

## **MTR Corporation**

### **Performance and Asset Management Review Executive Summary**

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## 1. Overview

MTR requested Lloyd's Register Rail (LR Rail) to conduct an Independent Review of their asset management and maintenance regimes. Originally the scope included: an examination of MTR's Asset Management system, comparisons of current performance with both historical and international benchmarks, examination of the current signalling and rolling stock maintenance processes, and examination of incidents and their management.

During the study the scope was extended to include a limited review of permanent way maintenance processes relating to rail management and an examination into certain power system maintenance issues arising from incidents.

The objective of this work was to determine if MTR are managing their assets effectively to deliver customer services sustainably and to verify whether the MTR Asset Management System meets the demands of service requirements and risk profile, taking into account the age of the assets.

LR Rail utilised a team of nine railway engineers and operations staff drawn from offices in Hong Kong and the United Kingdom. The on-site review was carried out over three months between October to December 2004, subsequent analysis and report preparation continued to the end of January 2005.

## 2. System Performance - Findings

### 2.1 Is the Performance of the MTR Deteriorating?

LR Rail took existing performance data from MTR to verify the internal collection, collation and reporting process. The output of this was used to examine the overall performance of MTR and compare with the key Governmental performance requirements, and also with the benchmark of other comparable urban railways from around the world.

Over the four years reviewed (from 2001 – 2004), the performance of MTR has shown the following trends:

- Total number of incidents have reduced by 35%.
- Customers affected by delays are down by 35%
- Number of peak incidents have reduced by 16%.
- Signalling & telecoms incidents have reduced by 63%.
- Rolling stock incidents have reduced by 32%.
- Operational incidents (those attributed to staff errors and passenger actions) have reduced by 27%.

MTR has met all of its Standard Performance Requirements (SPR) as set out in the Government Operating Agreement in every month of the period reviewed (January 2001 to December 2004). MTR has also met its more onerous Customer Service Pledges (CSP) on most occasions. MTR voluntarily sets these approximately one

percentage point higher than the SPR, and they have been achieved in 41 of the 48 months reviewed.

The annual performance averages for each measure, shown in Table 1.

Performance Measure	Targets		Annual Performance			
	SPR	CSP	2001	2002	2003	2004
A. Train Service Delivery (%) <sup>2</sup>	98.5 %	99.5 %	99.8	99.9	99.9	99.9
B. Passenger Journeys on Time (%) <sup>1,2</sup>	98.5 %	99.5 %	99.9	99.9	99.9	99.9
C. Train Punctuality (%) <sup>1,2</sup>	98.0 %	99.0 %	99.3	99.3	99.6	99.7
I. Train Reliability (car km / incident) <sup>3</sup>	N/A	500,000	577,247	620,238	1,213,247	1,027,233

1. Excludes AEL; 2. TKL excluded until July 2004; 3. K-Trains excluded until July 2004.

**Table 1 - MTR Performance 2001-2004**

MTR sets high targets for performance and consistently meets them. No evidence was seen to suggest that the system is declining; in fact performance is getting better.

## 2.2 Why does performance seem to drop when a large project is introduced given that MTR are meeting all the targets?

When any large project is brought online it takes some time and adjustment for the system to ‘settle’ and the reliability to grow to the levels expected by customers from their experience of the existing mature railway, i.e. it is not possible to implement a new project or upgrade and expect to achieve the same performance levels of a mature system. This is recognised by the Operating Agreement and different requirements for reporting the performance of new projects are set by MTR and agreed with the Transport Department. These measures are called the New Project Requirements (NPR). The two sets of figures are reported separately for an agreed two year exemption period after which, from a monitoring point of view, the projects are subsumed into the operating railway. From this point the data is no longer separated and only the SPRs apply.

While MTR meet the SPRs and NPRs agreed with the Transport Department, the experience of the customer will be that the reliability of the service has reduced when a new project is introduced into operation. It is not for the customer to know whether a delay is due to a new project or to a fault that has occurred on the existing railway. For example, in 2003 the mean monthly proportion of project related incidents ranged from 6.3% and 10.9% on the Island Line and the Tsuen Wan Line to 35.8% and 43.8% on Tseung Kwan O Line and Kwun Tong Line, respectively.

The measures used and the separation of reporting is reasonable from an engineering viewpoint. Greater focus on the combined figures would give a better feeling for the viewpoint and experience of the customer.

## 2.3 Was there an upsurge of problems towards the end of 2004?

Based on the analysis of the five minutes delay data (incidents causing a delay of five minutes or more to any train, not necessarily the initial train), it was found that 2004 had the fewest incidents of the four years reviewed. The number of

incidents in the last quarter of 2004 (October – December) was the lowest in any quarter of the 16 in the 48 month review period.

A further analysis was undertaken to compare the incidents in peak and non-peak periods from 2001 – 2004 to see if this was a factor in the perception of an upsurge in incidents. Although it was found that there was a slight increase in the proportion of incidents occurring in peak periods compared to non-peak (about 5%), the actual number of incidents in the peak has reduced by 16%. Effectively this means that the number of delays experienced in the peak periods during 2004 is almost the same as that in 2001. No statistically significant trends were identified to explain the increase in proportion

Events attracting special attention were identified for the whole of 2004 from the records kept by the MTR Corporate Relations department. This sample of incidents was too small to obtain statistically significant results from analysis, but it did show broadly the same characteristics as the whole 2004 data set. There were no discernable differences in the profile of the incidents that drew special attention, with regard to system affected, line or time, when they were compared with the normal incident population ( i.e. no reason could be identified for the special attention.).

The ‘Customer Satisfaction’ survey is conducted by MTR every six months, in March and September. In 2004 the Service Quality Index part of this survey increased a point in both March and September reaching the highest recorded level of 71. Although this is measured by MTR, this index dropped from 70 to 67 in response to the delays associated with the project works in 2002. This indicates that the measure is sensitive to customer experience of the railway.

The perception of an upsurge in problems may have been influenced over the long term by other factors such as memory of the performance issues associated with the introduction of TKL and K-stock trains, the arson scare at the beginning of 2004 and a number of incidents involving passenger distress such as the generation of “smoke” from the brakes hanging on the trains and the child walking on the tracks. It is not possible for LR Rail to comment on these factors, only to state that the analysis of the available data does not support the view that there was an upsurge in problems towards the end of 2004.

## 2.4 How Does MTR Compare with other International Metros?

MTR is a member of the Community of Metros (CoMET), a benchmarking group of urban railways focused on performance comparisons and continuous improvement. CoMET comprises ten metros from around the world (Berlin, Hong Kong, London, Madrid, Mexico City, Moscow, New York, Paris, São Paulo, and Tokyo). CoMET is managed by an independent research group at Imperial College London. LR Rail requested an analysis of the overall performance of MTR, relative to the other members of CoMET. This analysis was carried out by Imperial College London at the request of MTR.

MTR (excluding AEL) was compared with the other metros in CoMET, across six elements of performance of a metro: its outputs (in terms of reliability, service quality and safety), the effectiveness of its processes and how efficiently the metro uses its inputs (such as labour and asset utilisation).

The results show that in 2003, the latest year for which full data is available, the MTR attained the highest or second highest level of performance in four of the six areas: safety (fatalities due to accidents), the utilisation of its assets, its levels of reliability and the quality of service provided to passengers (proportion of passenger journeys on time).

The MTR achieved the second highest level of reliability in the CoMET group, at a cost that is below that of the majority of metros in the group. It was concluded by Imperial College London that compared with the world's largest metros, the MTR excels in providing a safe, reliable service at a reasonable cost.

## **2.5 Is it reasonable to expect better performance from MTR?**

It is not possible to achieve 100% reliability and even the best performing metro in the CoMET group does not achieve this. It has been shown that MTR achieve and sustain performance levels of over 99% on the SPR and CSP measures and reached levels at or higher than 99.7% in 2004.

MTR performance, and therefore stakeholder expectations, is already very high by world standards. Any further notable performance increase will be difficult to achieve without significant increases in both capital and maintenance costs. To increase reliability further would require justification of the additional cost against the expectations and priorities of stakeholders.

It is inevitable that a performance limit is approached for any given performance criteria, and as this limit is approached the effort and cost required to achieve a small gain can be disproportionate to the benefit. Setting and achieving even higher performance measures against existing performance criteria may not offer the most benefit to the customers. MTR could consider measurement against additional targets to ensure all objectives are being achieved.

## **3. Asset Management Review - Findings**

### **3.1 Are MTR Managing their Assets Effectively?**

Asset Management refers to an organisation's arrangements on how their assets are managed from design, through a life of service and finally to disposal or renewal. It covers all areas of management practice from the setting of strategy, development of plans, implementation, measurement of performance and review against targets and strategy to complete the cycle.

MTR have drawn together their existing Asset Management and Maintenance Practices into an Integrated Management System. The programme to roll out the new Asset Management Manual began in January 2004.

Performance was assessed against the requirements of the new BSI Publicly Available Specification 55 "Asset Management", 2004 as well as the experience of LR Rail staff. PAS 55 was developed by the British Standards Institute with input from a wide cross section of industries, such as power generation, power distribution and oil and gas as well as rail, that rely on strong asset management systems for the success of their business. It was developed to meet a need for a series of requirements based on best practice that organisations ought to meet if they intend to manage assets professionally. It therefore provided the ideal

structure on which to base both the management system assessment and the underlying investigations into the specific technical areas.

The review considered the overall Asset Management System design and its application in the areas of Signalling and Rolling Stock Maintenance. No major gaps were evident in the system design when compared with the requirements of PAS 55-1. The detailed examination of the application of the management system arrangements to the signalling and rolling stock disciplines did not reveal any major gaps in application. The review found that MTR's implementation of an asset management system appears robust and reflects best international cross sector practice. A number of areas were identified by LR Rail where enhancements to the system could be considered by MTR or where it is suggested to bring the asset management system roll out programme forward.

## 4. Maintenance Review - Findings

### 4.1 MTR is Over 25 years Old – Is this Leading to Deterioration in Performance?

Specific attention was given in the Review to maintenance tasks, maintenance intervals, defect management, corrective maintenance, feedback and improvement, risk assessment, asset condition. For guidance purposes, a Maintenance Review Checklist was prepared and utilised in interviews, document assessments and site inspections.

With respect to the Signalling, and Rolling Stock the equipment inspected was found to be in a condition considered acceptable by the LR Rail engineers. There were comprehensive asset replacement plans in place that provided for the future renewal of assets based on their condition and performance.

A small number of minor issues were identified during the maintenance review, however in general the recommendations made were with respect to the need to enhance the existing systems or to bring forward the roll out of the asset management system. The kind of issues included the level of detail and scope to which condition assessment is conducted, the use of a bridging document to bring risk assessments together to form a case for change, the implementation of maintenance management techniques that were seen to work well in one maintenance department to the others and the enhancement of asset information systems to make decision making more efficient.

Following the rail crack incident at Shek Kip Mei (on 9<sup>th</sup> November 2004) an LR Rail permanent way engineer looked at this incident and the condition of the track maintenance overall. It was verified that the findings of the external expert report by City University on the rail crack were acceptable and that the finding that the crack could not have been identified by any techniques prior to the incident. It was noted that due to the design of the permanent way system (a slab construction that provides continuous vertical support and appropriate lateral containment) the crack would not have led to derailment.

The review showed that MTR had implemented a plan to manage rail maintenance and it confirmed that the plan, testing methods and track standards are appropriate for MTR and meet current good practice. Planning for rerailing and rail grinding

activities were in place with adequate volumes of rerailing specified. Recommendations for improving planning and utilisation of resources were made.

The review of Power System maintenance was a late addition to the study and focused primarily on technical issues arising from specific incidents. A high level review of the associated maintenance management systems did not identify any problems with the processes. A minor issue was identified with respect to the installation commissioning testing.

As mentioned in Section 2.1 the data shows the MTR's performance to be improving. No evidence was found to suggest that MTR's assets are declining as the system ages; rather MTR's asset replacement plans focus on the proactive management and replacement of assets.

#### **4.2 Do MTR have priorities right, e.g. “smoke” into carriages affects passengers?**

Risk assessment procedures are in place to ensure that risks are adequately considered and mitigated including the risks associated with project work such as the impact on the operations of the railway during introduction and the impact on maintenance of new or modified systems.

Asset criticality (i.e. the asset's impact on performance) is also assessed but has generally been limited to defining safety and service impact. Although provided for in the system the application does not yet fully consider issues (although it is designed to do this), such as customer distress caused as a result of failure, or through the nature of the failure. For example, if a circuit breaker opens to protect a short circuit it could make a loud bang that could potentially alarm customers although there would be no safety concerns. The term customer distress was not clearly defined by MTR although recent events have given some clarity that issues such as the emission of smoke and loud noises in an incident should be considered in the definition. LR Rail is not aware of any other rail administration that considers customer distress in the way suggested so MTR would be redefining best practice in implementing this.

Asset criticality is not applied down to all key sub assemblies or components, a level which is more useful in better determining the level of attention required on an asset.

During the study it became apparent that prior to the roll out of the Asset Management System access to the running lines for maintenance was on occasion reduced due to requirements for project testing works. It was not clear what level of risk assessment had been applied, and the conclusion reached was that the trade off between system enhancement/renewal works access and routine maintenance access may not have been operating as effectively as possible. The issue appeared to be the application of the process rather than the process itself

The combination of service criticality reviews and the risk assessment process demonstrate an approach to risk management that supports the AM system decision making and prioritisation – both in delivery and in setting objectives for changes and improvements. Whilst no gap was observed in the system design, its use should be promoted and implemented as a priority as planned by the MTR to accelerate the benefits to all.

#### **4.3 How is the Outsourcing of Maintenance Affecting Performance?**

The issue of outsourcing maintenance has been reviewed with respect to signalling and rolling stock, through the assessment of contract arrangements, management systems, data analysis, interviews and site inspections.

It was evident, that a decision to outsource requires detailed internal consideration by MTR and is subject to risk assessment so that controls can be put in place to ensure MTR achieves value for money and that the risks are identified and mitigated. For example, by MTR defining the level of spares to be maintained by the Contractor to avoid the risk of the Contractor reducing costs through lowering the level of their inventory.

Implementation of the contracts has been managed using good management practices, common systems of work, a common performance reporting regime, partnering, and a commercial framework that encourages the contractor to achieve the specified targets. It also includes the use of enhanced defects liability arrangements, the adoption of appropriate financial incentives, and the managing of service disruptions and regular reviews of the contracts and inclusion in the behavioural safety program.

The decision to keep some maintenance in-house after reviewing the business case indicates a balanced approach to the sourcing of maintenance and suggests that MTR endeavour to optimise their maintenance resources.

LR Rail reviewed 28 incidents in detail, of these, 9 involved equipment under outsourced maintenance. These were fairly evenly distributed across four different contractors (3 each for power and rolling stock contractors, 2 for the PSD contractor and 1 for the signalling contractor) and no systemic failures relating to outsourced maintenance were identified.

Relatively, the outsourced maintenance contract is still in its early stages with initial contract performance influenced by any post-commissioning issues. Analysis was carried out on the performance of the M-train rolling stock, as part of the fleet is maintained in house and partly outsourced. The analysis showed no discernable difference in the reliability of the M-series rolling stock maintained by Contractor at the Tseung Kwan O Depot and by MTR at the Kowloon Bay Depot.

Outsourcing of maintenance activities has been professionally conducted and does not appear to have affected the performance of the systems contracted out or the performance of MTR as a whole. Whilst no concerns were identified over the process of managing outsourced resources, this will require continuous scrutiny over the coming years to monitor the contractor's performance.

### **5. Operational Incident Review - Findings**

#### **5.1 Is MTR managing incidents effectively?**

A sample of 28 incidents that attracted particular attention between 7th July and 9th November 2004 were reviewed in more detail by the LR Rail team. No statistically significant conclusions could be drawn from a sample this small and in addition, given that these incidents attracted special attention the sample was likely to be skewed towards the worst case. The purpose of the analysis was to

examine response to incidents and processes for investigation and mitigation. In addition, this analysis provided another means of looking for any systemic issues associated with asset management.

In 22 of these cases MTR were found to have responded professionally, i.e. in accordance with their rules, procedures and targets for managing incidents. In 8 cases staff were recognised for making exceptional efforts in response to the incident. Good examples of this were their ability to repair the SKM rail crack (9/11/04) without suspending the rail service, or the management of the “smoking” brake problem on TCL (18/9/04) where passengers were detrained safely to an emergency platform within 4 minutes of the notification of the problem. In both of these specific cases MTR implemented competent technical reviews, using external expertise where appropriate, to learn from the incidents. It is inevitable that on some occasions the response does not run as smoothly as desired and in the 6 cases when this occurred the consequence was an increase in the duration of the delay, not a risk to customer safety. Examples of this type of incident included the incident involving the high tension cable at QUB (13/10/04) where the power on the train was not reset incurring an additional 1.5 minutes delay.

In 7 (25%) incidents of the sample it was apparent that communications difficulties were hampering the response to the incident requiring the back-up systems to be used. The radio system (3) and centralised public announcement systems (4) in particular had caused these difficulties. MTR should speed up the planned improvements in communications systems to help improve the management of certain incidents.

No systemic issues were identified from the detailed incident review and the 28 incidents reviewed showed no distinguishing characteristics to warrant the attention they received compared to other incidents. Overall, considering that the number of incidents attributed to operations has reduced by 27%, it can be said that MTR do manage incidents effectively. Even where problems occur the result is an extension of the delay not a safety impact. Enhancements to performance could be achieved through addressing the communications systems and examination of the factors influencing the performance of people in those incidents where the response did not go as planned.

## **5.2 Are MTR identifying the causes of incidents and taking prompt effective action?**

The review verified and validated MTR’s data measurement, collection and reporting processes. Data analysis of all incidents in the period January 2000 to December 2004 revealed that MTR’s various lines have different key causes of incidents, and line managers should focus on the causes of delay that are specific to their lines. Passenger actions have more of a relative impact on performance as a line becomes more technically reliable. MTR could possibly gain benefits across all lines by analysing the variances between specific lines (recognising the differences across lines in terms of usage, station stops, passenger load, etc).

Within MTR the technical review of incidents and the operational (non-technical) aspects appears to be carried out separately and sequentially. It is not clear that this approach provides a sufficiently robust interface between the management of the physical infrastructure assets and the personnel and operational processes associated with their use.

MTR undertake investigations to identify the technical problem causing the incidents. If necessary, MTR seek external expert assistance to determine the reasons for the failure of components. Where known issues had caused incidents, for example problems with the SACEM system, plans were already found to be in place to address the problem, or solutions were being sought through working groups. Actions are determined to prevent or manage recurrence of similar events. The actions are tracked to closure, although this tracking may occur in different parts of the organisation.

The types of operational errors or passenger actions that impact the performance of the railway typically fall within the realm of ‘normal’ human behaviour and by investigating, recording and analysing these types of behaviour lessons may be learnt. Appropriate interventions such as engineering solutions, training, and provision of information, amongst others, may then be considered to prevent future recurrence of impacts to the railway.

MTR have many initiatives to address these ‘human factors’ issues in different parts of the organisation. By bringing the various activities together into one system MTR could improve the efficiency and approach to human factors.

## 6. Conclusions

The LR Rail Independent Review has concluded that there is little cause for concern in regard to how MTR is managing its assets in support of the delivery of service to customers.

The data demonstrates that MTR, relative to the other similar metros, is a reliable, safe railway that delivers a high quality service at a reasonable cost. MTR has met all of its Standard Performance Requirements as set out in the Operating Agreement in every month of the period reviewed.

Based on the evidence presented, MTR’s asset management system has performed well against the PAS 55–1 reference and to the detailed examination of the application of the management system arrangements.

The Independent Review has not found any evidence to suggest that MTR’s assets are declining as the system ages; rather MTR’s asset replacement plans focus on the proactive management and replacement of assets. Outsourcing was found to be professionally done and there is no discernable negative effect on safety or performance.

Adoption of the recommendations made in the report should take MTR into a leading position in rail asset management.

## 7. Recommendations

A total of 16 recommendations are made in two categories: those requiring a review of existing practices and those simply requiring enhancements to be made to the existing practice. An outline of the recommendations are given below,

### 7.1 Review – 7 Recommendations

#### *Integration of New Projects / Upgrades into Existing Operations (2 Recommendations)*

MTR should review the way in which the impact of new projects is assessed in terms of delivery of the project itself and the effect on the operation of the railway with the objective of minimising disruptions caused by new projects / upgrades. Consideration should be given to further integration of the Projects Division activities into the overall asset management system.

#### *Management of Stakeholders (1 Recommendation)*

MTR should review the management of stakeholder expectations, to minimise the risk of creating unrealistic long term expectations. Further significant performance increases could be difficult to achieve without considerable increases in cost. MTR should review how these stakeholder expectations can be managed realistically given the inevitable asymptotic nature of performance trends towards an affordable maximum figure.

MTR should also address how it manages the expectations of different stakeholder groups (e.g. customers, politicians, media) and improve their understanding of the necessity for a balance between performance and cost.

#### *Asset Criticality and Customer “Distress” (1 Recommendation)*

MTR should promote the use of the current risk management processes and widen their application as a priority. In particular consideration should be given to reviewing of the contribution of public perception issues (i.e. incidents that cause customer “distress” but in themselves have no safety implications) when introducing new equipment or reviewing/optimising maintenance activities and also consider extending the assessment to critical sub-assemblies

#### *Benefits from Integrated Human Factors (1 Recommendation)*

The activities that are undertaken within MTR to address the staff errors and passenger actions that impact the performance of the railway (human factors) should be pulled together into one system to improve efficiency and effectiveness.

#### *Track Rail Management Implementation (2 Recommendations)*

MTR have a good plan for rail management but need to recognise that the plan is embryonic and needs to be reviewed and developed as experience is gained during

implementation. MTR should also review their on track plant resources needed to deliver the plan.

Consideration should be given to enhancing the physical inspection regime at important locations including the evaluation of acquisition of specialist video inspection equipment.

## 7.2 Enhancements – 9 Recommendations

These recommendations focus on the enhancement of existing good practices and processes and are both detailed and technical. A summarised list is given below:

- Enhancements to the MTR Asset Management System (6 Recommendations)
- Project Implementation Commissioning and Testing (1 Recommendation)
- Assessment of Operational Communications Systems (1 Recommendation)
- Full use of Available Performance Data (1 Recommendation)