Autonomous TBM (A-TBM)  
MALAYSIA

Presented by:  
Justin Chin Jing Ho  
Acting General Manager - Tunnel
## Project

### 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

### Project Team

<table>
<thead>
<tr>
<th>Role</th>
<th>Name</th>
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<tbody>
<tr>
<td>Project Sponsor</td>
<td>Ng Hau Wei</td>
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<tr>
<td>Project Advisor</td>
<td>Gusztav Klados</td>
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<tr>
<td>Project Lead</td>
<td>Justin Chin Jing Ho</td>
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<td>Technical Lead</td>
<td>Russell Jon Batty</td>
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<tr>
<td>Lead AI Developer</td>
<td>John Lim Ji Xiong</td>
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<tr>
<td>Lead PLC Developer</td>
<td>Sam Liew Kit Shen</td>
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2. Problem Statement
3. The Solution
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5. Vision
Autonomous TBM Control

Tunnelling 4.0

Artificial Intelligence Algorithms

Auto Steering
Auto Advance
Auto Excavation
Auto Slurry

INTRODUCTION
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.
Competency & Sustainability?

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

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

Shortage of Operators
With a global tunnelling boom and the burgeoning of tunnel projects worldwide, there is an increasing demand for TBM operators. Hard to Gauge Competency. Risk and consequences of making mistakes is high and there is no formal way to validate an operator’s competency.
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.
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.
One System for All TBMs

Innovative Variable Density TBM

Multi-mode Operation

<table>
<thead>
<tr>
<th>MODE 1</th>
<th>MODE 2</th>
<th>MODE 3</th>
<th>MODE 4</th>
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<tbody>
<tr>
<td>EPB Closed</td>
<td>EPB Closed with Bentonite</td>
<td>Mixshield Mode with LDSM (Bentonite Slurry)</td>
<td>Mixshield Mode with HDSM</td>
</tr>
<tr>
<td>Mode</td>
<td>Support</td>
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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
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
Unifying TBM Subsystems
**Drastic Stability Improvements**

**Horizontal Steering**
- manu ally steering – horizontal
- auto steering – horizontal

**Vertical Steering**
- manu ally steering – vertical
- auto steering – vertical

RESULTS

Drastic Stability Improvements

Graph of Steering (X and Y Axis)

Ring Data for S-775 from Ring 10 to Ring 110

VMT: X-VALUE CUTTERHEAD — VMT: Y-VALUE CUTTERHEAD — Alarm Limit (+ve)
Alarm Limit (-ve) — Tolerance Limit (+ve) — Tolerance Limit (+ve)
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 TBM.
RESULTS

Intelligent Adaptive Control for Varying Geology

Program automatically changes control method in real-time to adapt to varying ground conditions.
Pilot Test - Breakthrough!

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

Linewide Deployment with Proven Results

Total Distance Completed (A-TBM)

5.0km+
RESULTS

Tested Under Real Urban Conditions

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

Tunnelling in Dense Built-up Environments
Centralised Control of TBMs

A-TBMs remotely linked to our Tunnelling Centralised Command and Control Centres (TC4)

TBM Operator in control cabin as a matter of procedure
The Autonomous TBM system is inherently scalable and can be deployed quickly on any number of TBMs on any project.

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.

Reduced Overheads & Increased Efficiency
Projects require lesser numbers of TBM operators and operators will be more focused on overall monitoring and systems troubleshooting.

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

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

VISION

A Tunnelling Game Changer
Thank You

Towards Tunnelling 4.0