Development of Digital Railway in Malaysia – An Approach for Implementation Post COVID-19 Pandemic

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Abstract

COVID-19 has impacted many railway transportations sectors globally. This unprecedented health crisis has opened up the eyes of many railway operators, government officers, and railway stakeholders to the future planning strategy and risk mitigation measures to be undertaken to ensure the sustainability of the rail network. Even though each railway operates quite differently from one another, the main objective of the business case is still fundamentally the same i.e., to maximize the real potential of the infrastructure investment for greater mobility of the passengers and freights services. In a situation such as the current COVID-19 pandemic, the railway had to implement many measures to curb the outbreak of the virus. Travel restrictions and social distancing are common measures put in place to mitigate the virus outbreak. Unfortunately, these measures do not support the sustainability of the railway network. This paper describes the literature review of how the implementation of Digital Railway will be able to assist the railway owners, infrastructure managers, operators, and railway stakeholders to ensure the availability and sustainability of the railway in the event of a similar pandemic situation in the future. Overall, this study contributes to the growing literature of Digital Railway especially in the case of implementation in Malaysia and it confirms that Digital Railway will be the future of railway operation.

Keywords: - digital railway, COVID-19 impact, modern railway, railway transportation

1 Introduction

SARS-CoV-2, or commonly known as COVID-19 has created an unprecedented pandemic globally since early 2020. The impact has been severe on multiple industries, economies, and lifestyles of the human population. COVID-19 alone will place a direct health-related economic burden of £39.6 billion (1.73 percent of GDP) on the UK economy (Keogh-Brown et al., 2020). Studies have shown that annualized GDP growth will have a larger impact on countries such as United States, Germany, Japan, and Italy (Jena et al., 2021). Malaysia's economy has also taken the hit with negative impacts on jobs, incomes, and livelihoods, disrupting supply chains and poverty rates increase (Lim, 2020). Figure 1 below shows the impact on Malaysia's currency against the US Dollar where Quarter 1 2021 has resulted at the lowest exchange rate from the start of the COVID-19 pandemic. This indicates symptoms of the economy being impacted due to the virus outbreak. Malaysian government has introduced multiple Economic Stimulus Package amounting upto approximately RM 400billion to assist the people and economic sector to jointly overcome the health and social constraints faced during the pandemic. The economic stimulus packages play an important role in balancing the impact of the pandemic to the lifestyle of the people and industries in Malaysia.

Figure 1: Malaysia / US foreign exchange rate (Fed, 2021)

The transportation industry has also taken the hit when global demands for the use of the service had been decreasing somewhat due to the restrictions of movements and strict health guidelines put in place to curb the spread of the virus. The impact faced in the transportation industry particularly the railways could leave substantial short-term and long-term impacts. Cui et al. (2021) highlighted that the outputs of the freight transport sectors and passenger transport sectors would decline by 1.03-2.85% and 2.08-11.44%, respectively due to the travel restrictions and economy sector lockdowns. Malaysia's rail

passengers' statistics comparison of the Year 2019 and Year 2020 has indicated an annual reduction of ridership by 50% impacted due to the same reason. Restriction of movements, economy sector lock-downs, changes of working culture (e.g., work from home) mainly contributes to the declination. Figure 2 shows the annual ridership data extracted from the Ministry of Transport of Malaysia website for the Year 2019 and Year 2020 for the various types of rail transit in Malaysia.

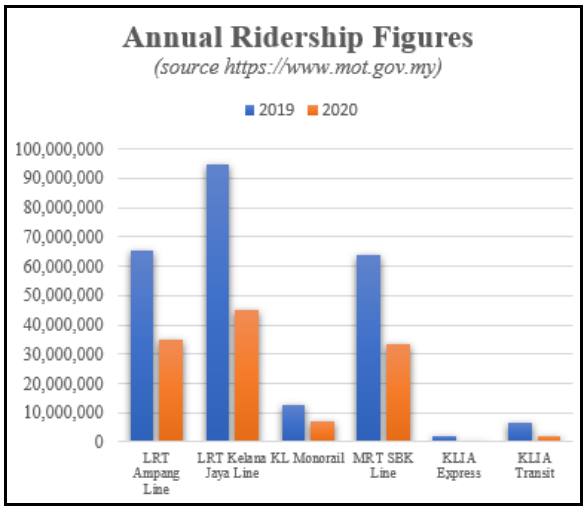

Figure 2: Malaysia annual ridership figures (Ministry of Transport Malaysia Official Portal Reports 2021)

Railway operators across the globe have put in place multiple preventive measures together with the assistance of their respective government's subsidization program to tackle the short-term impacts. Force (2020), of the Union of Railways (UIC), has identified and provided several concrete measures to reduce the risk of COVID-19 spreading, from the railway perspective. The measures include preventive actions from person to person and object to person transmission. The question is, what will be the implication of post-pandemic conditions to the railways and how will the railways react and steer themselves back to the forefront in the future. According to Ibn-Mohammed et al. (2021), apart from all the negative impacts of the COVID-19 pandemic, it also creates an opportunity to accelerate the implementation of railway digitalisation. Railway businesses should capitalize on digitalisation to be more sustainable and resilient through various forms of technological solutions. This paper discusses the digitalisation of the railway industry that could increase the productivity of the railway against the long-term impact caused by the pandemic, particularly in Malaysia, by improving efficiency and enhancing the safety measures.

1.1 Malaysian Railway Current Developments

The government of Malaysia acknowledges that the future of mobility will rely heavily on its rail network. Several key rail infrastructure projects are currently ongoing in Malaysia including the Electrified Double Tracking Project (Gemas – Johor Bahru), set to be completed in 2023. This will make up part of the railway spanning nearly 800km of the electrified double-track network connecting the Southern and Northern cities of the West Coast of Malaysia. This will create a backbone for passenger and freight movements in the country. The new East Coast Rail Link (ECRL) project, connecting the East and the West of Malaysia will provide connectivity to the main cities and ports along its route not currently served by a railway. Targeted to be opened for revenue service in 2026, the ERCL network will provide a major contribution towards the public transportation service and logistics for freight business to support the nation's economy. The urban rail projects such as the Klang Valley Mass Rapid Transit Project (Sungai Buloh – Serdang-Putrajaya) and the Light Rail Transit Project (Bandar Utama – Johan Setia) will add to the main networks of existing urban lines in Klang Valley providing efficient transportation for daily commuters. These projects are acknowledged as enablers to achieve the Greater Klang Valley transportation aspirations.

The development and future planning of operations of these mega-infrastructure projects will require comprehensive planning, strategy, and strong governmental commitment to ensure that the long-term impact of the current COVID-19 pandemic will not affect the sustainability of the railway industry in the country. Bayram et al. (2020) state that innovation policy could be used to steer the ideas to broaden the thinking and enhance the reflexivity of people and communities. This could be applied in the planning stage for the development of the Digital Railway framework for Malaysia.

1.2 Problem Statement

If the COVID-19 pandemic impact is not addressed promptly, the long-term effect on railway activities and its business case would be serious. The following concerns demonstrated the need for this study: -

i. Demand reduction of traveling passengers induces financial stress to the railway operation.
ii. Passengers fear the risk of a virus outbreak in an uncontrolled environment within the public transportation area.

iii. How can rail operators adapt appropriately? How can data-driven modern systems assist them?

COVID-19 is a recognized fundamental health crisis but it also provides an opportunity to rebuild a better railway network. The post-pandemic era will need to focus on behavioural and habit change of travellers, network resilience, and digital improvements to ease mobility.

2. Literature Review

2.1 Mitigation Measures by Railways During COVID-19 Outbreak

Railways in most parts of the world have come together to introduce programs and measures to mitigate the impacts of the pandemic. According to a report prepared by Jain (2020) for the United Nation Economic and Social Commission for Asia and the Pacific, there were multiple efforts taken by the railway authorities globally to face the challenges however most of the effort is concentrated into the following trends:

i. Most national railway strategies have yet to assess the full impact of the COVID-19 pandemic in the medium and long term;
ii. There is no central funding assistance for railways at the local as well as international level yet;
iii. The pandemic gave further momentum to the digitalisation of railway transport even in the countries with a relatively low level of digital services; and
iv. A new solution for customers and services, primarily digital, was proposed in many countries.

This unprecedented condition has paved the way for the further advancement and implementation of modern railway technologies to enhance railway network capability, traffic control, reliability, energy efficiency, and running costs. This is further supported by Asad et al. (2020) who developed a new method for dealing with overcrowding in trains carriages, stations, and platforms which is aided by the accuracy of mobility estimation using machine learning classifiers. The methodology utilizes technology such as WiFi, RFID, Bluetooth, and UWB to monitor regular passenger movements. Khalid et al. (2014) acknowledge that public transportation services need to be operated more effectively especially to overcome the issue of traffic congestion. Amir et al. (2020) also further suggests that it is important to learn from this pandemic to improve our quality of life and foster creativity through the use of the latest, safe, effective, and reliable design in the industry. This will enhance the usage of technology to curb the virus outbreak.

2.2 Modern Digital Railway

Innovations in current trends covers monitoring the customers' preferences, passenger's movements control, operator's information, train movements, and including payment processes. Technological development is not only limited to the operation of the railways but can also be implemented in maintenance processes to increase the availability, reliability and ensure the safety of the railway. These technological enhancements offer more effective solutions to support the business continuity of the railways impacted by the long-term impact of the COVID-19 pandemic. According to Scordamaglia (2019), Roland Berger, a management consultant company, has identified four layers of digital innovation for European industries as highlighted in Table 1 below. These layers of digital innovation can be used as guiding principle in developing the overall Digital Railway programme in Malaysia.

Table 1: Layers of digital innovation - (Scordamaglia 2019).

Layer	Descriptions
Layer 1	Digital data, which once collected and analysed, provide for better predictions and decisions
Layer 2	Automation systems, which increase speed, and reduce error rates and operating costs
Layer 3	Connectivity, which synchronizes the supply chain and shortens innovation cycles
Layer 4	Digital customer access, which enables companies to offer customer transparency and new services

Many countries globally have also provided their focus on enabling Digital Railway technology to achieve higher efficiency, safer travel, and optimization of the rail solutions and its service. They have several plans and strategies put in place through their government-funded programmes such as "The Digital Railway Programme" by Network Rail in the United Kingdom, "Digital Systems Program" by New South Wales government for Australia, "Smartrail 4.0" in Switzerland, and many more. In general, the shift towards railway digitalisation is preferred to meet the objective of increasing capacity, enhanced safety, reliable service, and economical solutions whilst maximizing the output of the systems. Table 2 summarises several of the key initiatives adopted worldwide as part of their Digital Railway transformation.

Table 2: Key initiatives of digital railway programmes.

Location	Key Initiatives
Digital Railway Programme, UK	• European Train Control System (ETCS) • Traffic Management (TM) • Supervised Automatic Train Operation (ATO) • Connected Driver Advisory System (C-DAS) • Smart Infrastructure with remote condition monitoring • Telecommunications & Data
Digital Systems Program, NSW, Australia	• European Train Control System (ETCS) Level 2 • Supervised Automatic Train Operation (ATO) • Traffic Management (TM)
SmartRail 4.0, Switzerland	• FRMCS for ETCS • Automatic Train Operation (ATO) • Virtual Electronics signposts and train integrity (for ETCS Level 3) • Traffic Management (TM)

All the key initiatives as highlighted in Table 2 were developed using data-driven and software-based technology used for the railway operation systems. This clearly indicates that the future of mobility can be well managed by enhancing the technological capability of each specific railways. Apart from the key initiatives highlighted above, there are many more initiatives currently being planned and under the implementation process globally such as driverless trains, autonomous trains, automated planning and scheduling, digital twin environment, integrated traffic management, digital spatial data, industrial Internet of Thing (IoT) equipment as part of railway components, smart diagnostics and monitoring and many more. The main objective of digitalisation focuses on safety, cost optimization, and maximizing the capacity and performance of the railway network.

The digital environment through its automation processes could provide a shift of paradigm on how the railway operates in Malaysia. This may include the application of multi-use tools and technologies such as data integration, Artificial Intelligence (AI) and machine learning, smart sensors, digital ecosystem, and satellite data. These modern elements can be used from the concept to the implementation phase ranging from traffic operations, maintenance, safety, security, rolling stocks, and data transmissions.

Sirina and Yushkova (2021) have mapped out the summary of the SWOT analysis on their findings for the Digital Railway implementation in the Russian railway network. These findings on the threats and weaknesses are described in Table 3.

Table 3: Extract of SWOT analysis on digital railway implementation (Sirina and Yushkova 2021).

Layer	Train Control System
Threats	• Competent trained personnel • Compliance with train schedule • Constant monitoring of legislation • Transit potential • The emergence of new ways of transporting goods
Weakness	• Decrease in human and personnel opportunities • The study of the competitiveness factors of world practitioners • Release of innovative microprocessor-based floor and board devices • The speed potential of the existing infrastructure

The threats and weakness findings by (Sirina and Yushkova 2021) are relevant to the Malaysian railway context. Further strategies, governing policies, and frameworks are required to ensure that the elements as highlighted in Table 3 are addressed for implementation in Malaysia.

3. Methodology

The information evaluated in this research was based on systemic literature review obtained from online databases and web portals. Searches were conducted on several academic databases (ScienceDirect, ProQuest, IEEE Xplore Digital Library, Scopus, and Google Scholar). The search strategy included the combination of three terms related to the main theme – railway digitalisation (combination 1); COVID-19 impact (combination 2); modern transportation (combination 3). The results gleaned from the searches were read and analysed. Information was then compiled and classified into main topics of discussion to meet the objective of the study.

4. Finding and Analysis

4.1 Modern Train Control System (TCS)

The Train Control System (TCS) has been a platform for introducing digitalisation in most railway operations. TCS enables the railway operators to operate and maintain their railway most efficiently and safely. Modern TCS allows for more railway integrated solutions and higher interoperability. TCS varies from the origins of the manufacturer as described in Table 4.

Table 4: Train control systems.

Layer	Train Control System
Europe	European Train Control System (ETCS) ➢ Level 1 ➢ Level 2 ➢ Level 3
China	Chinese Train Control System (CTCS) ➢ Level 1 ➢ Level 2 ➢ Level 3
Japan	Digital Automatic Train Control System (D-ATC)
Korea	Korean Train Control System (KTCS) ➢ Level 1 ➢ Level 2 ➢ Level 3

The development of the train control systems architecture has evolved from conventional to fully automatic operation to allow maximization of the network capacity through efficient planning and enabling more trains on a length of line. Capacity increment would enable railways to serve the public for their mobility, in the sense that social distancing would require to be implemented in crowd-based traffic zones.

4.2 Usage of IoT, Big Data and Cloud Computing in Railways

IoT in railway encompasses interrelated devices and machines using intelligent interfaces. Cloud computing assists the asset owners to avoid massive infrastructure investments in railways. Big Data analytics enables railways to increase productivity and efficiency of respective equipment and systems. Combining these elements provides a path to railway digitalisation programme and can be used in the strategic planning of the railway modernization frameworks Scordamaglia (2019). These modern elements also assist to minimise human interventions which could also be helpful in terms of minimizing person-to-person interactions. Going digital also means that railways can migrate important documents such as Standard Operating Procedures, Rule Books, and Operations & Maintenance Manuals to a digital-based environment and will provide greater efficiency to the front liner staff and the company. Railways currently are replacing paper with electronic documents sent to tablets for conductors, engineers, and other frontline employees – along with how their approach to digital documents enables them to confirm employees received updates and increase understanding of updates. Capitalizing IoT, Big Data, and Cloud Computing will increase the efficiency and productivity of railway companies in preparing themselves for the challenges during any crisis in the future.

4.4 Safety Enhancement

Digitalisation provides the aptitude that allows the objects to be remotely monitored, controlled, and sensed across the network due to which, there is improved efficiency, accuracy, less human intervention, and a lot of dependability as a result there are economic advantages. For example, railway digitalisation can provide a variety of options for coping with social distancing and crowded spaces. UIC Covid-19 Task Force has identified the following on how digitalisation may support the safety measures such as:

i. Information on train occupancy using mobile application
ii. Smart CCTV usage to manage crowd
iii. Big Data and/or Artificial Intelligence in managing both station and train occupancy
iv. Use of thermographic cameras

Railway digitalisation also provides an opportunity to plan the maintenance activities efficiently, which are labour-intensive and require access to the operational areas within the railway network. Whilst most maintenance works are carried out outside the operational hours, comprehensive pre-planning must be undertaken to ensure that the availability of the railway after the operational hours' window is optimized. Intervention during operational hours particularly by the live train movement must be avoided whenever possible due to risks to personnel safety. The pandemic situation has made it even more difficult to undertake maintenance because of the travel restrictions and physical distancing requirements. Digitization provides the capability that allows the objects to be remotely monitored, controlled, and sensed across the network due to which there is improved efficiency, accuracy, less human intervention, and a lot of dependability as a result there are economic advantages. Further to that, predictive maintenance within the railway network utilizing data analytics enables the asset owners to strategically plan any replacement, troubleshooting, and repair works. This will help to manage resource mobilisation during emergencies on the worksite.

4.5 Human Capital Development for Implementing Digital Railway

Concerted efforts will be crucial in migrating the current human capital development framework to the new Digital Railway era. A good mix of conventional, digital technology and solid Research & Development (R&D) will be the essential ingredients to prepare the nation for future challenges. A Human Capital Development framework that focuses on and addresses the gap in

the need, competency, implementation, enforcement, and supply chain will be able to prioritize and determine the timeframe for the Digital Railway implementation.

Scordamaglia (2019) acknowledges that digital skills will probably be a challenge in the implementation of Digital Railways. There is a need to encourage educational institutions and industry players to come together to develop the educational need to support the future digital railway. As many advantages that digitalisation provides, these fundamental rely on developing the digital skills in the Malaysian workforce is essential in creating the transition platform and preparing the work force to leverage the benefits of the digital railway. Rahim et al. (2021) support that human capital plays a vital role in facilitating technological innovation. This would catalyse economic growth and provide a platform for sustainability in the future.

4.6 TVET readiness for Digital Railway

The development and implementation of Digital Railway require strategic planning from human capital development, industry readiness, and provision of competent Technical and Vocational Education and Training (TVET). This will strengthen Malaysia's position in promoting the implementation of the Digital Railway thus supporting the growth and sustainability of the railway network. Industry players play a pivotal role as well in promoting the TVET to support the migration into modern railway operations. This would require collaborations between the government, educational institutions, and the industry. There have been many programmes introduced in association with the TVET development in Malaysia such as exchange programmes, industry collaboration programmes, performance-based funding, centre of excellence, and even the provision of grants for TVET institutions. However, these programmes will require more focus on embedding the necessary digital skills in the syllabus. In line with the 10th Malaysia Plan, TVET is categorized as an essential element for the development and maintenance of human capital (Minghat and Yasin 2010). As an example, Section 115 of the Malaysian Land Public Transport Act 2010 expresses that, in analysing the competency requirements, skills, and qualifications of future train drivers, an important factor to be taken into account is the experience of the candidates. Digital Railway implementation requires our local workforce has sufficient skills and competency for the management of the modern rail network.

5. Conclusion

The review shows that Digital Railway is the future of how rail networks can be managed to achieve sustainability. The local environment of railway operation requires planning for the migration, implementation, and acceptance of the Digital Railway network. Lessons learned from the current Covid-19 pandemic necessitate that railway networks must be prepared to overcome the risk. The authors jointly agree that the digitalisation of the railway will ensure that the impact on the rail operation is kept at a minimum level. It is recommended that a further study be conducted to develop the conceptual framework of digitalisation of the railways in Malaysia.

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