

# Rail

Services and Solutions



# Where will our knowledge take you?

BMT provides its customers with professional, cost effective and timely service and specialises in developing realistic, imaginative and innovative ways to make transport services safer, more competitive and more sustainable.

BMT delivers proven and measurable improvements to its rail customers at a project, fleet and industry level by improving performance and cost effectiveness, using risk based techniques. Using our

experience of working alongside manufacturers, rolling stock owners and operators across the whole industry, we have a proven record of being able to develop and implement solutions.



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# Rail Engineering and System Assurance

BMT delivers practical technical expertise, providing through-life engineering support from concept design and construction, through operations and life extensions/upgrades, and ensuring that best practices from all business sectors are transferred, where feasible, into the rail industry around the world. System Assurance has been widely adopted to assure systems engineering processes and products conform to requirements for operational safety, reliability, availability, maintainability, National & International standards, procedures and regulations.

## Specification and Design Review

Through our extensive experience in the development of technical specifications and completing design reviews on wagons, passenger vehicles and sub-systems, we assist purchasers of new railway assets through a specification and design review process. We can contribute to the technical specification of the assets to be purchased; and after the contractor has been selected, we undertake a detailed design review to ensure the specified mechanical and structural requirements have been achieved in the final design. The specification and design review process provides very high value by avoiding costly design oversights.

## Structural and Detail Analysis

Our Test, Measurement and Analysis team have extensive experience measuring strains, accelerations and displacements on rail vehicles and structures facilitating structural redesign, fatigue evaluation, load case definition and compliance with collision and impact loads in line with Collision Code Compliance.

## Technical Feasibility and Fitness-For-Service Assessment

BMT uses the collective experience of our engineering team in combination with a practical understanding of the operational environment to assess proposed changes to vehicles or track side equipment.

## Structural Integrity Assessment, Welding Engineering Services and Design

BMT provides guidance for the repair of damaged vehicles, weld specification and assessment to achieve the desired fatigue or strength requirements.

## Failure Investigation, Design of Life Extension Modifications

BMT has conducted various types of failure investigations within the rail industry; from wheel failures and noisy brake equipment in Canada to bearing failures in the UK. Utilising our wide technical experience we have developed suitable solutions for our customers to improve reliability of components and availability of assets.

BMT has supported our customers in optimising their maintenance plans and reducing the overall cost of maintenance by utilising various techniques, including Reliability Centred Maintenance (RCM).

## Prototype Stress and Deformation Acceptance Testing

BMT has completed numerous static and semi-static trials on wagons, passenger cars and locomotives. Our work in this field has included comparisons to Finite Element Analyst (FEA) to assess the modelling strategies and conclusions. We have developed in-house instrumentation for this testing and can competently carry out testing anywhere in the world.

## Ride Quality Analysis and Testing

We have completed ride quality testing on passenger cars, locomotives, and ride performance tests on wagons. We have used this data to guide the tuning of bogie suspension and identify causes for poor ride performance. We understand this environment and have a good understanding of the pitfalls and requirements of ride quality testing and analysis.

## Internal and External Aerodynamics, Computational Fluid Dynamics (CFD) Analysis

Using advanced CFD analysis techniques BMT undertakes pre-production modelling of airflows inside passenger cars as well as external aerodynamics.

## Reliability Engineering

Whilst reliability targets may form part of the design/contractual requirement, reliability prediction (modelling) on the whole system, using calculations based on assumed component failure rates and repair rates, provides an early indication of whether the proposed design/components meet the design requirements. Comparisons of different design options can then be made and alterations to components, maintenance or spares holding strategy can then follow.

## Electromagnetic Compatibility (EMC) Review and Management

EMC analysis assures that the various railway sub-systems remain compatible between themselves and the environment to prevent potentially hazardous errors and mis-operation.

EMC management begins with the development of an EMC Management Plan. It follows with the identification of potential EMI hazards within the premises, assessing the EMC performance required for the design of the system / sub-system / equipment including all necessary control measures, verifying the EMC performance of individual equipment procured and reviewing the overall design of the system / sub-system to ensure all EMC issues identified have been addressed.

BMT also assists customers in identifying the tests that must be carried out in order to verify EMC performance. This helps to identify where, if any, performance flaws exist and form the basis for further control measures or design modifications.







#### System Assurance for large-scale rail extension development in Hong Kong

BMT is providing System Assurance, EMC Management, as well as other Rail Consultancy services for the full suite of rail extension projects across Hong Kong. These strategic developments include the West Island Line, Guangzhou-Shenzhen-Hong Kong Express Rail Link, Shatin to Central Link, Kwun Tong Line Extension and the South Island Line (East), all managed by MTR Corporation Limited (MTRCL). Project works began in 2009 and is expected to reach completion within a decade, upon which these 5 lines will represent a further expansion of MTRCL's existing 218 km rail network.

Hong Kong's MTR (shown left) is considered one of the most efficient and reliable commuter train systems worldwide.

#### RAMS consulting for an automatic fare collection system of a railway terminal , Bangkok, Thailand (shown below)

BMT was appointed as the RAMS (Reliability, Availability, Maintainability and Safety) consultant of the Automatic Fare Collection (AFC) System of Bangkok's Suvarnabhumi Airport Rail Link and City Air Terminal, which includes eight stations and is 28km in length.

The terminal's AFC System automates the ticket accounting and selling processes and provides detailed data on system usage. BMT assisted in the planning and implementation of all RAMS activities including, hazard/ risk analysis and management, hazard log management, FMECA, Fault Tree Analysis, RAM Analysis and Reliability and Maintainability demonstration.







## Maintenance Strategies

The primary goal of maintenance is to avoid or mitigate the consequences of failure of equipment. This may be by preventing the failure before it actually occurs which Planned Maintenance and Condition Based Maintenance help to achieve.

Preventive maintenance activities include inspections, overhauls at specified periods, oil changes, and lubrication and so on. In addition, workers can record equipment deterioration so they know to replace or repair worn parts before they cause system failure. The ideal preventive maintenance program would prevent most equipment failure before it occurs.

BMT strives to ensure that best practices from all business sectors that they work in are transferred, where feasible, into the rail industry around the world.

### Developing Condition Based Maintenance (CBM)

CBM is an opportunity to improve business processes, with the principal objective being improved maintenance performance across a broad range of benefits, including greater productivity, optimised maintenance cycles, lower material and labour costs, increased quality of the process, improved availability, and enhanced reliability of the rolling stock.

BMT works with customers to identify which maintenance tasks are compatible with various forms of condition monitoring and assists in the development of the criteria to identify when (CBM) will be required.

### Train Maintenance Depot and Overhaul Workshop Management

BMT has an extensive history of placing our staff into the Engineering teams in the depots of train operators and overhaul workshops to assist in the identification and implementation of policies to improve the workflow being conducted.

### Maintenance Optimisation and Production of Maintenance Documentation

Maintenance Optimisation is about developing the most cost effective and worthwhile preventive maintenance regime for equipment of trains. This simply means empowering staff to take ownership of doing the maintenance that is right for the operation of the asset.

BMT's approach to maintenance optimisation uses our knowledge and expertise gained in other industries and in particular Reliability Centred Maintenance (RCM), a methodology originally developed in the Aerospace industry. Using this approach, BMT has achieved significant benefits for our Rail clients, with a significant improvement in reliability performance coupled with a 30% reduction in preventive maintenance workload for one fleet of electric locomotives.

### Stress Monitoring of Subsidence Affected Railway Tracks

Longwall mining or other underground excavation can often produce surface subsidence which affects operability and safety of surface assets. BMT has developed and managed several installations where rail track or other assets will be affected by ongoing subsidence. Our systems enable stress or movement to be monitored remotely, via 3G or other networks, so that adjustments can be made to ballast at appropriate times.

### Mechanical Component Root Cause Failure Analysis

The fundamental or root causes of failures of mechanical, structural and electrical assets are often complex and subtle, involving more than one factor. Failures are frequently not due to simple causes such as being overloaded, or a clear-cut material defect, but can involve aspects of design, transport, installation and maintenance. BMT has unequalled expertise in undertaking RCFA in a wide range of industries.





**Rolling Stock Condition Monitoring, Performance Health Monitoring & Condition Based Maintenance**

BMT and VIA Rail Canada Inc. (VIA Rail) came together to undertake a pilot study into the application of Condition Monitoring (CM) and a Condition Based Maintenance (CBM) approach to the GPA-30H locomotive (a fully refurbished and overhauled F40PH-2).

BMT carried out a Reliability Centred Maintenance (RCM) study of the Locomotive and its Genset. We identified

that an alternative overhaul strategy for the Genset would deliver the benefits that VIA Rail were looking for: increased availability and decreased cost, without having to remove the Gensets from service prior to overhaul.

During the RCM study, BMT identified a number of components that were previously subject to intrusive maintenance tasks and would benefit from CM tasks, and would also reduce the risk of maintenance induced failure.

In order to assist VIA Rail in reaping the benefits of CM and transition to a CBM plan, BMT grouped together various CM techniques to enable VIA Rail to develop a fully integrated Performance Health Monitoring task (PHM) for the locomotive. As a system, it is the PHM task that gathers the data and dictates if, and potentially when, intrusive maintenance is required.

BMT trained a number of key VIA Rail staff in the techniques required to implement and support the changes.

**Safety Assurance**

Our Safety Assurance services support our customers in the design, manufacture and operation of rail rolling stock and infrastructure.



**Risk Assessment and Management**

Applying safety techniques developed to the standards of the UK Rail Industry and other internationally renowned safety levels, and drawing from our multi-discipline experience, we are able to provide safety support ranging from modification risk assessments through to the development and authoring of complete safety cases.

BMT also provides design and construction stage risk management services to ensure efficient, timely and safe project delivery and optimal design for safety and constructability.

**Independent Safety Assessment (ISA)**

ISA has been widely implemented in the railway industry to assure that systems conform to safety requirements and standards. Its aim is to provide an objective and independent analysis of safety, especially for safety critical elements.

Our independence allows us to undertake independent reviews and audits of safety issues. We acted as ISA for the introduction to service of the Class 3000 to Northern Ireland Railways (NIR), the first new train introduction by NIR to follow

the safety case approach. We also acted as ISA for the Singapore Downtown Line Platform Screen Door (PSD) system.

**Safety Management Systems**

A Safety Management System is the basis for making sure that a transport system runs safely and in line with transport regulations. It ensures that an operator keeps records of all arrangements for managing safety risk on the rail network. BMT has worked with operators throughout the world to ensure that the systems and processes they have in place comply with the required regulations.

**Hitachi Class 395 Project Risk Management**

BMT was involved in the development of a new Hitachi fleet of dual voltage Electric Multiple Units (EMUs) for use on domestic services on the UK’s Channel Tunnel Rail Link (CTRL). We were contracted by HSBC Rail, the vehicle owners, to ensure that project and technical risks that could impact on the timely introduction of the trains into service were identified and appropriately addressed.





# Operational Optimisation

Determining how to optimise rail operations will reduce system downtime, improve throughput rates, reduce human injury risk, and improve the bottom line. BMT uses simulation and human factors engineering to help rail clients optimise their operations.

## Simulation

Simulation is a cost-effective way to make operational and investment decisions, but also with a well built and validated simulation virtually any situation can be analysed and potentially improved.

BMT uses a range of simulation approaches, built on highly versatile, reliable and flexible proprietary software platforms. Our approach can model virtually any scale of project, from small scale studies such as individual equipment usage to the optimisation of entire transport networks.

## Electric Railcar Bogie Strain Gauging

As part of the design proving process, BMT was commissioned to carry out a series of strain gauge measurements on a motored bogie for the use of the Brisbane suburban network. Fifty-six linear and 3-element rosette gauge elements were attached to the bogie. Amplifier

outputs associated with these elements were monitored using a 64 channel PC based data logging system developed by BMT. The measured data were stored on disk during each test for subsequent processing into stresses. The results compared favourably to the output of Finite Element Models of the bogie.



## Human Factors Engineering

BMT is applying human factors engineering (HFE) methods and technology to rail systems to improve human performance and reduce safety risks with a particular focus on new system design, technology insertion human performance assessments, and facility design.

## New System Design

BMT HFE specialists provide expertise to teams designing new systems such as communications systems to

optimise operability, maintainability, and the passenger experience through the application of methods such as task analysis, human error risk analysis, design reviews, and ergonomic analysis.

## Technology Insertion Human Performance Assessments

BMT applies HFE methods, including video data analysis, to assess the impact on human performance, passenger acceptance, and safety of new technology being inserted into existing rail systems such as automated platform gates (APG).

## Facility Design Support

BMT provides HFE support for the design of new rail stations. We plan and conduct human performance risk analysis for the design and user tasks of planned new stations to identify human performance issues. Particular areas of focus include station layout and the design of man-machine interfaces, workspace design, and human error identification and quantification.

## Human Factors Engineering Consulting Support for the implementation of a Mechanical Gap filler (MGF) for a Hong Kong MTR Station

BMT successfully provided HFE reviews of control panel, display, control, and workspace design of a MGF system that are being considered to be integrated into active rail stations in Hong Kong. A key part of this project was the planning and implementation of a study to assess the impact of the MGF on passenger behavior and safety. BMT developed the methodology and analyzed the data and performed the on-site data collection in Hong Kong.

BMT provided HFE consulting services on the following:

- Identified anthropometric design considerations relevant to the design of the MGF system with BMT acquiring the relevant data.
- Performed multiple reviews of drawings for the design of the control panels and MGF devices to identify human performance and human factors design issues. Provided recommendations for the redesign of the MGF system.
- Developed a methodology for a study to understand how passenger behaviour at the stations changed after the implementation of the MGF. This included identifying passenger behaviours to be observed, developing data collection and analysis methodology, developing data collection forms, and consulting

on the placement of cameras. Video and observational data was collected by BMT prior to and after the implementation of the MGF to allow for a robust comparison of passenger behaviour. BMT performed an analysis of the results which demonstrated that the passenger behaviour did not significantly change with the introduction of the MGF.





# Specialist Products

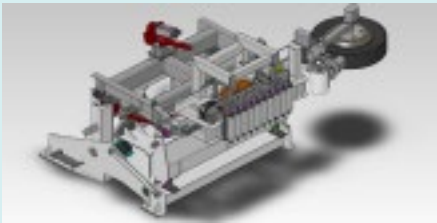
BMT also designs and supplies a range of products to meet specialised operational and maintenance needs in certain markets.

## Wagon Discharge Assist – Robotic Wagon Vibrator

High-capacity coal export terminals receiving coal in bottom-dump rail wagons can experience major delays due to discharge failure when handling sticky coal. These delays can have a serious impact on the capacity of the rail system feeding the port and on the terminal unloading capacity. BMT’s robotic wagon vibrator overcomes the sticky coal problem - significantly reduces unloading delays and increases throughput rates.

## I-trigger System for Maintenance

Monitoring of Wagon Door Mechanisms  
In rail freight networks with large numbers of bottom dump wagons, there can be thousands of hopper doors. The door opening/closing mechanisms require maintenance to ensure product is not lost in transit and the door opens as it should at dump stations. BMT’s I-trigger product monitors the characteristics of door action at the dump station. Using intelligent diagnostics, it auto-generates email reports of “wagon ID / door ID” which require maintenance.



# Business Process Reviews and Audits

Audits are an integral and essential part of the Assurance regime, and when conducted effectively and efficiently they have a positive impact on business performance and customer/supplier relationships.



They are a key driver for continual improvement strategies both internally and externally with your suppliers. They should, at a minimum, provide clear visibility of the following:

- Compliance being achieve
- Contractual conditions being met
- Best practice being investigated
- Risk being managed appropriately
- Suppliers performing to your requirements

BMT offers a consolidated approach to auditing. All of our auditors are Lead Auditor trained and are experienced in conducting the following type of audits:

- Project audits
- Product and process audits
- Quality and safety audits
- Safety critical supplier audits
- Supplier accreditation audits
- Surveillance and condition audits

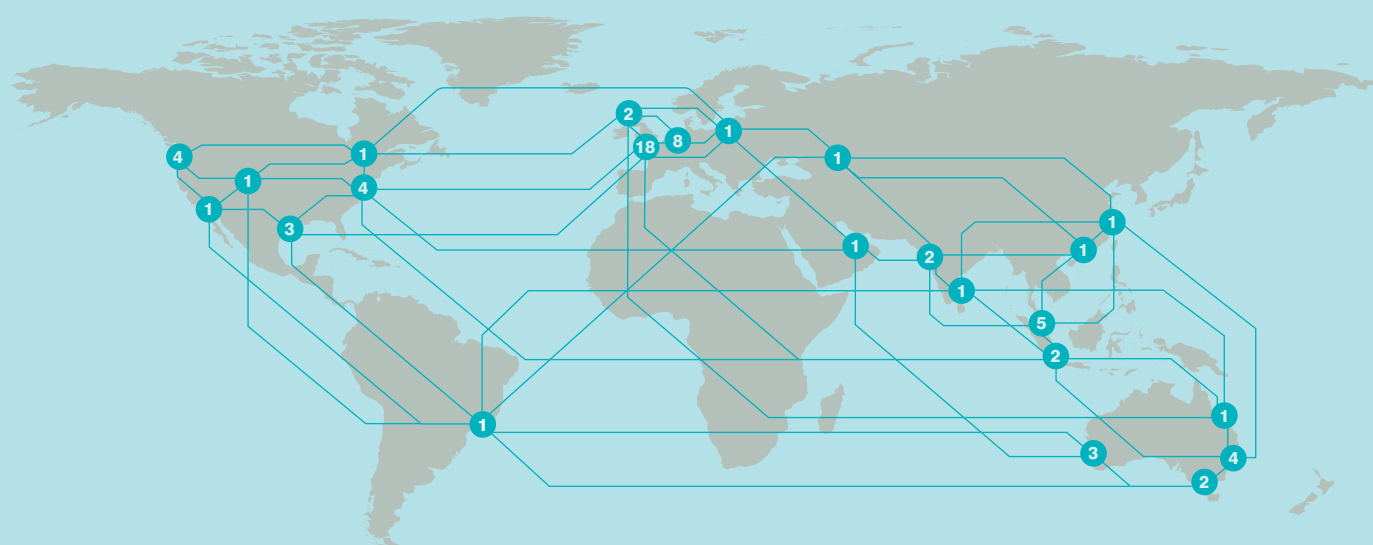
BMT also provides a service that facilitates and manages your audit programme for you. We set and implement an audit programme that applies the audit budget where your business most requires it to be focused. We achieve this by applying a risk based process that ensures the audits are conducted where they can have the most positive effect on reducing risk to





your business aims and objectives. We can harmonise your audit programme to reduce repetition and wastage. Irrespective of the type of audit being conducted. The auditor will endeavor to:

- trace problems back to the root cause rather than merely report them;
- ensure a proper assessment of the whole organisation’s competence is made; and
- analyse findings based on industry best practice and make recommendations.



**With locations in all of the major markets we serve, ours is an active network that sees us sharing skills and knowledge, combining disciplines and building international teams to create integrated answers to the questions of our national and international customers.**



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