5-2021

A smarter way to manage mass transit in a smart city: Rail network management at Singapore's Land Transport Authority

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Citation

A Smarter Way to Manage Mass Transit in a Smart City: Rail Network Management at Singapore's Land Transport Authority

(By Steven M. Miller and Thomas H. Davenport)

There is no widely agreed upon definition of a supposed "Smart City." Yet, when you see city employees — in this case city-state employees — working in what are obviously smarter ways, "you know it when you see it." One such example of a smarter way to work in a smart city setting is the way that employees of the Land Transport Authority (LTA) in Singapore are using a new generation of data driven, AI-enabled support systems to manage the city's urban rail network. We spoke to LTA officers Kong Wai, Ho (Director of Integrated Operations and Planning) and Chris Hooi (Deputy Director for Communications & Sensors, a unit within LTA's IT, Cybersecurity & Digital Services Group) to find out more about their roles in implementing the FASTER system, and to Meng Fai, Leow (Deputy Group Director in the Rail Asset, Operations & Maintenance Group) and Christine Wee (Principal Manager for Asset Management Data and Analytics under LTA's Rail Asset, Operations and Maintenance Group) about the usefulness of the Rail Enterprise Asset Management System.

Kong Wai, Ho, Chris Hooi and the FASTER system

In mid-2014, LTA announced they were partnering with IBM to do an applied research project to create a design blueprint for the Fusion AnalyticS for public Transport Event Response (FASTER) system. The announcement also mentioned that two other private sector companies, a local telco provider and one of the rail network operators, would also be participating by providing data access. In 2016, after nearly two years of applied research trials and solution blueprinting and design, the FASTER project moved into the full-scale development phase jointly with ST Engineering and IBM. In mid-2018, the Land Transport Operations Center (LTOC) was re-launched with digital capabilities for comprehensive situation awareness and integrated response management based on the new FASTER system which was put into use at this time.

Kong Wai and Chris who worked on FASTER explained , "Our rail network operational challenge is to prevent interruptions to the regular flow of the trains as well as to the regular flow of commuters who are waiting on the platform to board trains, and those who are riding on trains. We need to be alerted as early as possible that an incident has happened or that it will soon happen, so that we can respond quickly and in a well-informed way. The key is to be alerted as early as possible so we can take actions that prevent the incident from turning into a major problem or a crisis."

The duo elaborated how FASTER aids them. "Our LTOC serves as the bridge between the rail operators, LTA, and all relevant government authorities who would be involved in responding to any type of incident in the rail network system. FASTER gives us comprehensive situational awareness of the entire rail network and its linkages with other parts of our public transportation network. We get real-time alerts of service degradation that warns us that an incident is evolving. Once the incident occurs, we can see the situation and how the impacts are propagating to other rail stations on the network and assess what is happening. This gives us the ability to make informed decisions on how to deal with the problem. For example, FASTER helps us to quickly assess the impacts of responding to an incident by injecting additional trains onto the track to handle backlogs of passengers, or in more severe incidents, by advising passengers to board special bus bridging services that we quickly deploy to take them to rail stations not impacted by the incident."

LTA shared, "For more than a decade, we have supported our long-term strategy of achieving smart urban mobility in a fast-changing digital world. This is the works of a joint ops-tech team focused on building and sustaining a land transport digital ecosystem through an extensive network of sensor feeds, analytical processes and commuter outreach channels, synergistically put together to deliver a people-centred land transport system."

The team highlighted the distinguishing feature of FASTER which is an emphasis on a commuter-centric approach to IOT sensing, situation assessment and incident response planning. "In the past, we only used measurements of engineering parameters to determine the efficiencies of our rail network system (e.g., use of rail signals, fault detectors, and alignment to schedules). However, these don't provide a direct measurement of the commuting experience on the ground, such as the number of times a passenger on the platform could not board an arriving train because it was too packed or the crowd size on the train platform or in the trains, and the duration of delays faced by the commuters. This gave rise to the need to explore more commuter-centric sensors with FASTER."

They provided a more technically-oriented description of the FASTER system. "It is a big data AI platform which mines IoT sensor sources such as WiFi, cellular, farecard, train, and taxi, for early warning of potential rail anomalies in real-time. Using fusion analytics, FASTER provides round-the-clock visibility of the rail network. It detects unusual network events and provides automatic alerts in advance when service levels fall below the acceptable range. The system supports real-time monitoring and situation assessment which enables the LTOC team to evaluate the effectiveness of incident response measures such as putting additional trains into service or dispersing passengers stranded at a rail station with bus bridging. It does not stop with FASTER. FASTER's outcomes are fed into a broader Command, Control and Communication (C3) system that draws insights across other land transport domains such as roads and buses for a comprehensive view of the land transport network to co-ordinate effective response to anomalies and incidents."

LTA noted that when they first introduced FASTER in mid-2018, alerts on service degradations only predicted about 40% of incidents. With accumulated operating experience, continuous tuning and enhancements, the ability to provide a forewarning of an impending incident increased to 70% by early-2019, and further increased to 80% by end-2019 . As the team, in combination with LTA data scientists and LTOC operations specialists, continue to work on further improving sensing, data fusion, and analytics for situation assessment and response planning, they expect this percentage to further increase.

They highlighted what has changed in terms of how the LTOC team does its work. "In prior years, we had fewer rail lines and our LTOC staff did not have FASTER. We relied on our rail network operations veteran staff with many years of experience to qualitatively anticipate how incidents would impact the rail network and to assess different options for response. That approach does not work anymore because our rail network is now much more complex due to increases in both the number of rail lines and number of stations, and we will further expand the rail network over the next 20 years making it even more complex. We would not be able to manage either our current situation or our future situation without the aid of the FASTER platform and without the help of Data Science and AI."

LTA added that with FASTER, "Our younger LTOC staff with just a few years of network operations experience can more accurately and quickly assess the situation, understand the network-wide impacts of the incident and develop response plans." They note that another benefit of using FASTER is that, "We are now more inclusive as there is sharing of information and collaboration with our rail line operators. The fact that our rail line operators want more access to the information in FASTER is a strong endorsement of its usefulness and value.

FASTER provides us a smart and integrated use of data and technology that facilitates LTA in building an agile, lean and inclusive land transport ecosystem that can serve the needs of our commuters and stakeholders better and faster."

LTA commented on the way FASTER has increased the productive capacity of the LTOC team for rail network operations. "We have substantially increased our rail lines and stations, and we can still do the system-wide monitoring with this same size team of four monitoring officers. In fact, since 2012, the number of stations we are monitoring has nearly doubled yet we have the same lean monitoring team. FASTER has made us much more agile, productive and efficient in our ability to monitor and to manage the response to incidents."

LTA summed up the benefits of FASTER. "As FASTER's capabilities and performance have improved over the past several years, we are now more in control because we always know what is happening across the rail network and the other parts of our public transit system, and we know how to respond efficiently and effectively."

Christine Wee, Meng Fai, Leow and the REAMS system

Even with a system like FASTER, good asset management, including maintenance planning and support, is essential so that LTOC monitoring staff would not be overwhelmed with operational issues resulting from equipment breakdowns due to poor asset management and support.

About a decade ago, in the earlier (and pre-FASTER) days of the LTOC, that was indeed the situation LTA was dealing with. One of the rail operators was faced with challenges in the maintenance of ageing assets, breakdowns were increasing, and the Singapore public, accustomed to a norm of superior service levels for their city services, were quite vocal about their displeasure with increased rail system breakdowns. The government had already announced a plan in 2008 for phasing in a New Rail Financing Framework where all pre-existing rail operating assets like trains, power, signalling systems and station equipment, owned by the two private sector operators would eventually be purchased back by LTA and all ongoing and future capital purchases would be done centrally by LTA as well. By 2018, the private operator rail asset transfers to LTA were completed and this new arrangement greatly accelerated the national priority for a better and smarter approach to rail asset management.

LTA officially announced the award of the contract for the Rail Enterprise Asset Management Systems (REAMS) to Siemens Mobility and ST Engineering in late-2018, and the very first phase of a multi-phase, multi-year production deployment effort started in mid-2020.

Meng Fai and Christine explain that "asset management is much more than maintenance. It's about a whole interconnected set of concerns: the performance of our total rail system over the total lifecycle of each asset type; resourcing for maintenance where we plan for the levels of labour and capital that will be needed for maintenance work in the next month, quarter, year, and multi-year period; assessing whether we are overusing the assets and driving up system performance at the expense of increasing maintenance costs and shortening asset lifetimes; planning for the capital investment for new train lines and for refurbishing existing train lines in ways that balance overall capital costs with overall maintenance costs and levels of operating performance; determining how we keep assets in good working condition and how we extend the working life of our rail assets, and also supporting real-time troubleshooting and fault-fixing of existing assets."

LTA notes that with the new REAMS system, "We have started on the journey of using machine learning with all of our asset data to do planning for maintenance needs, maintenance

costs, and total lifecycle costs, and also for supporting real-time troubleshoot and repair. Now we have the data, and we have REAMS as the supporting platform to do this, and it is very exciting to see the results." LTA is convinced that "we need the AI and ML to be there to help us, as our asset management-related needs are complex and massive. We are on a transformation journey to use the data-driven, AI-enabled REAMS approach to asset total lifecycle management."

LTA added that the railway data science team that is focused on supporting asset management and for REAMS development has expanded in recent years from four people to 20 people as a result of the combined effect of the asset transfer and the REAMS project. Within this expanded railway asset management data science team, one-third are internal LTA staff and two-thirds are contractors from vendors. This enables the team to build up technical expertise in the relevant analytics and AI skills more quickly than they would be able to do on their own. Over time, this LTA team will take on more applications on the local urban rail systems.

LTA explains this data science team has provided the REAMS system the ability to do maintenance and asset-related support over a varying range of time horizons. "We do reliability predictions for our train fleet over the horizon from months to several years. We do asset health predictions to predict faults over the next seven-day horizon. Once rail equipment or system faults occur, we enable the maintenance technicians on the ground who work for the rail operators to key in the various train alarms and train on-board event status codes received at the operating centre into REAMS. REAMS will then mine past failures and prior causes found in the maintenance records and do fault diagnostics based on associations with the real time alarms and event status information to derive the possible fault causes. This type of support can decrease our fault troubleshooting and repair time. All of these types of maintenance and repair data feeds into the long-term asset planning modules of REAMS, and gives us the data we need to make better asset management predictions for our longer-term asset lifecycle management over the time horizon of one decade and more."

The team is not at all worried about whether their jobs will ever be fully automated. They said, "We will never finish the exploration and exploitation of our data, no matter how much effort we put into it, as there are so many new opportunities and use cases that can be done. The combination of these new sources of data and the AI/ML based analysis is creating value for us and also creating an enormous amount of new exciting work for us."

Initially, REAMS was deployed on only one of the six existing rail lines in Singapore. Over subsequent phases, the new AI/ML enabled asset management systems will be used for systems on all of the other existing lines as well as for the new lines that will be built over the next decade. The team emphasizes how time-intensive it is to do the work that they are doing with REAMS. They said, "The process encompasses design, delivery and improvements to make steady progress. It takes a lot of time to build up the data sources and develop these asset management analysis and prediction models for each of the key asset systems within a rail line and then to integrate all of this together for that line. And then we have to do this across all of our current and new rail lines."

The people on the LTA teams working on expanding and using the FASTER system for rail network operations and the REAMS system for rail asset management will be busy for years and decades to come. These are good examples how AI support systems are enabling people managing city infrastructure and services – in this case urban rail systems– to work in smarter ways and towards the vision of being a smart city.

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Tom and Steve are working on book that will be published by MIT Press in 2022 tentatively titled, "The Future of Work Now: People Collaborating with Smart Machines."

An abridged version of this article will appear as one of the case studies in their book.