FINAL REPORT

International Study Mission to Hong Kong, Singapore and Tokyo

Safety Culture, State of Good Repair and Innovative Operations

September 2017

EXECUTIVE SUMMARY

APTA organized a study mission from March 29 to April 7, 2017 on safety culture, state of good repair and innovative operations in Hong Kong, Singapore and Tokyo. The key focus was how internationally leading transit operators in Asia have developed a comprehensive risk management approach that prioritizes safety and state of good repair.

Twenty-three APTA members participated in the study mission with two-thirds from the public sector including numerous senior transit officials responsible for safety and asset management, and one-third representing APTA business members.

In addition to site visits, mission delegates participated in extensive round table discussions with senior transportation officials from 5 host agencies:

- MTR, Hong Kong's main public transportation operator of light & heavy rail;
- SMRT, one of the largest multi-modal transit providers in Singapore;
- JR East, the high-speed and commuter rail operator for Tokyo;
- Tokyo Metro, one of two subway operators in Tokyo, and;
- Tokyo Metropolitan Government's Bus Division.

These organizations face the same challenges as U.S. systems; aging assets and increased ridership demands including customer expectations for safe and reliable service. The fundamental difference is how they are structured to deal with these challenges and their cultural understanding of what constitutes acceptable performance and customer service. They all have well-developed management approaches that internalize and ingrain safety and asset management as a part of everything they do, from planning, design and procurement to operations and maintenance to training and customer service.

Study mission participants determined that there are many guiding principles and lessons learned that are transferable:

- A holistic, risk-based business model based on predictable, long term funding for operations and capital;
- A spirit of continuous improvement focused on the customer experience;
- Service excellence based on an ingrained focus on safety and good performing assets;
- Collective mindfulness and a sense of individual ownership instilled in the workforce;
- The extensive use of technology, data analytics, and sound processes to achieve efficiencies;
- A significant investment in human capital, with an emphasis on the professionalization, integration and engagement of the workforce.

I. INTRODUCTION

The U.S. transit industry is undergoing a generational shift in how safety and asset management programs and regulations are impacting and influencing service delivery to our customers. The U.S. Department of Transportation has received and is implementing significant new regulatory authorities which are transitioning the industry from a system safety to a safety management systems (SMS) approach. This model emphasizes safety policy, safety risk management, safety assurance and safety promotion.

In this context, APTA organized a study mission from March 29 to April 7, 2017, focusing on safety culture, state of good repair and innovative operations in Hong Kong, Singapore and Tokyo. This study mission was designed to give participants an opportunity to explore strategies in three countries that have continued to stay on the cutting edge of public transportation innovations.

Twenty-three APTA members participated in the study mission including APTA Chair Doran Barnes and Richard White, APTA's Acting President and CEO (see Annex 1). Two-thirds came from the public sector, with numerous senior transit officials responsible for safety and asset management, and one-third represented APTA business members.

The 2017 study mission focused on how internationally leading transit operators in Asia have developed a comprehensive risk management approach that prioritizes safety and state of good repair. These operators have highly developed asset management programs, capital planning for State of Good Repair programs and mature safety cultures that engage and empower employees to maintain and continuously improve service reliability and customer service. They do long-term planning and have a sustainable business model to support both operational and capital funding needs.

The study mission started in Hong Kong with a focus on building a robust safety management system and taking a risk management approach to planning and operations. Participants gained insight into innovative solutions for maintaining, rebuilding, and expanding transit systems, especially in a near capacity operating environment. Next the group traveled to Singapore to study a high-performance safety culture in planning, operations and maintenance in a multi-modal environment with fully autonomous rail operations. The mission continued to Tokyo to

view world class maintenance and operations centers for metro, commuter and high-speed rail as well as station management. In addition, participants visited top training facilities for the Japanese public transportation workforce and explored Tokyo's largest bus depot.

In addition to site visits, mission delegates participated in extensive round table discussions with senior transportation officials from all 5 host agencies:

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- SMRT, one of the largest multi-modal transit providers in Singapore;
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1) MASS TRANSIT CORPORATION, HONG KONG (MTR)

MTR is the primary rail operator for Hong Kong, a special territory of China with a population of 7.3 million. With only 30% of Hong Kong's land developed, it is a very densely populated territory where MTR has a market share of 48.4% of all trips, carrying over 5.5 million passengers daily with 2110 rail cars over 135 miles of rail across 161 heavy and light rail stations. It has an on-time performance rate of 99.94% and an exceptional fare box recovery rate of 186%.

A profit-making corporation receiving no subsidies for its rail operations, MTR has a vertically integrated business which brings together the full life-cycle of rail construction, operations and maintenance with station retail, advertising and telecommunications and commercial and residential property development and management in and above its stations. MTR also owns and operates 13 shopping malls in Hong Kong as well as approximately 100,000 housing units and a share of 5 office buildings.

The net profits made from the value capture of its properties, 1% from rail operations and a 5-6% return on its ancillary businesses, allows it to maintain the system in Hong Kong in a state of

good repair and invest in new railway projects while keeping fares at an affordable level and receiving no public subsidies.

MTR is committed to a model of continuous improvement and is focused on how to attain the additional .06% of on-time performance rather than maintain existing high service levels. They plan 40-50 years ahead and take a risk management approach to decision-making. They place an emphasis on an investment in human capital to ensure a high standard of service reliability and customer service, and the motto “safety first, quality always” is embedded in everything that they do.

2) SINGAPORE MASS RAPID TRANSIT (SMRT)

SMRT, is one of 2 metro operators in Singapore, a country with a population of over 5.7 million and a peak hour modal share of public transportation trips of 67%. It carries over 2 million passengers a day on its heavy and light rail network with a 99.3% on-time performance rate. A fully multi-modal agency, it also operates bus, taxi, and autonomous vehicles as well as providing commercial and engineering services. SMRT sees themselves as a mobility integrator rather than a dominant player in a specific business sector.

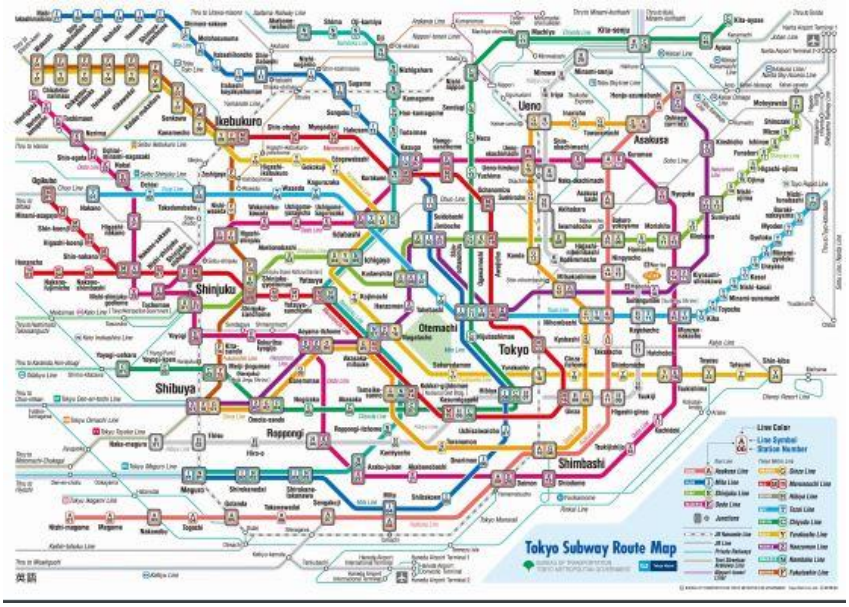
The organizational timeline - which appears in SMRT’s annual report and along the entrance wall in their main depot and training center - communicates a clear relationship between the organization and its contribution to societal progress. SMRT’s vision “Moving People, Enhancing Lives” and their multi-media materials have themes which always return to the customer.

In October 2016, the company delisted from the Singapore Stock Exchange, where it had been listed since 2000, and transferred asset ownership back to the national government. The need for direct and on-going governmental support for capital funding makes SMRT a somewhat more relevant comparator to US transit systems. It is self-sustaining for operating funding.

SMRT managers make safety a core organizational value, aiming to achieve “collective mindfulness”. SMRT places a clear organizational imperative on security with impressive investments in fire/life safety systems, emergency exercises, approximately 200 closed circuit television cameras per station for security purposes, and train sweeps for bomb threats.

3) TOKYO

Tokyo has the largest urban rail system in the world with ten passenger rail operators (two metros and eight commuter/railroad agencies). Tokyo, with a population of 37.8 million and a public transportation modal share of 33%, has a goal of increasing rail access. This is remarkable for a few reasons, the first being that most residents already have a rail station within 1 mile of their homes, but perhaps most of all because much of Tokyo’s rail network is built out, and significant expansion may be limited. This demonstrates the commitment to transit and critical role it plays in livability and community.



APTA was hosted by multiple agencies while in Tokyo: East Japan Railway Corporation (JR East), a commuter/railroad agency; Tokyo Metro, a subway operator and Toei Bus, a bus transportation agency that services the Tokyo Metro area. Like the other rail agencies visited on this study mission, JR East and Tokyo Metro have very high levels of reliability. Further, both are constantly striving to do better. To support these goals, both agencies are organized and function as high reliability organizations.

a) EAST JAPAN RAILWAYS COMPANY (JR EAST)

JR East divides its operations into Metropolitan, Regional, and High Speed in and around as well as to the North East of Tokyo. JR East is one of seven private Japanese railway companies formed in 1987 after a government decision to privatize and split up the severely debt-ridden National Railway Company. JR East moves 17 million passengers per day on 12,400 trains and has over 58,000 employees. JR East's interagency Suica Card focuses not only on paying rail fares; it can be used at vending machines and merchants both within and outside of stations. JR East self-generates 56% of its own power, 100% in the Tokyo Metro area.

JR East's revenue is split between rail operations and a lifestyle business, with significant business and retail development at their rail stations. JR East has over $20 billion in annual revenues with a net annual income of $2.2 billion with 32% generated in lifestyle facilities, i.e., hotels and retail and 68% in rail operations. The Shinkansen high speed rail service provides a substantial percentage of their revenues.

Their business model allows the agency to proactively support operations, maintenance and safety initiatives as well as long-term capital planning. They pursue "extreme levels of safety" with a goal of zero accidents involving passenger and employee injuries or fatalities. JR East's safety approach includes a five-year safety plan and multiple layers of safety culture (proper reporting, learning, noticing, etc.). The company embraces the "investigation of causes" and speaks of how employees in the field create safety. The statistics show their efforts in safety are working; their accident rates have fallen dramatically. They diligently and effectively track hazards and risks, investigating and managing causal factors. This is all accomplished without sacrificing punctuality.

b) TOKYO METRO CO., LTD

Tokyo Metro has 9 subway lines totaling 195.1 km with both overhead- and third rail-powered lines. The agency moves 7.07 million passengers per day with 2700 railcars and 170 stations. Like JR East, it obtains revenue from its affiliated businesses including retail and advertising in

stations, credit cards, real estate development and renting fiber access. This diversity of revenue provides for profitability and the ability to invest.

Tokyo Metro provides a single seat passenger ride; passengers may board a train that can run over several agencies' rail lines, with crew changes based on ownership of the rail being utilized. This arrangement requires Tokyo Metro operators to be familiar with over 80 railcar configurations, as they could be operating any one of the railcars owned by others in this shared configuration.

Tokyo Metro conveys a relentless pursuit of safety and a substantial emphasis on meeting customer needs. Customer service representatives are trained to assist in English and are provided tablets with relevant information to answer customer questions. There is free wi-fi in the stations and considerable thought and planning has been devoted to signage and information.

c) **TOEI BUS**

Toei Bus is a unit of the Tokyo Metropolitan Government, operating 1400 buses, 18 depots, and 129 routes moving 600,000 passengers per day. Toei is one of 10 metro Tokyo bus operating agencies which collectively move 1,250,000 daily. Toei is preparing a fuel cell bus program for implementation during the 2020 Summer Olympics in Tokyo.

Toei Bus has developed some unique training tools and operator evaluation tools. One bus is equipped to evaluate operators on a yearly basis and indicate potential operating weaknesses. Bus analytics can track not only where the bus has been, but where the operator's eyes were looking throughout the trip. This data is used as a training and review tool. The training bus visits the various depots on a rotating basis throughout the calendar year.

II. KEY TAKE-AWAYS

What became very clear during the visits to each of these operators is that their success is based on:

- A consistent risk-based approach that considers the cost of doing nothing;
- Driving for continuous improvement;
- Very effectively planning and resourcing for the long term with horizons of forty to fifty years and the incorporation of life cycle costs into any new services;
- Strong strategic planning /management approaches to inform their work, and;
- Having the means to ensure adequate and reliable sources of funding to support both operating and capital (State of Good Repair & capacity funding needs).

The operating companies visited have well-developed management approaches that internalize and ingrain safety and asset management as a part of everything they do, from planning, design and procurement to operations and maintenance to training and customer service.

1) SAFETY CULTURE WITH A FOCUS ON RESPONSIBILITY, ACCOUNTABILITY, TRANSPARENCY

A critical feature is how each of these operating companies approaches safety:

- They have developed a culture that has truly internalized and ingrained safety as a part of everything they do;

- They do not necessarily have an individual responsible for ensuring safety, but each employee clearly understands his or her role relative to safety;

- Collective mindfulness and a sense of individual ownership are instilled into the workforce. For example, several operators make use of the fingering procedure as steps are taken for critical tasks i.e. the employee points out with their finger and states the action to be taken such as a train operator pointing to and stating aloud that they are stopping for a red signal;

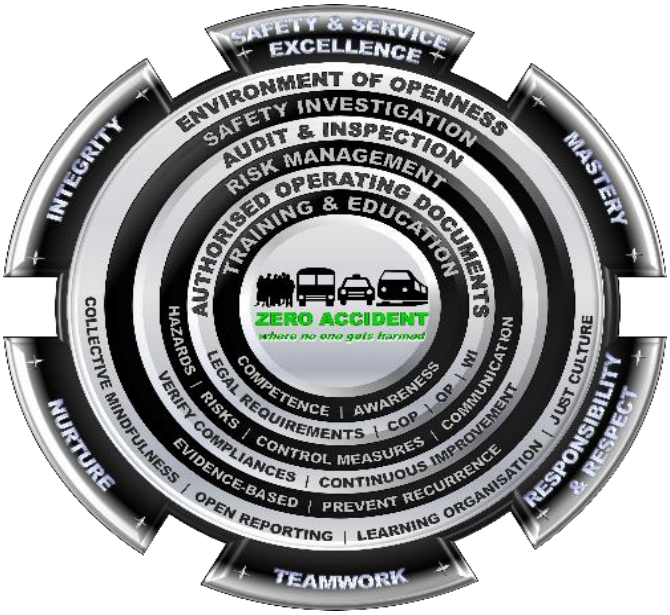
- Safety is a way of doing and thinking about the business, a core process that drives all activities: there is safety in customer service, safety in operations, safety in maintenance, safety in engineering, safety in procurement, safety in training;

- They have strong governance processes for reviewing safety performance.

With **MTR**, the motto is “safety first, quality always” and corporate safety is viewed as a precious resource. The agency places a clear emphasis on employee and community engagement and the responsibility and accountability that comes with working for or riding the system. The emphasis on safety is integrated in all organizational functions and there is clear and continuous communication on safety standards, processes and ownership coupled with substantive training programs. Accountability and responsibility start at the top.

MTR uses a model of risk mitigation that focuses on being alert, reporting anomalies, taking action, and prevention by design. They also design out safety issues. They focus on risk tolerance conducting continuous reviews and job hazard analysis with an emphasis on creating and sharing “lessons learned without attribution – no name, no blame”.

SMRT also communicates and reinforces a strong safety culture. A visual representation of the SMRT approach and commitment is the “zero accidents” medallion given to all employees.



This medallion is **SMRT**’s Roadmap to safety culture excellence. It starts from the center of the shield, the vision of zero accidents, and radiates outward with the processes and behaviors that reinforce the vision.

SMRT expects all employees to be competent and mindful of safety through training and education, ensuring compliance with all authorized operations documents and execution of their risk management before every work activity. The immediate supervisors and organizational management are then responsible for conducting audits and inspections to verify compliances and seek continuous system improvement. Any near misses or accidents reported are subject to a safety investigation to prevent recurrence. And finally, an environment of openness must be established to achieve an open reporting and organizational learning culture to inculcate organizational safety habits.

SMRT considers the following factors as critical for creating a strong safety culture:

1. People:
    - Leadership and engagement
    - Communications
    - Competence training (including on the job)
    - Performance management (discipline and reward)

2. Workplace:
    - Workplace processes and resources
    - Organizational safety systems
    - Technology enhancing performance

3. Annual Assessment and Incentives:
    - Individual, team-based and corporate-wide incentives
    - Monthly incentives
    - Annual incentives (safety performance is 10% of bonuses)
    - Safety and Service Excellence awards and recognition
    - Safe driving incentives

SMRT has a policy that calls for employees to speak up and advise their supervisor when they see an unsafe practice/situation and as a backup, empowers them to call for a “Safety Time Out” or, if not comfortable, to report (via phones call, email or mobile app) to a Safety Hot Line.

A sound governance structure is also in place to review safety performance:

- A SMRT Safety and Security Steering Committee chaired by the CEO
- A SMRT Safety Board (for Rail and Roads) that include respective subject matter experts that meet monthly to review and approve system modification and operational changes

- A SMRT Safety and Security Working Committee which reviews all incidents and focuses on workplace safety and health as well as security matters
- A Division Safety Committee at each business division which includes local work groups
- A Workplace Safety and Health (WSH) Committee incorporating management and line personnel
- A Fire Safety Committee at each depot

SMRT always carries out a root cause analysis following incidents and the investigations are reviewed by the Safety Steering Committee as a quality check. They demonstrate a very strong sense of transparency internally and externally and make use of international benchmarking to measure process among peer operators. They are also creative in their risk management approach, protecting service with extra trains staged along different lines and using different colors for seating in each car to facilitate the ease of incident reporting by customers while on board.

JR East's key to success, especially as it applies to safety, is cultural.

Five cultural fundamentals work together to ensure individual ownership, responsibility and action:

- Prompt and proper reporting of accidents and incidents and the prevention of reoccurrence;
- Recognition and sharing of information regarding risks and problems;

- Open and honest discussion and exchange of opinion in investigations to identify cause and take truly effective countermeasures to prevent reoccurrence;
- Continuous awareness of others, learning from accidents and incidents no matter where they occur, and;
- Personal responsibility to think and act for oneself – the core of safety or what they call "my Hiyatto" - stressing individual responsibility for zero violations.

JR East emphasizes extreme safety levels and zero accidents. They also made a conscious change in focus from the "pursuit of liabilities" to "investigation of causes", aka, root cause analysis.

The strong culture of responsibility and accountability, as demonstrated by employee empowerment, is constant. They now emphasize and teach problem-solving skills and allow operators to manage situations on their trains, much like a captain of a ship. For example, during one of the natural disasters that hit Japan, the operator of one of the trains did not follow protocol; rather he evacuated his train to a place that he believed they would be safe. His actions resulted in all his passengers being saved. Had he followed protocol there would have been a different outcome.

JR East spends significant time on lessons learned and conducting risk assessment with a focus on designing out hazards. Stations are designed to protect the public and employee hazard detection systems have been put into place. The location of the Museum of Accidents at the Employee Training Center is a dramatic statement about emphasis on preserving the history of all accidents. Lessons learned are displayed with an unusual level of candor and transparency. They prepare 5-year safety plans.

Tokyo Metro describes peace of mind as "Safety and Service". They have a proactive approach to designing a safe system with measures such as the:

- Installation of platform doors
- Safety alert panels
- Security cameras throughout the facilities and equipment
- See-through garbage cans allowing for visual inspection
- Detection mechanisms to protect the employees, customers and the system in the event of natural disasters like flooding, eg. flood doors, wind gauges on key bridges and evacuation systems and enclosed stations
- The installation of emergency batteries to allow trains to be operated in the event of power disruptions.
- The utilization of glass doors on gangways between railcars to preserve visibility and mobility, and contain fire and smoke.

At an organizational level, agencies like **JR East** and **Tokyo Metro** look at reliability issues before they become actual incidents. As such, both agencies concentrate on close-call and near-miss reporting and try to identify at-risk behaviors and trends before they turn into incidents or delays. Both agencies invest heavily in safety and hazard management with an understanding of the costs related to incidents. They seek to use technology applications to mitigate risks and reduce costs and are make regular investments in technology for this purpose.

Key safety analytical tools include root-cause analysis, close-call reporting and division of incidents into key categories. The categories include three commonly used in the US: accidents, incidents (generally near misses), and rules/procedures violations. **JR East** adds a fourth layer – *My Hiyatto* – which could lead to rules violations. JR East tries to concentrate on predictive behaviors and, in doing so, minimize the occurrence of accidents and incidents, including grade crossing accidents, trespassing, and passenger falls from platforms to tracks.

2) A ROBUST STATE OF GOOD REPAIR

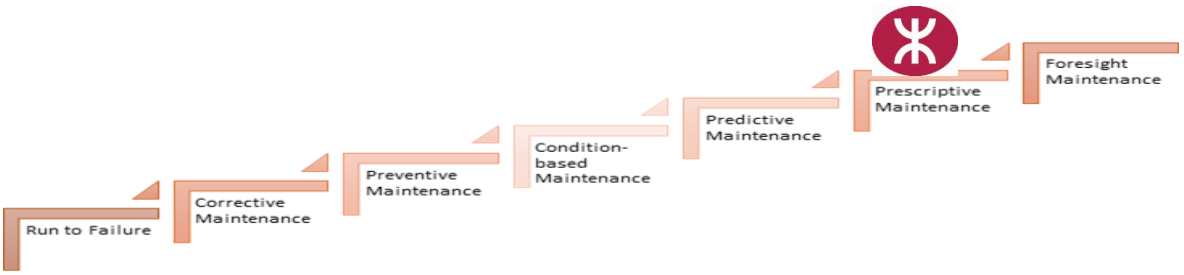
As with safety, each of these high functioning organizations has a holistic approach for ensuring that assets are maintained to support operations. The agencies visited approach "State of Good Repair" as the cornerstone for their business and it is ingrained into everything they do to support the service provided to customers. All organizational activities including maintenance work are directed toward safety and providing the reliability and capacity necessary to ensure continued high performance. A robust asset management/ State of Good Repair culture is central to this.

The fundamentals of asset management/ State of Good repair systems employed at these agencies include:

- a risk based asset management framework backed by strong engineering that considers the cradle-to-grave asset life;
- the required performance level and service load of the asset;
- the organizational structure and roles and responsibilities relative to asset performance;
- a robust financial management system which supports and drives asset maintenance and asset performance, and;
- an investment in employee competence.

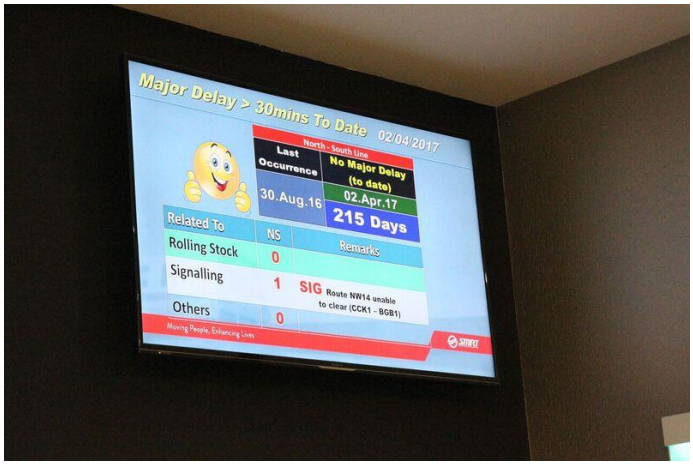
These Asian systems face the same challenges that U.S. systems are facing; increased ridership demands including customer expectations for better service and aging assets. The fundamental difference is how these organizations are structured to deal with these challenges and their cultural understanding of what constitutes acceptable performance and customer service.

MTR effectively articulated an asset management continuum. The most basic and dysfunctional asset maintenance system is the run-to-failure model. Investment in preventive maintenance is minimal and assets are run until they fail, then repaired and returned to service. This system results in high maintenance costs and poor service reliability. Mid-way up the continuum is Condition Based Maintenance. Here performance data is used to develop enhanced preventive maintenance and system modification improvements aimed at increasing reliability, reducing unscheduled failure and associated service disruptions and expenses. The further an agency progresses up the continuum the less available failure data becomes because assets are performing more reliably. Prescriptive maintenance assumes that all potential failure modes have been considered and maintenance plans address them such that unscheduled failures do not occur. MTR identifies their program as currently entering the Prescriptive Maintenance stage. Their vision for the future is to have a Foresight Maintenance program. This is a program that cannot learn from asset failure because none exists. It rather must depend on excellent engineering and strict adherence to very defined maintenance protocols.



With an expected annual growth of 5.5%, an aging network and infrastructure, rising customer expectations and limited availability of maintenance/engineering hours, **SMRT** in Singapore is experiencing increasing demands on its rail network. To combat service disruptions, speed restrictions, train failures and safety breaches, SMRT senior managers are focused on major system rehabilitation needs in asset categories similar to US systems (e.g. track ties, power systems, vertical transportation, existing fleet, train signals). They are very upfront about the system's legacy problems and the need to address them responsibly. Their marketing expresses recognition that a vast system renewal effort will inconvenience customers. Consequently, their messaging to customers is direct: "We're working on it!" and they seek patience and feedback.

SMRT created an Asset Management Excellence Model by identifying best practices. It tracks all conditions with an integrated operations center which includes an Operations Control Center (OCC), a Maintenance Operations Center (MOC) and a Track Access Management Office (TAMO).



SMRT includes all assets, not just trains, and employee conduct in the calculation of the Mean Kilometers between Failure (MKBF). Their goal for 2018 is 800,000 kilometers or 479,097 miles. They are committed to moving from what they call preventive maintenance to predictive maintenance. The launch of the Maintenance Operations Center is the most compelling expression of this data-driven approach to maintenance. Armed with data on wheel flats,

collector shoe condition, power supply health and track alignment, SMRT has the ability to stage real-time deployment of labor, supplies and materials to maintenance issues.

SMRT also draws a connection between the caliber of its physical assets and the caliber of its human assets. Despite financial considerations and more assertive government regulation, the organization has committed to boosting its technical expertise, citing a 30% increase in rail maintenance staff and a 70% increase in executive rail engineers. In addition, it is worth noting that pay for performance is utilized in some form by all three agencies. The most creative is SMRT which has established frontline employee base salaries with two levels of "bonus" salaries. The first is a maximum overtime allotment and the second is based on competent work which is measured strictly on performance data.

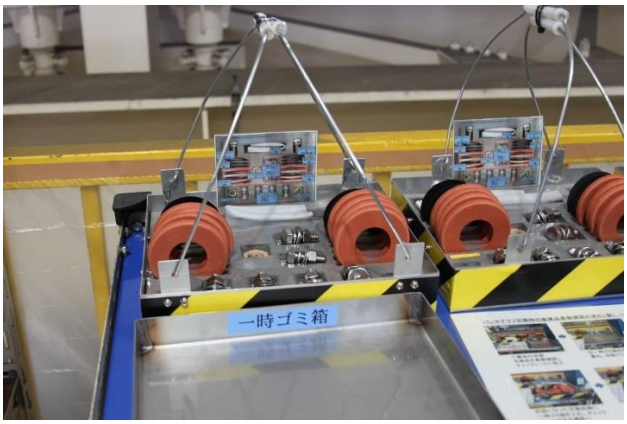
Management of physical assets is also handled in similar ways across all three organizations. Asset management begins with the procurement process which must clearly define the current and projected functional and load requirements of the asset, reliability requirement, maintenance plan, and all related documentation. A long-term plan is developed which details maintenance, overhaul and end of life processes for assets. They adhere to a very prescriptive monitoring, evaluating, and refining process based on data analytics overlaid with the asset life cycle plan. Deep, root cause analysis, as well as intensive monitoring of trends and statistics, is used to identify problems and address them. Maintenance, engineering and, in many cases, the manufacturer play critical roles in the process and must work collaboratively to identify and implement the best solutions for asset reliability and life.

This process of continuous improvement yields regular adjustments to maintenance practices. Sufficient controls exist to ensure changes are appropriate for desired results. Not surprisingly, it is typically easier to add additional maintenance processes than removing existing procedures. Like most U.S. systems, these agencies have limited non-revenue time to complete work on critical assets. This has driven them to develop process efficiencies and technological solutions. The importance of process efficiency cannot be understated. **SMRT** maintains strict adherence to maintenance procedures that have been developed to assure the right maintenance at the right time. Any change of these procedures, which are regularly reviewed with proposals for revision when warranted, must be approved by a Maintenance Review Board of stakeholders. Proposed changes are reviewed against the original equipment manufacturers recommendations and historical functional performance data of assets to determine whether a change is warranted.

JR East maintains a very high on-time service rate despite the fact that it carries more than half of the 23.5 million daily transit riders in Tokyo across not only their own network of nine rail lines but also across eight lines operated by partner agencies. They achieve this excellence not

because they have a robust asset management program, but rather because the fundamentals of asset management are embedded in their daily operation. They have achieved excellent asset reliability and now focus and assume responsibility for all the other factors that could impact customer service like sick patrons, police actions, and acts of nature. As an example, they have a very public campaign aimed at getting and keeping sick passengers off trains.

JR East uses Kaizen maintenance practices in its railcar shops, and the packages and tool kits for each task are clearly well-controlled. The facilities visited were very orderly with everything accounted for and in its place. The utilization of Lean Manufacturing principles in its maintenance shops has significantly reduced equipment out of service time and labor costs. One of the significant benefits of this approach is supply chain quality and efficiency. Inventory Management starts with a well-defined and scheduled maintenance plan. Each activity has a defined bill of materials that must be received and staged at the point of work just in time for work to commence.



As an example, materials for Preventive Maintenance are staged on the carts identified by the car number ready for the car to roll into the shop.

As a demonstration of their dedication to continuous improvement, **JR East** has developed a production line to service, test and replace critical components, including trucks and HVAC units, within one day. Each station along the line is staffed with just the right number of appropriately skilled personnel, tools, and materials to perform the required task. The train advances along the line per a defined schedule but any employee can stop the line due to a safety concern.

The APTA group witnessed the “7 Minute Miracle” during which a team of JR East personnel quickly clean an entire Shinkansen high speed train while it lays over at the station. The train is at the platform for exactly 12 minutes. The passengers take 1.5 to 2 minutes to disembark and the cleaning crew must be done 3 minutes prior to pull out. This leaves the cleaning team 7 minutes to completely clean the train, wiping seats and tables, turning the seats for the return journey, sweeping the floor and, finally, having a supervisor check the work.

It is clear that the Asian agencies visited employ the latest technology in creative ways to develop solutions to monitoring asset performance. An example of a technology solution is the telemetric equipment mounted on revenue trains that provide real time track geometry and condition monitoring in Tokyo. Use of this technology has significantly improved data quality while reducing the need to have personnel inspecting equipment in the right of way, which is both a path to cost savings and a way to enhance employee safety. **JR East** is also developing a new trainset that includes on-board track and catenary (overhead wire) inspection systems. The new systems use both camera- and sensor-based technologies and will change the focus of systems inspections. Going forward, inspections will focus on hotspots and defects the system identifies, reducing or eliminating visual inspections.

The need to fully fund maintenance and engineering to ensure asset functionality and lifelong performance is always a challenge and often results in tension between the Budget Department and Operations. It is a global phenomenon that MTR, SMRT and JR East have addressed in unique ways. Although all three agencies are privately operated with considerable business diversity, the expectation is that their transportation business is profitable.

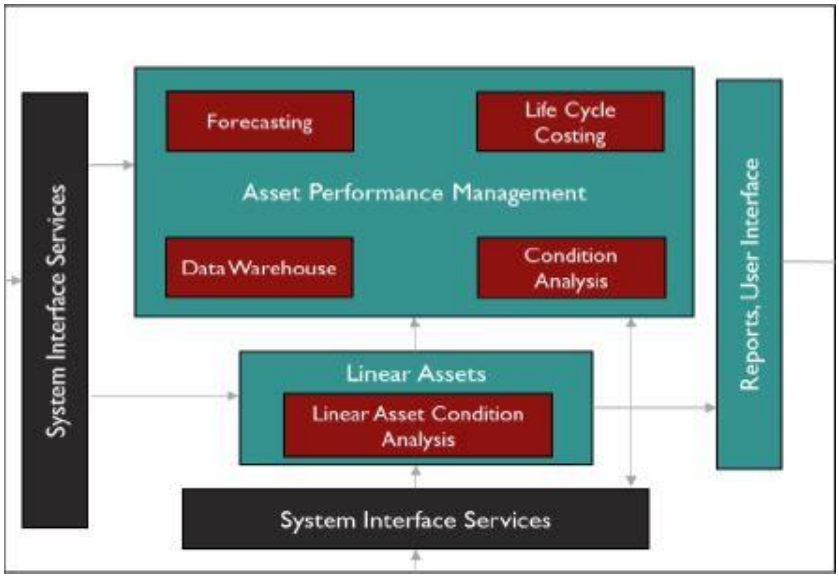
At **MTR,** a formal ISO 55001 certified asset management process exists. The process begins with the corporate goals and policies, considers ridership and business demands, and then focuses on assets. The asset plan includes an investment plan, how assets will be on-boarded, a life cycle maintenance plan, asset condition and performance management and asset end of life retirement and decommissioning. The budget process assumes a level of capital investment associated with the asset life cycle plan. However, a Reliability Centered Maintenance (RCM) structure provides systematic review of maintenance requirements based on failure and consequence of failure. This process is intended to be a regular check on the asset life cycle plan and necessarily identifies the need for additional maintenance investment. Driven by data analytics, needs are ranked by risk and evaluated against each other for annual capital investment.

Like in the U.S., not everything gets funded. While there is consideration and investment on the capital side there is an expectation that capital investment reduces operating expenses. Maintenance departments, both rail vehicles and infrastructure, are expected to reduce their operating budgets by 2%, soon to be 4%, a year. This saving comes from technology and reliability improvements that reduce headcount and material usage.

SMRT has a very formal asset management plan which includes a structure that is consistent with the FTA MAP 21 mandated asset management program. Unarguably, SMRT's program is more developed and advanced than that of most U.S. transit authorities. One of the unique features of SMRT's asset management program is that they have a formal process for including

stakeholder engagement. Stakeholders include entities that may not traditionally be thought of as having a role in asset management such as regulatory agencies, political entities, citizens and customers. Additionally, there is an elaborate public communication campaign designed to generate support for capital maintenance improvements despite the disruptions they create. These public relations campaigns humanize the agency and help make the customer feel valued.

SMRT's Asset Information Management System (AIMS)



The major take-away regarding asset management is that it is not a standalone activity but a journey. Success is dependent upon asset management being an organizational commitment; everyone in the organization understands their role and responsibility. A robust asset management program includes a detailed asset lifecycle plan beginning with the procurement process, with consideration of operational demand and customer expectations. It must involve constant asset condition and performance management, monitoring, innovation and investment. The use of data analytics and dashboards to ensure risk based investment and continuous improvement is critical. The most successful organizations will view their employees as valued assets. Appropriate investment and certification to ensure employee competency at all levels contributes to high organizational and asset performance. They consider and plan for the impacts of regulatory oversight, and political and public interests. Stakeholders and customers matter and engagement and communication are key.

3) A SIGNIFICANT INVESTMENT IN HUMAN CAPITAL

All agencies identify their employees as their most valued asset and demonstrate this by:
- Investing heavily in training, education and certifications at all levels;
- Ensuring that everyone understands their role in providing excellent service to the customer, including across functions;
- Developing and maintaining consistent communication, engagement and empowerment, and;
- Putting in place effective systems and processes to ensure good performance.

Their commitment to their workforce is exemplified by proactive employee engagement, directing significant resources to training and professional development and use of discipline and rewards to reinforce performance at individual and group levels. As profit-making businesses, they are keenly aware that the investments made in their workforce are far outweighed by the benefits (e.g. employee expertise and engagement, staff and customer safety).

Working for these agencies is a career that is held in high esteem. They promote and invest in advanced degrees for their management team and respect is paid to all their front-line employees. **SMRT** even refers to their bus operators as "bus captains" to reflect the level of responsibility these positions hold. **JR East** hired 1700 new employees this year and spoke of their efforts to attract the best employees.

MTR has very clearly defined competencies for every role in the organization. Training and certification is provided for at every level in the organization from front line to executive management. Managers are developed through a very defined process of cross-functional responsibility, training and certifications. As evidence of the commitment to developing employees, promotions are dependent not only on one's preparedness for the role but also on the employee having identified and trained their successor.

They have developed an innovative approach to integrating delivery, organizational structure and governance where technical competencies are reinforced in an integrated manner. Each member of the **MTR** leadership team has line responsibility and rather than separate staff departments, each executive has an SME role; for example, one line managers also has the lead for HR and incident management; the COO is strong in customer experience; another executive is responsible for performance metrics.

MTR always integrates the operations and life cycle considerations into their planning and they use a "war room" focus for special projects and new projects/programs/expansions to ensure the new system is operationally sound. The chair of each special task force is generally a leader

from operations; sometimes there are joint chairs with one from operations and one from capital/construction.

MTR has developed a world class academy which ensures that each employee is prepared to fully provide the functions required of their position.

MTR provides a full suite of in-house training programs for over 17,000 of its work force including apprentice programs and operations and management training. It also offers a local focus for the general community on railway system and engineering related areas and has added applied learning about the railways in secondary schools.

Similarly, **SMRT** has a comprehensive educational program to ensure appropriate competency at each level of the organization. They have recently transitioned to a more holistic human resources strategy using a competency based process and link to lessons learned from incidents. Not only is there investment in training frontline employees, but there is significant investment in professional and management development.

SMRT programs include:

- development of customer service core values;
- vocational programs for operator and maintainers with a training review body that assesses if each person following the apprentice program is a good fit for the role. If not, they recommend more training and or other positions;
- a three-year post graduate program for engineers;
- a six-month field supervision program after all formal training;
- competency-based training attached to management promotions, and;
- extensive partnerships with institutions of higher education.

They have also raised the profile and value of mature professionals serving as mentors and recognize the value of time provided to new employees. They place a strong emphasis on the progression of engineers from entry to charter level as an industry standard.

SMRT is focused on developing a learning culture: lessons learned from incidents are shared with relevant staff immediately and incorporated into the training instructions; there is strong communications and engagement during audits and inspections; positive reinforcement and the use of incentives for individuals and work groups exists on a monthly and annual basis. SMRT holds an Annual Safety, Security and Quality Day (SSQ Day), where personnel come together to share with each other the work they are doing and invite their vendors.

SMRT has also recently restructured to create a better interface between planning and operations. They emphasize the need to create an environment of openness by thinking through employee engagement. The operating structure is bottom-up: every staff member is considered a safety "sensor". Rather than being externally driven, they aim to foster an internally driven ethic where employees display a "habit of looking after one another."

JR East has an equally strong focus on human capital. It established a General Education Center in April 2000 with significant resources committed to training its workforce. It is an impressive training campus set up like small private colleges in the U.S. with dormitories and recreational facilities. It includes 40 lecture rooms and practice equipment.

The center is used to train over 30,000 people annually and provides 320 courses. It has 558 guest rooms and a staff of almost 300. All new employees reside at the training center while they achieve their initial certifications. There are comprehensive programs including hands on

training for skilled labor, train operators and station personnel. The campus includes a mock station attached to a test track. Rail Operators with JR East spend 3 months at the training institute to learn all facets of rail operations. Supervisor and management programs are also provided.

The **JR East** Training Center incorporates an extensive museum of the history of railway accidents including detailed and well-prepared exhibits of several key Japan Rail incidents, dating back to the mid-20th Century. Setup very much like the World Trade Center Memorial, this museum educates employees about the cause and effect of major accidents and helps them understand their responsibility in operating a safe and reliable service. The museum entrance shows a train axle and wheelset that was near complete and catastrophic failure. The incident arose because of a process failure in the railcar maintenance shop and was kept at a near-miss only because the defect was noticed by trackside employees. Those two messages are very powerful ways to start the museum tour.

The accident museum also includes several full-scale displays of actual railcars involved in significant JR East accidents. This display is quite impressive and will likely have a strong impact on new and returning employees. All employees are expected to learn from the past incidents and are reminded of their impacts to passengers and employees.

JR East's General Education Center and the Museum of the History of Railway Accidents reflect both the importance the agency places on training and safety, as well as the resources it has available to concentrate on both.

Likewise, the **Tokyo Metro** comprehensive learning and training center, with its full-scale training tracks, tunnel, bridge, station, and other resources, is impressive. Established in April 2016, the scope of the training center has grown to include a strong focus on customer service and safety. The actual revenue train equipment includes mock up platforms, tunnels, and bridges so training staff can simulate accidents and work to restore services. The facility also has numerous classrooms, maintenance equipment and train simulators. The center incorporates a Safety Consciousness Development Center which has displays about previous accidents. There is a new emphasis on English-language training and accessibility training to prepare the employees for the 2020 Summer Olympics in Tokyo. Tokyo Metro places a strong emphasis on cross functional teamwork during training through on the job behavior.

Both **JR East** and **Tokyo Metro** value varied experience in employees' career paths. Both agencies have senior personnel with deep resumes. The Vice Stationmaster of Tokyo Station, for example, has a background in human resources in addition to station operations. The Vice Chairman of JR East has, amongst other areas of expertise, a strong background in safety.

III. CONCLUSION

There are certainly tremendous cultural and structural differences between these Asian operating companies and public transportation agencies in the U.S. Despite these differences, there are many guiding principles and lessons learned that are transferable:

- A holistic, risk-based business model based on predictable, long term funding for operations and capital;
- A spirit of continuous improvement focused on the customer experience;
- Service excellence based on an ingrained focus on safety and good performing assets;
- Collective mindfulness and a sense of individual ownership instilled in the workforce;
- The extensive use of technology, data analytics, and sound processes to achieve efficiencies, and;
- A significant investment in human capital, with an emphasis on the professionalization, integration and engagement of the workforce.

It all starts with organizational core values and an expectation that employee behavior supports excellent customer service. Everyone in the organization understands the expectation that service to the customer is a top priority and achieving continued improvement is dependent on maintaining employees, assets and organization systems in optimal condition to perform the function they provide to as near perfection as possible.

ANNEX I

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