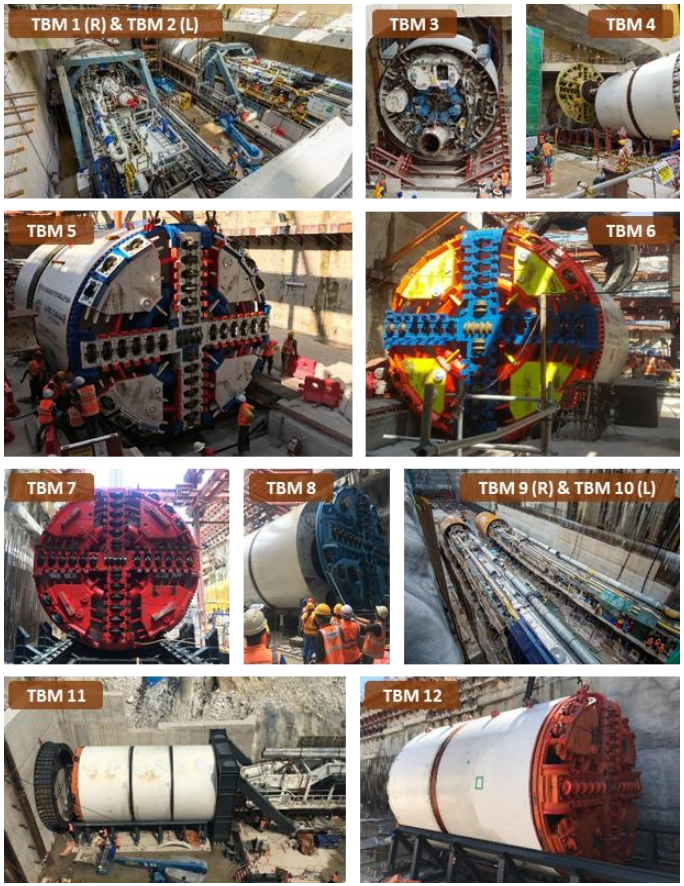
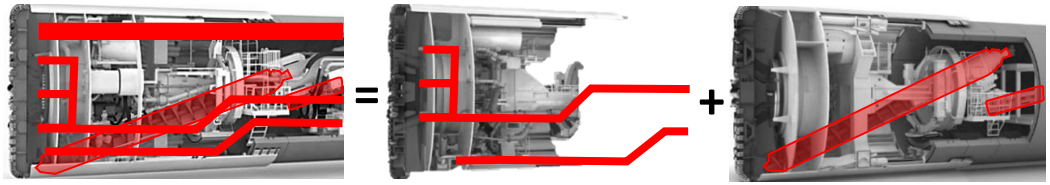
THE SOLUTION

One System for All TBMs



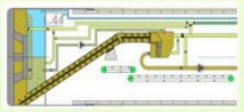
HERRENKNECHT
Tunnelling Systems

Innovative Variable Density TBM



NEW VD Technology | **STANDARD SLURRY** | **STANDARD EPB**

Multi-mode Operation

MODE 1	MODE 2	MODE 3	MODE 4
EPB Closed Mode	*EPB Closed Mode with Bentonite Support*	*Mixshield Mode with LDSM (Bentonite Slurry)*	*Mixshield Mode with HDSM*
			

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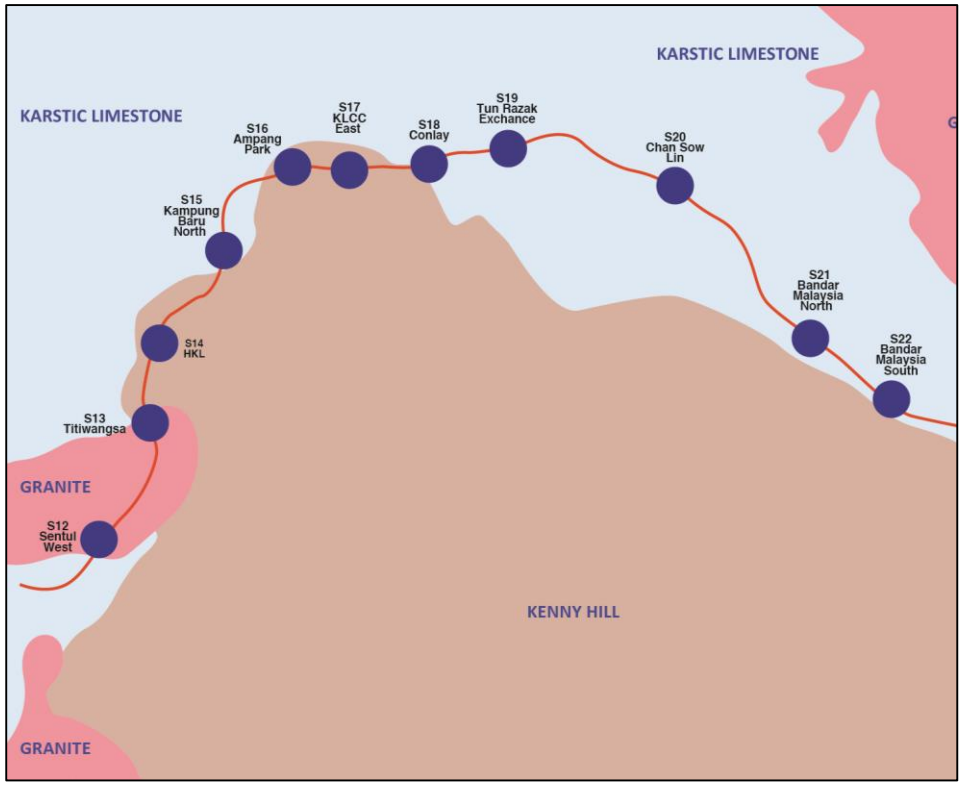
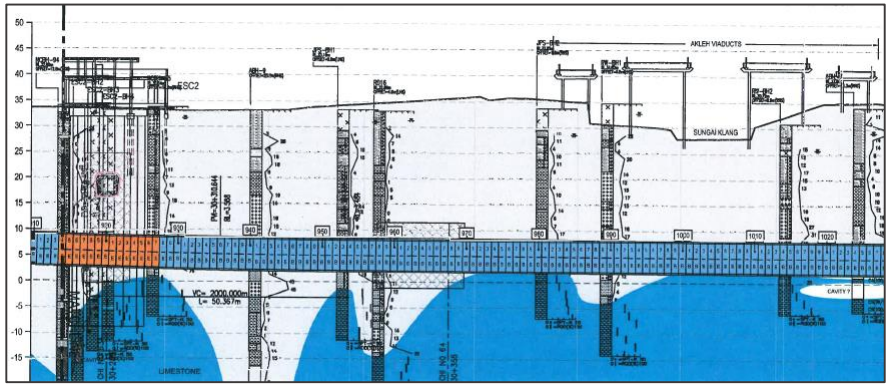
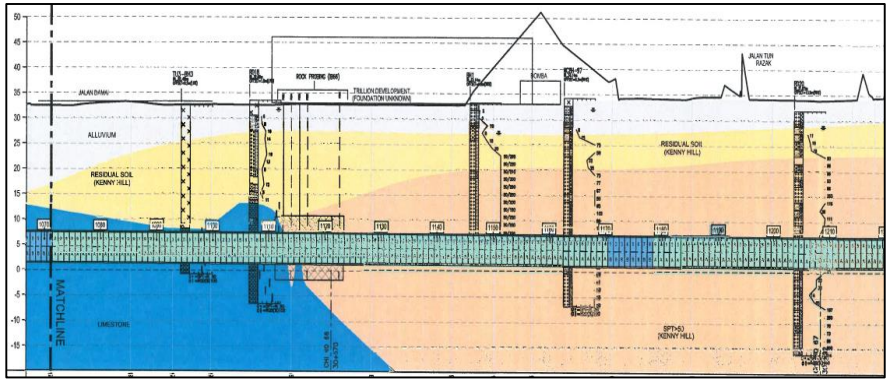
THE SOLUTION

KVMRT2: The Perfect Testing Ground

The underground alignment traverses through highly variable geological conditions, crossing at least six known fault zones and over a dozen interfaces between different geologies.



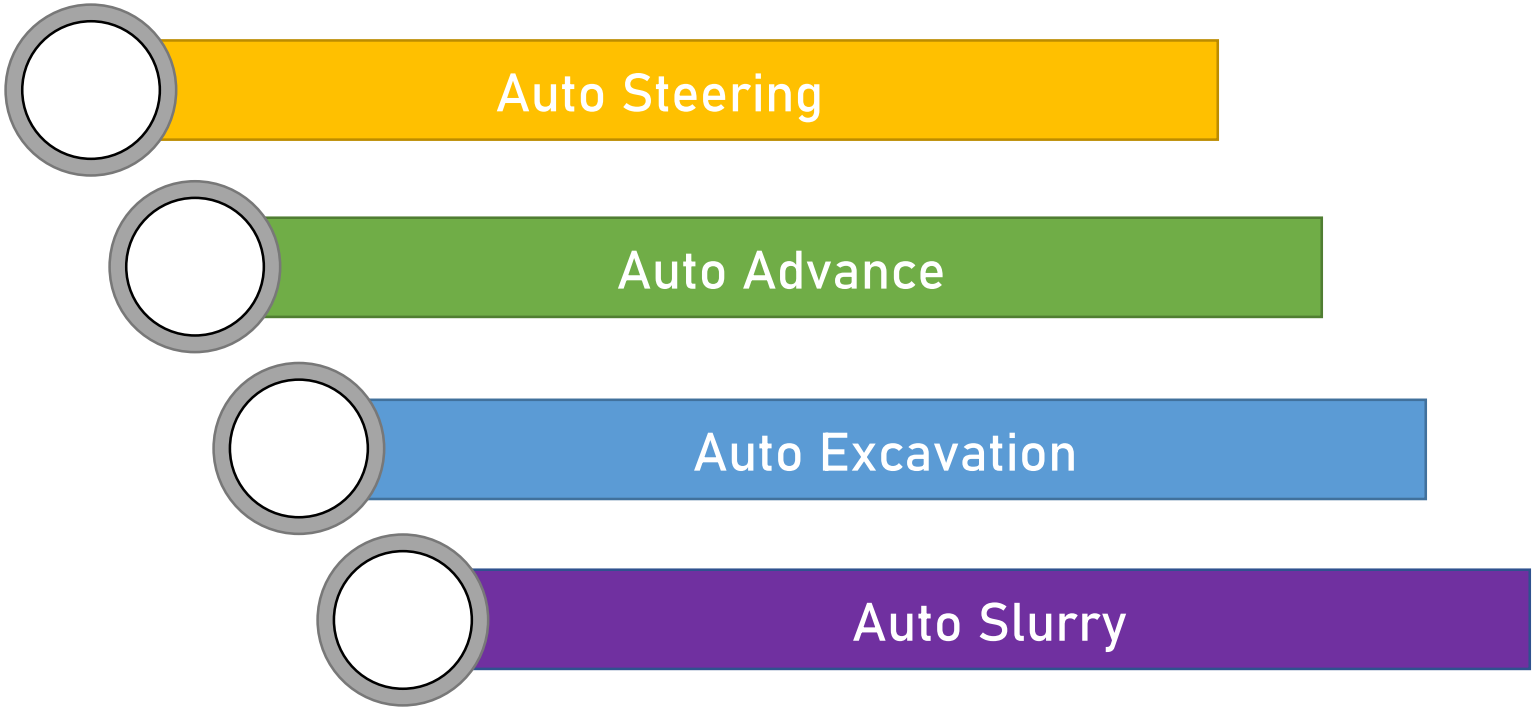




Controlling TBM Subsystems

TBM operation requires control over **multiple subsystems**. A human operator would have to concentrate on each particular subsystem it in turn.

- **Slower reaction times**
- **Inability to optimise efficiency** across all subsystems



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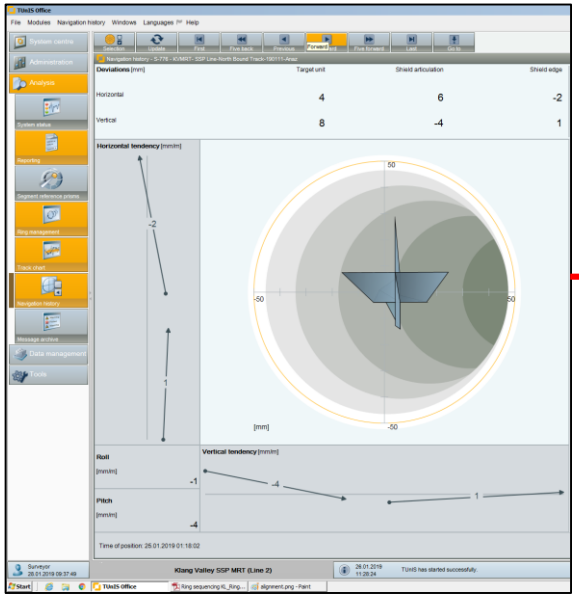
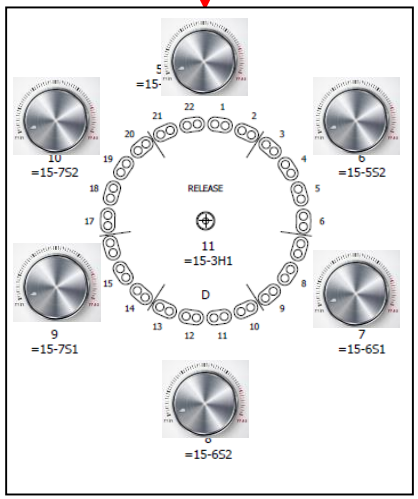
THE SOLUTION

Crash Course in TBM Steering

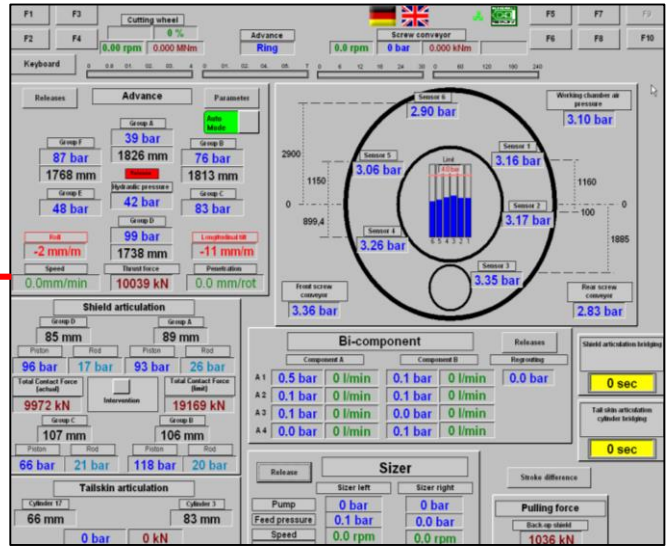


TBM Navigation System

Human Operator



Input from Operator



TBM Data Visualisation

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THE SOLUTION

TBM Control with AI Algorithms

A-TBM Monitoring Interface

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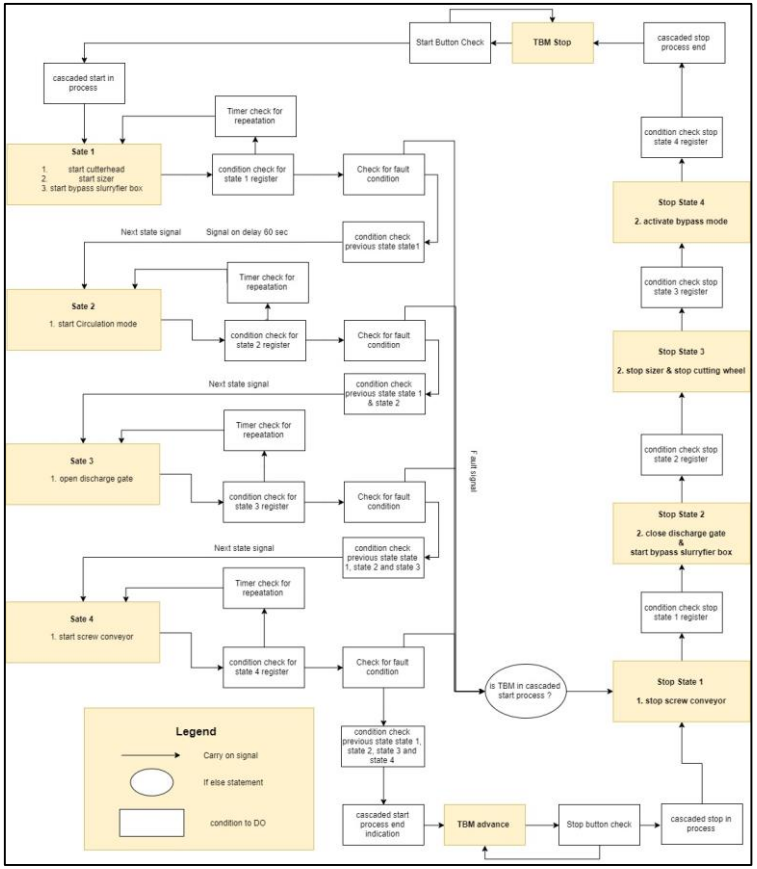
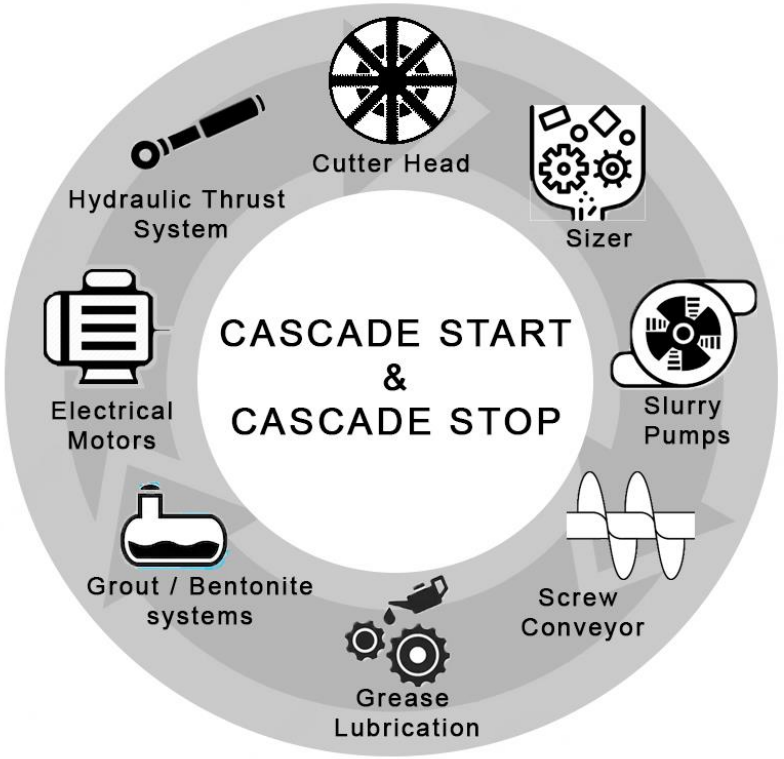
THE SOLUTION

Unifying TBM Subsystems





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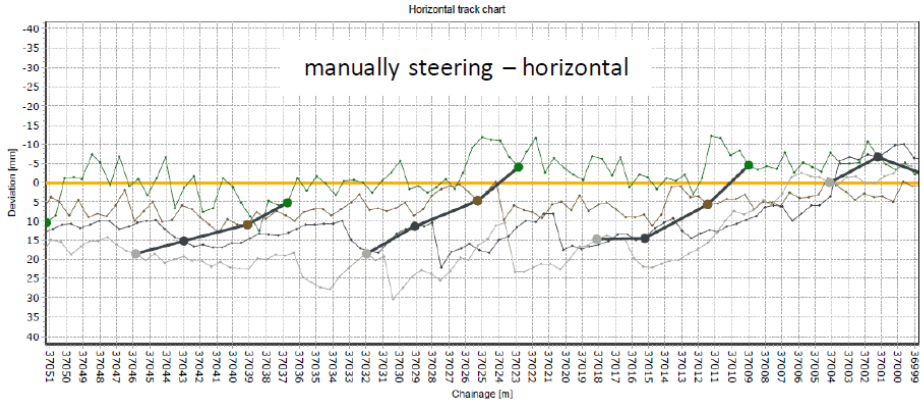
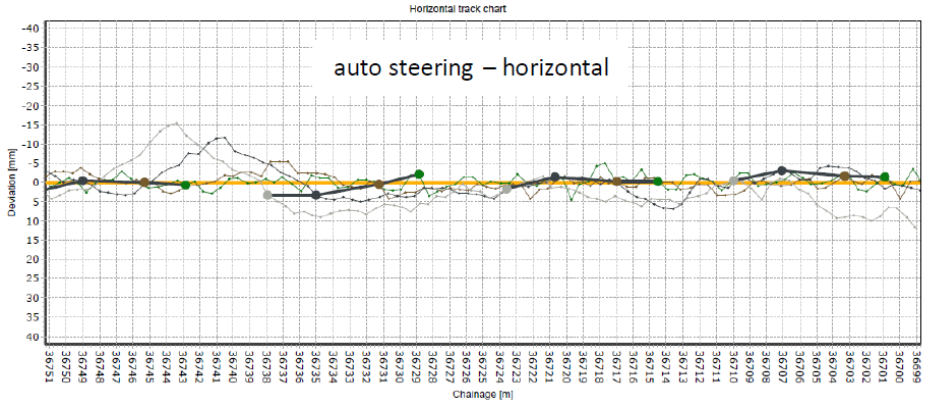
RESULTS

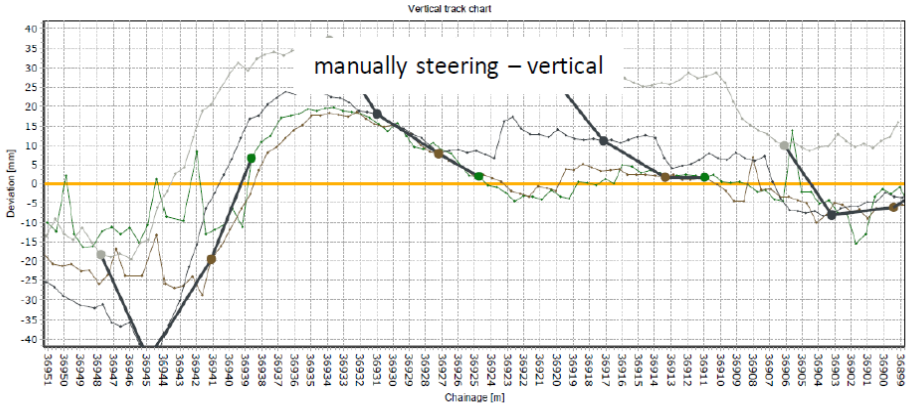
Drastic Stability Improvements

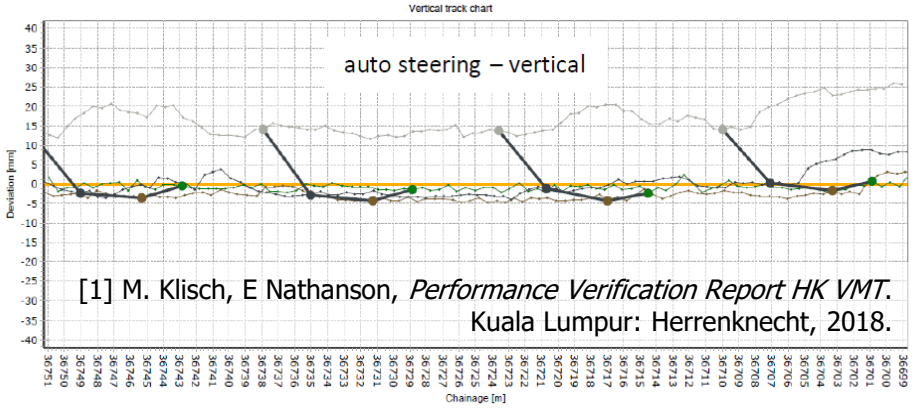
Horizontal Steering ⟷





Vertical Steering ↕





[1] M. Klisch, E Nathanson, *Performance Verification Report HK VMT*. Kuala Lumpur: Herrenknecht, 2018.

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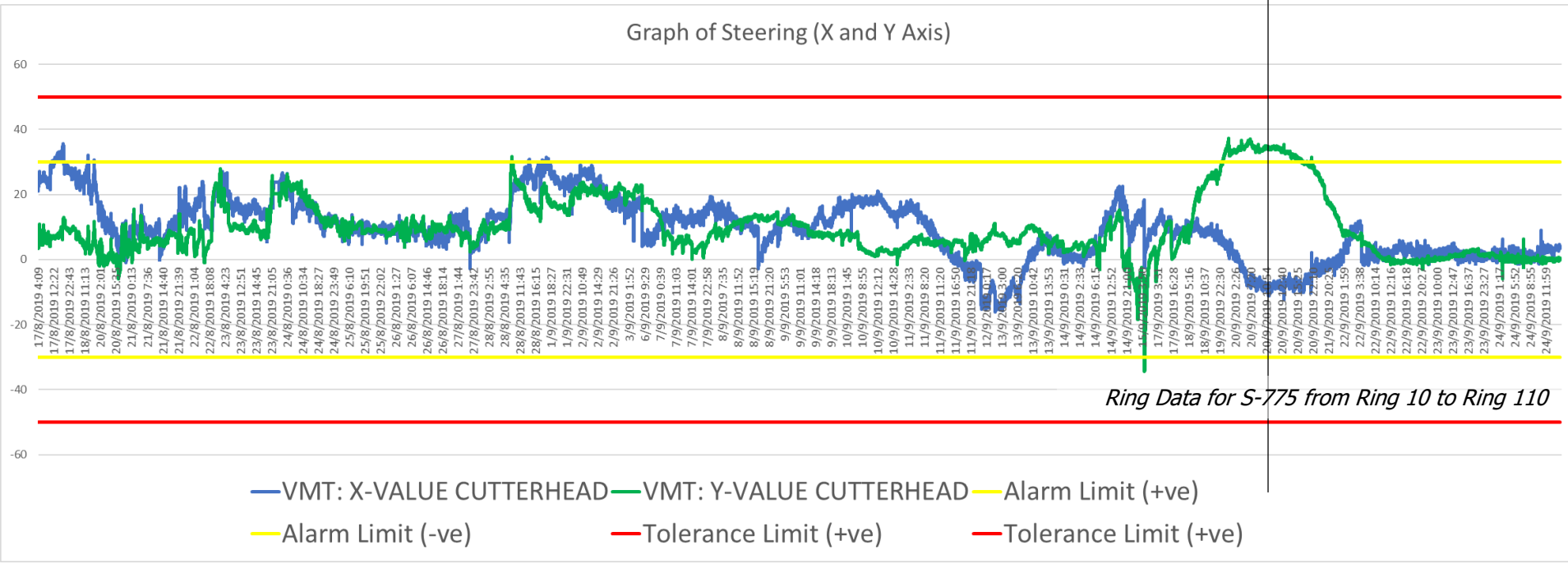
RESULTS

Drastic Stability Improvements

Auto Start

Manual **Auto**



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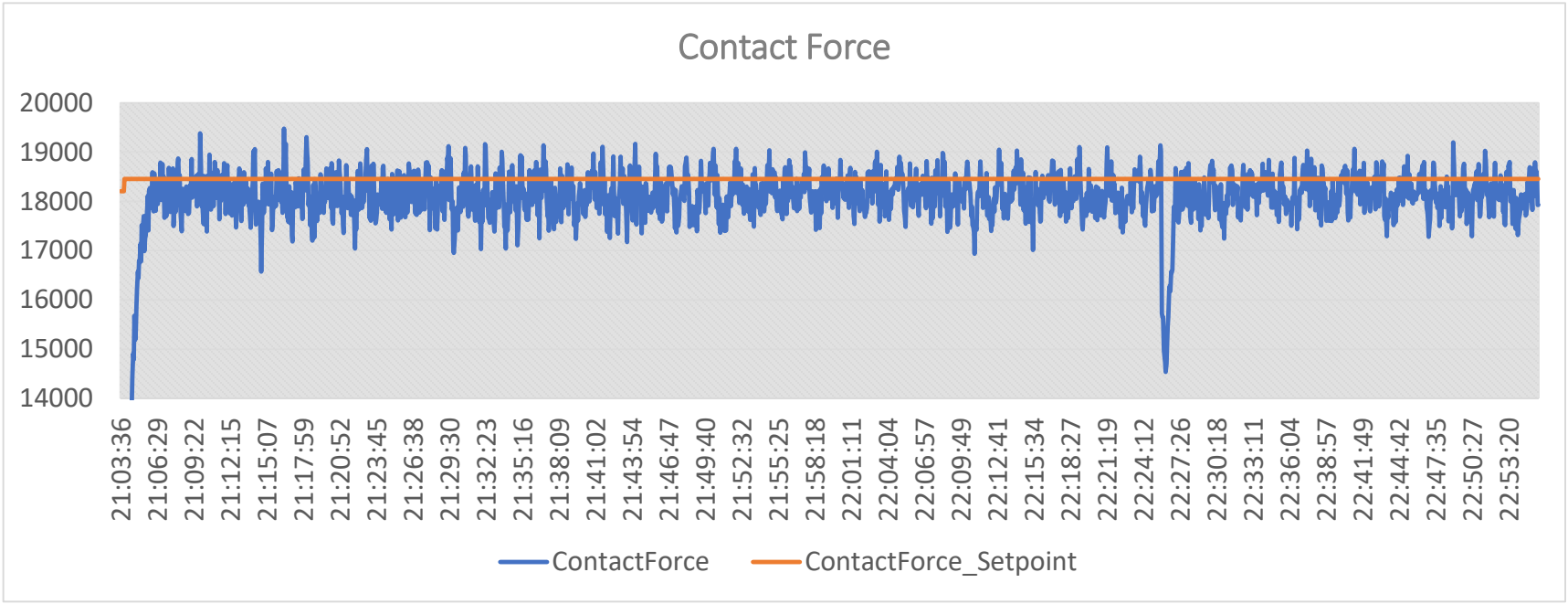
RESULTS

Productivity Gains via Parameter Optimisation



Contact Force Limit is calculated using real-time data and is used to protect the cutting tools on the TBMs

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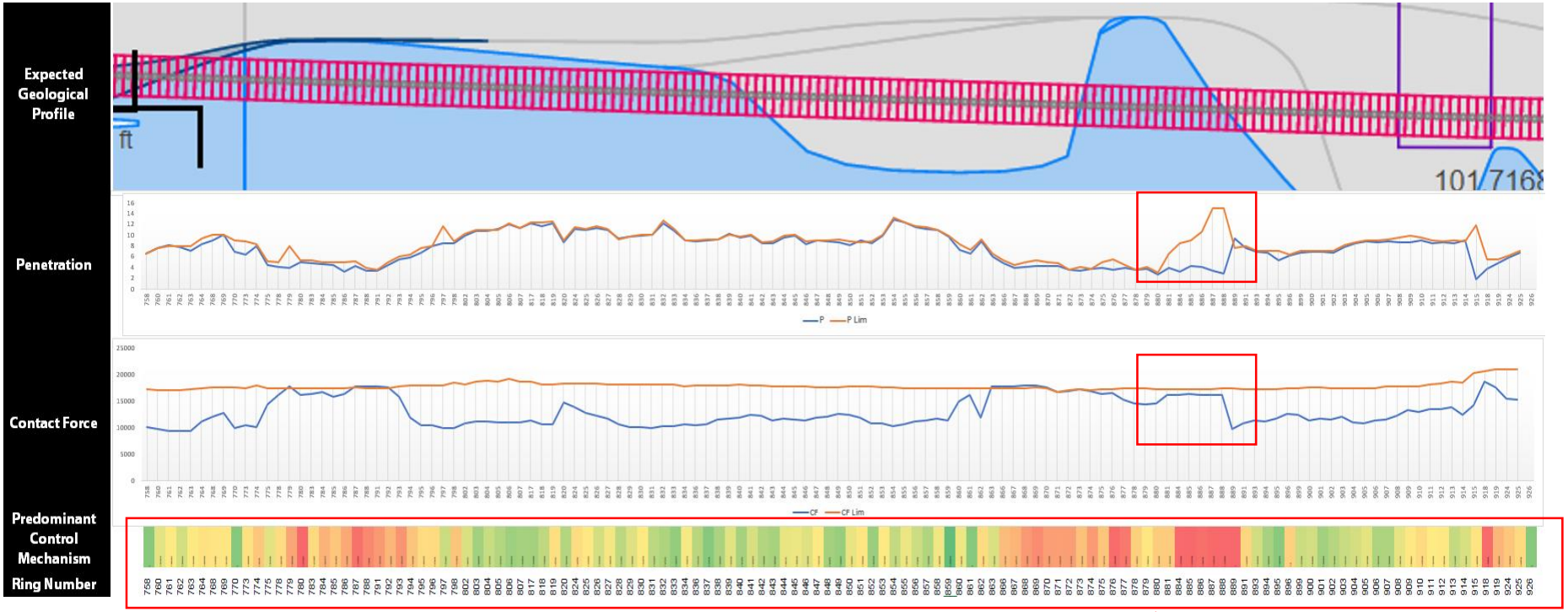
RESULTS

Intelligent Adaptive Control for Varying Geology



Speed Control

Contact Force Control

Program automatically changes control method in real-time to adapt to varying ground conditions

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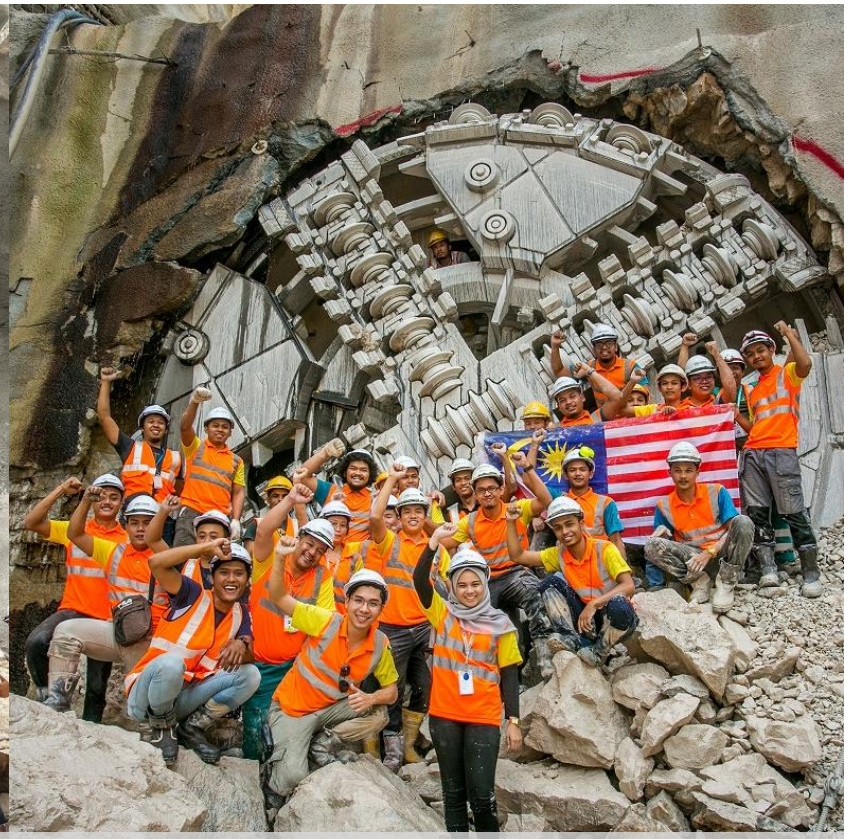
RESULTS

Pilot Test - Breakthrough!



Breakthroughs of S-776 and S-777 – The first VD TBMs to Pilot Test our Autonomous TBM System

Linewide Deployment with Proven Results

Total Distance Completed (A-TBM)

5.0km+

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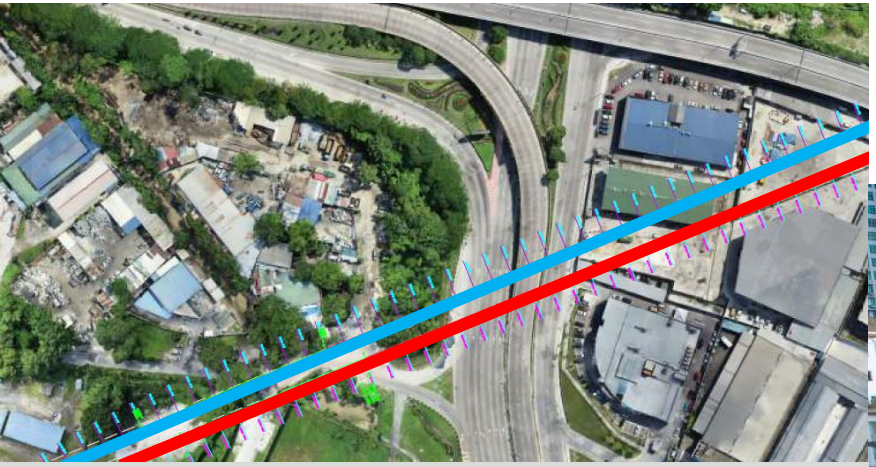
RESULTS

Tested Under Real Urban Conditions



14-lane Sg. Besi Highway Crossing
(Main Artery into Kuala Lumpur)

Tunnelling in Dense Built-up Environments

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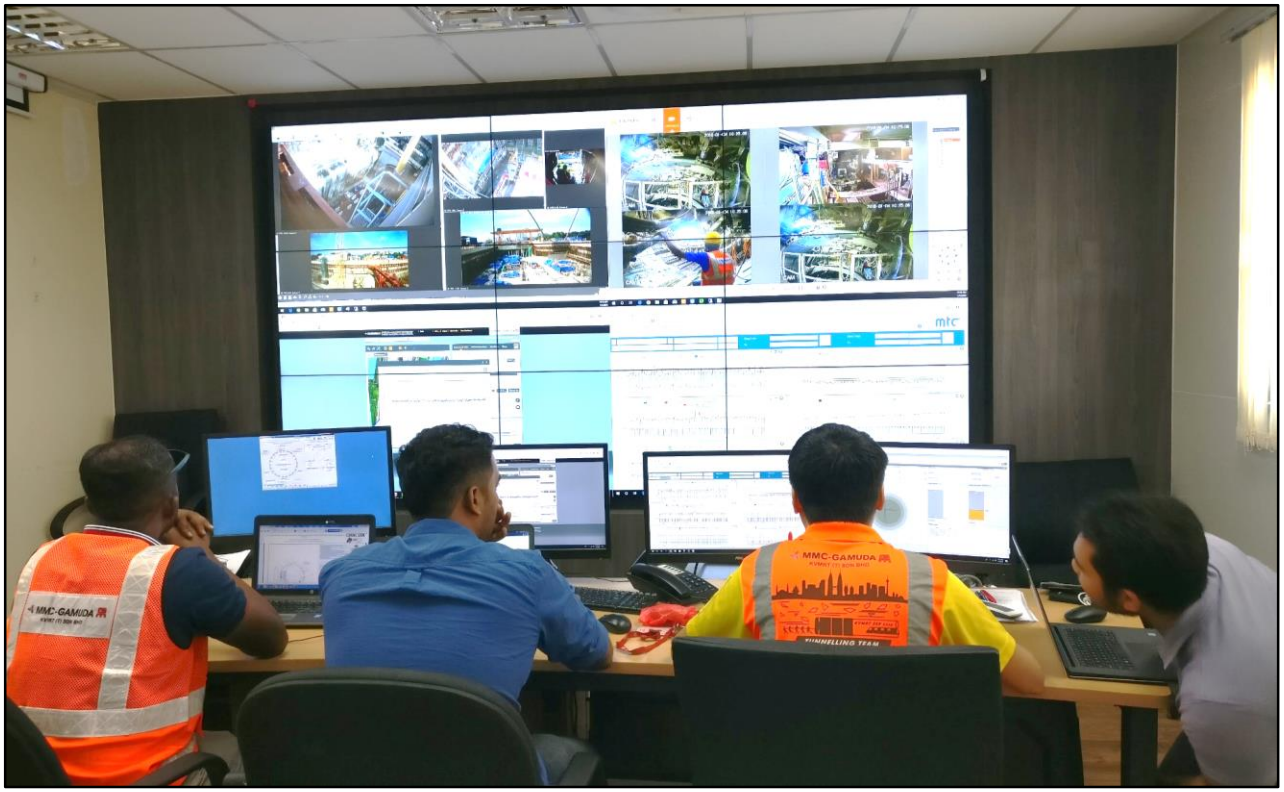
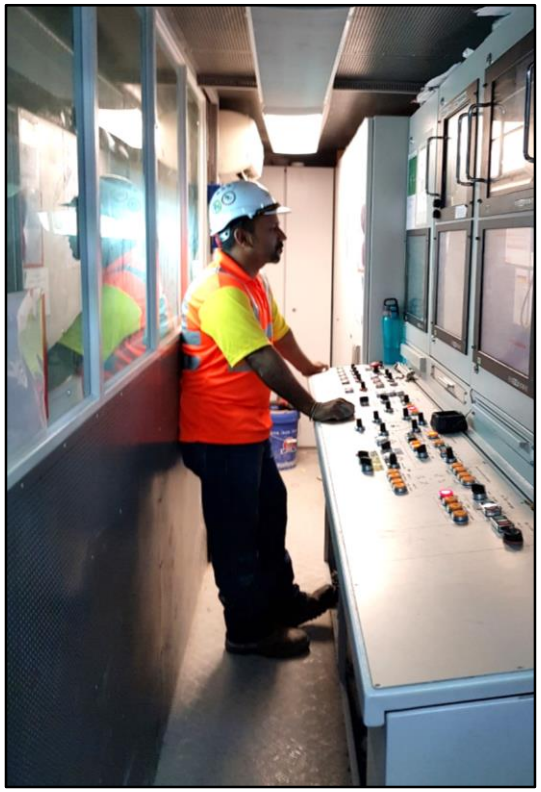
VISION

Centralised Control of TBMs



A-TBMs remotely linked to our
Tunnelling Centralised Command and Control Centres (TC^4)



TBM Operator in control cabin
as a matter of procedure

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VISION

A Tunnelling Game Changer

Transforming Operators

Operators will be upskilled from semi-skilled operatives to highly-skilled TBM technical experts who monitor multiple machines from a centralised control centre.

Scalable System

The Autonomous TBM system is inherently scalable and can be deployed quickly on any number of TBMs on any project.

Reduced Overheads & Increased Efficiency

Projects require lesser numbers of TBM operators and operators will be more focused on overall monitoring and systems troubleshooting.

Reduced Risk, Improved Safety

Operator errors due to data overload or fatigue can now be avoided. AI control is robust, consistent and predictable.

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Thank You

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Towards Tunnelling 4.0