International Conference on Railway Engineering (ICRE) 2020

Engineering SMART Railway for Future

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Good Morning President, distinguished guests, ladies and gentlemen.

Introduction

"S" "M" "A" "R" "T". In this year's conference, we will look closely at the word – "SMART". It stands for "**S**ustainability", "**M**obility", "**A**sset management", "**R**eliability" and "**T**echnologies" for railways. In short, the "SMART Railways" also literally means "Intelligent Railways". Let me first kick-off with a few remarks on an interesting movie - "The Current War", and I hope this would be a "SMART" way to begin with.

"The Current War" is a 2017 American historical drama set in the late 19th century. It is inspired by the real-life competition between Thomas Edison and George Westinghouse and his partner Nikola Tesla. It tells a story about a contest, a contest that decided which electric power transmission system would prevail in the United States, a contest that shaped the modern life in the 20th century and beyond. The story begins in 1880 when Edison unveiled his electric light bulb. He advocated the use of direct current (DC) which was cheaper and cleaner than gaslight but also limited in range and expensive to transmit. On the other hand, the entrepreneur and engineer Westinghouse, believed that alternating current (AC) was a better technology because it could be transmitted over longer distance at a much lower cost. Edison and Westinghouse competed to get cities across the United States to use their preferred power supply systems. After all the twists and turns, Westinghouse and Tesla won the contract of the Chicago World's Fair in 1893 and it signaled the triumph of AC over DC.

"The Current War" is literally a battle between "DC" and "AC". I believe that we all as engineers have our own little theories and questions about this contest, like "Why use DC?" and "Why use AC?" Or maybe… "Why not use both?". And more importantly, which one is better?

Looking back at Hong Kong's railway history, Hong Kong's first railway running on

steam was opened in 1910. The first DC railway in Hong Kong debuted in 1979, which is now part of the Kwun Tong line and Tsuen Wan line, while the East Rail Line (EAL) completed AC electrification in 1983. Both of our first DC and AC railways ran on DC traction motors in view of their superb speed control capability and high starting torque. AC and DC are both in use up to now. They can indeed co-exist in harmony without a "war"!

Today, there are numerous interaction between AC and DC in developing "SMART" railways for meeting the rising demand for passenger services in a more intelligent way. Before I elaborate this point by focusing on the sustainability, mobility, asset management, reliability and technologies for railways, let us first look at some facts about electric railway.

Sustainability

- Today, about 75% of passenger rail transport activity worldwide takes place on electric trains. The rail sector is the only mode of transport that is widely electrified[1].

- Railway is also among the most energy efficient modes of transport for freight and passengers. While the rail sector carries 8% of the world's passengers and 7% of global freight transport, it represents only 3% of total transport energy demand[1].

- Given that railway is the most sustainable and energy efficient low-emission transport mode, it plays a crucial role in the decarbonization of transport sector.

- Indeed, railway is evolving as the backbone of a low-carbon, multimodal transport system in the 21st century. It becomes a key solution to address the Paris Agreement's long-term temperature goal and keep the increase in global average temperature to well below 2 °C above the pre-industrial levels.

Nowadays, railway transportation is more environmentally friendly compared with other transportation modes in terms of energy consumption and greenhouse gases emission. To achieve sustainability, governments and operators should be open-minded and keep abreast of the latest technological development of railway, not only just limited to electric

[1] The Future of Rail Technology report – Jan 2019 - https://www.iea.org/reports/the-future-of-rail

trains, but also other alternative energy source. Wider adoption of railway can minimize the energy demand and environmental impact of our transportation system as a whole in fighting the climate change.

Mobility

Thanks to the rapid expansion of high-speed rail, people in different areas or countries can nowadays be easily connected with railways. Mobility of people is greatly enhanced. Since most high-speed rail stations are located at city centers and it takes less time for luggage check-in, travelers can enjoy the flexibility and high efficiency of high-speed rail over air travel.

Every year, over two billion passengers travel on high-speed trains even though high speed is still an experiencing development around the world. Nowadays there are nearly 52,000 km of high-speed railway lines operating in the world. In the next 30 years, this figure is expected to double. Undoubtedly, there should be significant challenges from industrial, technological, financial perspectives ahead, and we need to overcome them one by one in order to support the fast-growing development. To take the leap, Hong Kong opened its first high-speed rail in 2018. It connects to the 36,000 km high-speed railway network in the Mainland of China and the network will be further expanded in the future.

Asset Management

Our urban railway line, operated by the MTR Corporation Ltd or MTRCL, was first opened in 1979 and has been running for over 40 years. Same as other railway operators in the world, MTRCL is facing similar challenges of aging equipment, aging workforce and labour shortages. Even though MTRCL has a sound Asset Management System and spent over HKD 9.8 billion in 2019 on upkeeping its railway assets[2], it also faces a universal problem that besets operators in other parts of the world. The problem is "How to find enough manpower resources to complete the huge amount of asset replacement work?". Population aging is bound to continue on a global scale too.

[2] MTRCL Annual Report 2019

Reliability and Technology

So how are we going to face this challenge? Let's look back to the AC and DC war for some clues. Westinghouse and Tesla finally won the bid to power the Chicago World's Fair in 1893, and AC emerged as the winner. After more than 100 years, what do we have? With the advancement in power electronics, notwithstanding the strengths of DC traction motor in speed control and its high starting torque, it has yielded to the variable voltage variable frequency controlled AC traction motor, which also features the same superb speed control and high starting torque, but using simpler and cheaper AC motor requiring less maintenance, and with the additional benefit of energy saving via regenerative braking. In fact, our local DC and AC railways had long switched to AC traction motors through modernization. And what else? While the majority of electricity is transmitted from generator to consumer through high voltage AC transmission lines, after continuous technological breakthrough, again enabled by power electronics, we have been using High Voltage DC to transmit power. In 2019, the world's longest Ultra High Voltage DC transmission lines at 800KV transmit power in Brazil over a distance of nearly 2,540km[3].

All of the above would not be possible with innovation and technology breakthrough. Innovation is all about creativity and intelligent trial and error. Persistence and courage to fail and try again and again are the elements of successful innovators, and yet success is not guaranteed in each innovation process. Innovative design entails endless trials and testing processes that take endless patience and time, even Thomas Edison has failed more than 10,000 times before he invented the light bulb. But thanks to his persistence, the world has become a better place since.

We all know that it is a world trend to tackle manpower shortages and face keen market competition through "INNOVATION and TECHNOLOGY". I&T supports and adopts automation to raise productivity with less manpower and enhance market competitiveness. In retail sector for example, there are new concepts like "Unmanned Stores". In these stores, there are no service personnel or cashiers. The customer is in complete self-service mode from product selection to payment transaction. In the world of railways, I&T can also respond to the public's ever-rising demand for safer, more reliable, comfortable and

[3] The world's longest power transmission lines - https://www.power-technology.com/features/featurethe-worlds-longest-power-transmission-lines-4167964/

energy efficient railway services.

However, this may be easier said than done in Hong Kong. According to the 2018 Hong Kong Innovation Activities Statistics conducted by the Hong Kong Census and Statistic Department, more than 90% of respondents from various industries do not see the need for undertaking innovation activities. Among those who have undertaken innovation activities, around 30% are doubtful of its high cost. In another research, the 2019 Global Competitiveness Report of the World Economic Forum, it found that Hong Kong ranked a respectable No. 3 in overall competitiveness, but ranked much lower in the metrics of innovation. Hong Kong's total spending on R&D is only 0.8% of GDP[4], lower than that of China's 2.12%, Singapore's 2.22%, and Korea's 4.55%. It is obvious that Hong Kong needs a more aggressive innovation and technology (I&T) strategy to maintain its competitiveness and sustainable development as an international financial hub.

At this point, I must give credit to all fellow engineers gathered here (or via Zoom) today who have contributed to railway industry in recent years, in particular those who have created a supportive community that encourages all to explore I&T applications in the industry despite all the challenges. As the Hong Kong's railway safety regulator, the Electrical and Mechanical Services Department (EMSD) is committed to working with the industry to advocate a wider use of I&T to enhance railway safety. One of our tools is the E&M InnoPortal launched in 2018. The InnoPortal is a platform for I&T collaboration and for the development of a database comprising a detailed list of technology application needs from various government departments, public bodies and the E&M trade in Hong Kong. Through the database, which is open to the public, I&T startup companies can match their new ideas and solutions with potential users' needs and implement them in government premises for trials. We warmly welcome universities and startup companies from all over the world to put their cutting-edge E&M solutions on our InnoPortal for a meaningful and productive match.

Furthermore, we have been actively promoting the extended use of Building Information Modelling (BIM) as an asset management tool in the architecture, engineering and construction sectors. BIM can be equally valuable to the planning and construction of new rail lines and ongoing railway safety maintenance. A new initiative, what we called BIM-Asset Management-Railway Safety, or in short "BIM-AM-RS", is jointly initiated

[4] UNESCO Institute for Statistics

and developed by EMSD and the railway operator, MTRCL to facilitate railway asset management. "BIM-AM-RS" acts as a digital platform to facilitate operation and maintenance (O&M) staff to carry out O&M work properly by utilizing its 3D visualization capability of the railway assets and its prompt retrieval of the assets' O&M information. Specifically, it can improve railway safety and reduce incidents via the application of artificial intelligence (AI) and data analytics technologies. It analyzes the real-time operating data collected from sensors installed in major railway assets to enable predictive maintenance, and is therefore less labour-intensive and more effective than traditional corrective maintenance practices.

Moreover, the "health" conditions of railway assets could be continuously monitored through the checking of the real-time values of operational parameters. With the aid of historical data and big data analytic technologies, the AI engine of the BIM-AM-RS platform provides early warning, health indices and kicks off maintenance strategy before failure of the monitored equipment. It forms the basis of predictive maintenance of railway assets for prevention of incident and enhancement of train service reliability.

For example, MTRCL has installed a "Point Monitoring System" in High-speed Rail to monitor the health status of point machines. Operational parameters, including current, throwing time etc., are monitored and recorded for analysis which can assist in maintenance planning. Another example is the installation of "Overhead Line Condition Monitoring System" on train roof to monitor the condition of overhead line system during train operation. The system records high definition video and image covering the whole pantograph and cantilever assembly and uses video analytics to identify defects of the overhead line system through comparison between historical and current image records. The system will send fault alarm to off-board computer server and relay message to alert maintenance staff via mobile network.

By making use of 5G communication networks, Internet of Things (IoT), or even satellite navigation, more advanced, fully automatic and wireless control of train operation could be achieved in near future to raise the reliability, efficiency and safety of train services.

Reliability of train services can also be enhanced by the application of BIM-AM-RS which enables VR training to O&M staff. Through VR interactive training using the 3D models of relevant railway facilities in an immersive virtual environment, O&M staff

would be able to improve the quality of O&M work.

In this day and age, nothing seems impossible and new things are coming every second. Many new ideas are blossoming into successful businesses and contributions to humanity. And may be one day, a more powerful and effective energy and technology may become the backbone of future railway systems and replace the one we are now using. How about Hydrogen Trains, or Hyperloop? Who knows? The very essence of the future is uncertainty and enormous possibility.

Conclusion

To sum up, I look forward to working with the industry and the community to turn our smart and innovative ideas into actions. As mentioned before, let's engineer a more **S**ustainable railway with high **M**obility, well-managed **A**ssets and **R**eliable performance, through the aid of innovation and **T**echnologies. One day, which I hope is not too far off, Hong Kong will become a model city with a healthy, livable and sustainable environment empowered by a "SMART" railway infrastructure network that all of us can be proud of.

Thank you very much.