"Railway LMS on INFOPRISM" Contributing to the Sustainability of Transportation Business

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1. Introduction

Railway operators have shown a greater need for digital technologies illustrated by its use to enhance inspections and improve the efficiency of maintenance work. In fact, in Asian region, Japan, Hong Kong and Singapore are struggling to secure a labor force with the decline of the working age population. The adoption of digital technologies is an effort that hopes to not only save labor and enhance railway functionality but also improve the on-site work environment and make the railway industry more attractive to prospective employees.

The Railway Lifecycle Management Solution (LMS) on INFOPRISM developed by Mitsubishi Electric has built a consistent track record of helping railway operators increase efficiency throughout the entire life cycle from train services through maintenance via Internet of Things (IoT) and Artificial Intelligence (AI) technologies since the service launched in 2019. This platform enables wayside equipment to collect data from trains in service to monitor and analyze the rolling stock and equipment in real time. This reduces suspended operations caused by equipment issues, increase the efficiency of maintenance work, and supports train services. LMS on INFORPISM also helps improve railway operations using data from railway operators as well as equipment and system manufacturers. In addition, these solutions can store and use the diverse data that has been collected to increases railway management efficiency and optimize asset management, which in turn contributes to the sustainability of transportation businesses.

This paper provides an overview of the work and success done in the development and provision of the Railway LMS on INFOPRISM services and describes initiatives to innovate solutions that use the wide range of data that has been aggregated to further drive railway management efficiency and optimize asset management.

2. Railway LMS on INFOPRISM

Railway LMS on INFOPRISM is built on the unique Mitsubishi Electric INFORPISM IoT cloud platform as a value-added solution that helps increase the efficiency of train maintenance and ensures reliable and safe railway operations by rapidly troubleshooting onboard equipment failures and other such issues (Fig. 1).

Railway Maintenance Solution, one of the applications of the Railway LMS on INFOPRISM, stores and utilizes the operational data from onboard equipment collected via the TCMS, which provides broad functionality. Wayside equipment can verify the operational status of onboard train equipment, view information displayed on driver's cab, detect or monitor signs of potential trouble with rolling stock, and remotely conduct exterior inspections at railway depots. Our driver assistance solution offers features that range from the visualization of the rolling stock in service between railway lines run by different railway operators to the optimization of train schedules based on passenger occupancy and support of energy-saving operations. Beyond the Railway LMS on INFOPRISM platform, our collaborative work solution enables multiple operators to use data and closely coordinate with one another. This supports greater on-site operational efficiency, especially when responding to various types of mechanical trouble using maintenance data provided by railway operators as well as equipment and system manufacturers.

The use of the diverse data aggregated by Railway LMS on INFOPRISM will expand the features and solutions available in the platform in the future. These will contribute to higher railway management efficiency, whether optimizing asset management throughout the entire life cycle of railway transportation services or analyzing the energy consumption throughout all trains in service.

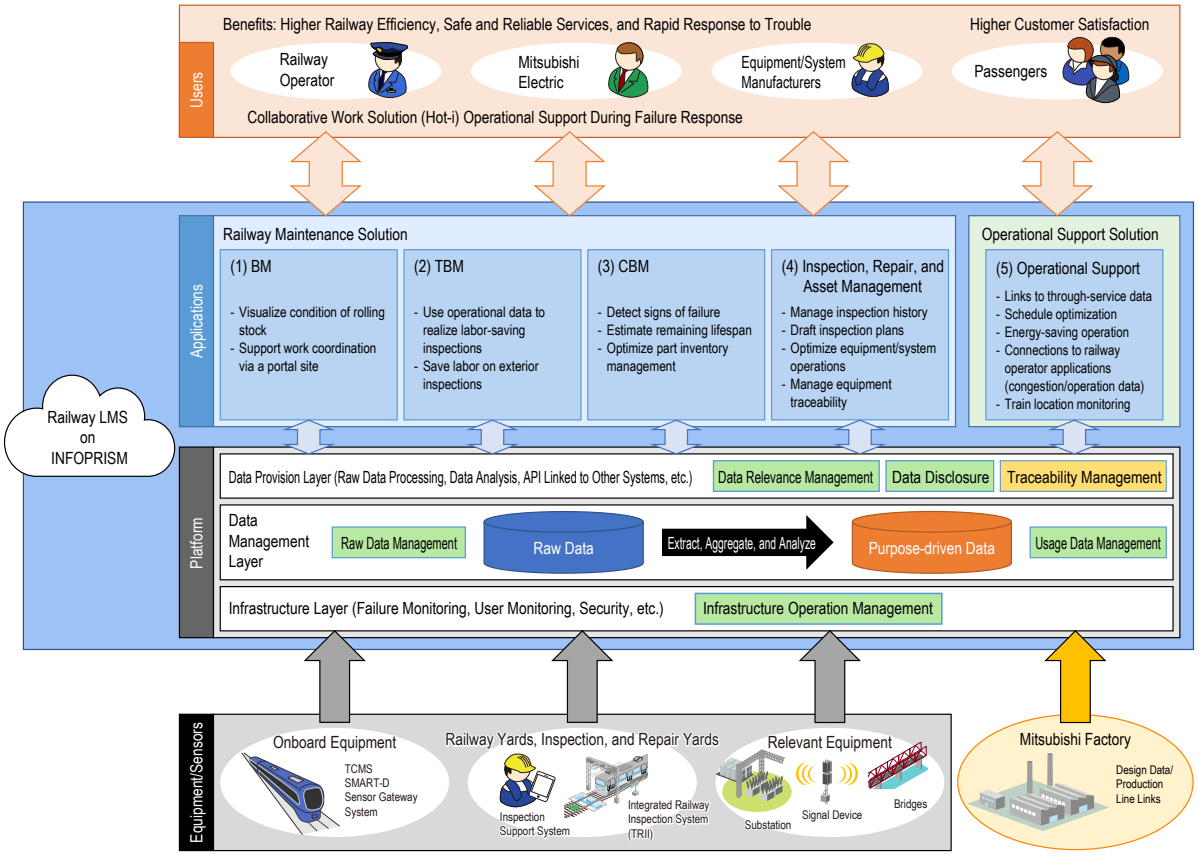

Fig. 1 Overall structure of Railway LMS on INFOPRISM[1]

3. Past Initiatives and Development Results

3.1 Railway maintenance solution using operational equipment data

The railway maintenance solution encompasses monthly and routine inspections as well as general and critical part inspections done primarily by railway operators in accordance with mandates stipulated by the Japanese government to prevent service disruptions caused by equipment failures or degradation. However, the scope of maintenance work has grown with the greater functional complexity of equipment as well as the new systems built into rolling stock. Railway operators are struggling with a shortage of inspectors due to the dwindling labor force caused by an aging population with a declining birthrate, which presents a challenge in efforts to guarantee safe and reliable services while reducing the manpower required to carry out this maintenance work. Information and Communication Technologies (ICT) and the digital technologies are two strategies that could potentially overcome the challenges brought by this labor shortage. Mitsubishi Electric has been promoting its railway maintenance solution as a means to save labor in maintenance work through the use of operational equipment data.

3.1.1 Visualization of the conditions on rolling stock for higher efficiency during repairs

Train crew has been identifying conditions on each train based on failure detection data exported to display units in driver's cab when an issue arise on a train that is in service, while verbally coordinating with officers in the Operational Control Center (OCC) to conduct repairs. Accurate information exchange is essential to carry out these repairs quickly. However, a lack of information or any misunderstanding between train crew can extend the time it may take to recover standard service operations. Railway LMS on INFOPRISM constantly receives and stores the operational data generated by the equipment on rolling stock to address these issues as an application configured to visualize the location of each train, any malfunctions, and other conditions of the rolling stock in service as much as possible in real time (Fig. 2). OCC can use this data to quickly and accurately assess failures and other conditions on rolling stock, which drives the efficiency of any repairs and more quickly recover regular train services.

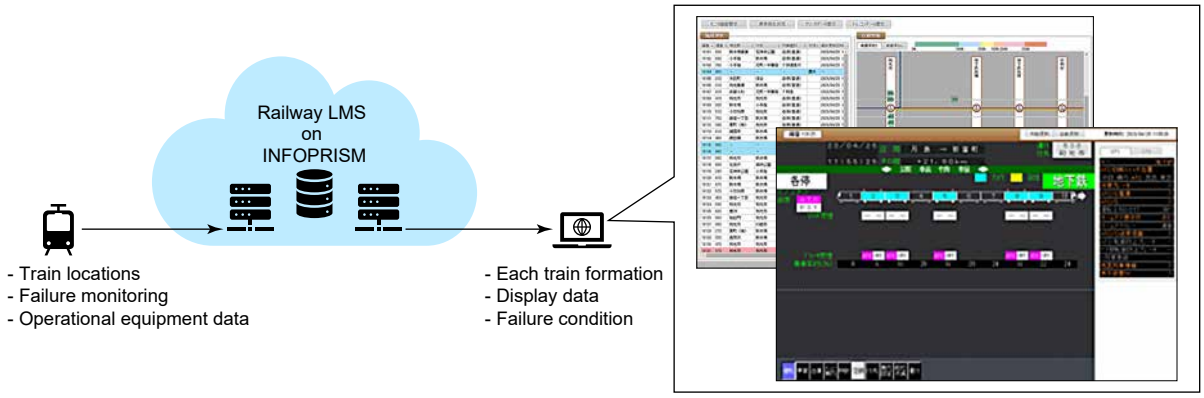

Fig. 2 Visualizing application and examples of vehicle status display

3.1.2 Labor-saving inspections during time-based maintenance

The railway industry conducts routine inspections of rolling stock according to Time Based Maintenance (TBM) practices that guarantee safe and reliable railway transportation. These routine inspections replace brake shoes and other wear-out parts, clean out clogged filters and conduct any other necessary repairs, run operational checks on train doors and other equipment, and measure the brake cylinder pressure in activating and after releasing the brakes. The inspection of doors and some of the other equipment could use the operational data aggregated from rolling stock in place of these operational checks because train crew operate the equipment during commercial train services. As one railway maintenance solution, Mitsubishi Electric developed a labor-saving inspection application that reviews operational logs for information equivalent to inspections in the operational data aggregated from onboard equipment in order to submit those findings as inspection results (Fig. 3).

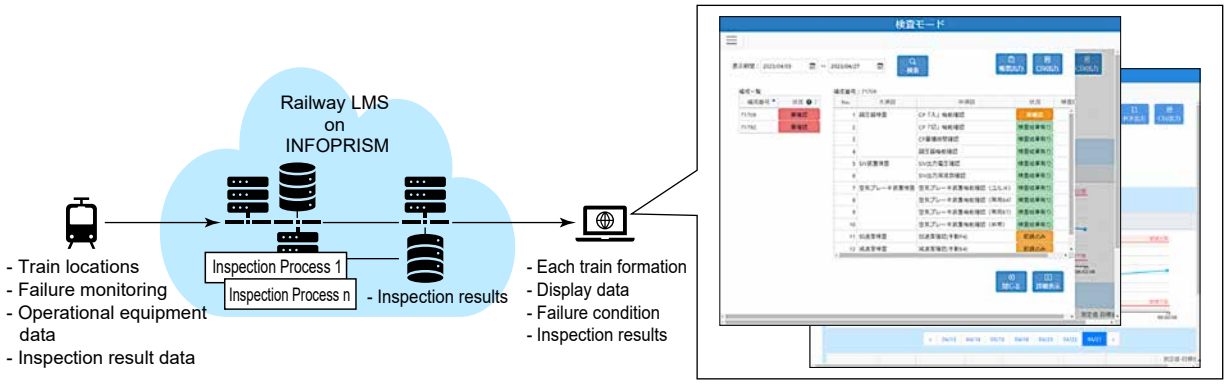

Fig. 3 Labor-saving application of railway inspection on TBM

These types of analysis applications come with concerns of higher management costs because operators have to handled more and more equipment operations as the number of train formations for inspection as well as equipment operations for analyses (inspection logic) grow. As a measure to mitigate the rising costs, our application narrows any analysis to only train formations coming up on routine inspection to optimizes the amount of data stored by the Railway LMS on INFOPRISM. To do this, the solution limits data to only the inspection results deemed valid by an inspection validation process running on equipment when collecting operational data.

3.1.3 Failure detection and monitoring to achieve condition based maintenance

Typical railway maintenance today consists of mainly Breakdown Maintenance (BM) and Preventive Maintenance (PM), which are two main aspects of TBM. Sections 3.1.1 and 3.1.2 have described solutions to enhance the efficiency and speed of maintenance work.

Railway maintenance going forward though will strive to reduced costs by emphasizing Condition Based Maintenance (CBM) that approaches repairs based on the degradation of equipment with the hope of reducing costs. CBM not only requires the aggregation of the operational data described in Section 3.1.2 but also constant monitoring of the equipment in operation. To respond to these needs, Mitsubishi

Electric has configured an analysis system to monitor operational data aggregated by the Railway LMS on INFOPRISM from each piece of equipment to identify degradation trends of aging equipment. This analysis system triggers alerts based on “warning” and “abnormal” values surpassing a certain threshold determined in advanced to enable crew to check the severity of equipment degradation according to the number of each of these alerts.

3.1.4 Small monitor analyze record terminal-depot/Onboard sensor gateway systems

Railway condition monitoring and control communication functions play a central role in the conventional Train Control and Monitoring System (TCMS) built into most rolling stock worldwide. The TCMS expands functionality and enhances stability, which contributes to safe and reliable transportation as well as reduces Life Cycle Costs (LCC). However, conventional TCMS does not have the recording functions to obtain all the different types of condition and monitoring data necessary to take full advantage of Railway LMS on INFOPRISM. Therefore, the system requires a means to select, record, and transmit all of the required data to wayside equipment. To satisfy these requirements, Mitsubishi Electric developed the SMART-D small monitor analyze record terminal-depot system to enable TCMS data collection without making any drastic modifications to rolling stock.

3.2 Development of solutions to support safe and reliable operations

Wayside equipment can monitor railways that can visualize the condition of rolling stock. However, Japan has numerous railway lines operated by different companies that offer through-services to one another, especially in the Tokyo metropolitan area. If a failure occurs while a train is operating on a railway run by another company, OCC can only communicate these issues verbally because the systems are not currently linked to one another. We developed a system to link and share through-service data from onboard equipment by visualizing rolling stock operating on every through-service railway line so that OCC of each railway operator can grasp the condition of through-service trains on any line via Railway LMS on INFORPISM.

In addition to the operational equipment data that it collects, Railway LMS on INFOPRISM emphasizes the use of passenger occupancy, car temperature, power consumption and other such data. For instance, the use of passenger occupancy data enables various analyses to revise train schedules and alleviate congestion, while the visualization of power consumption can help optimize service patterns for the purpose of saving energy.

3.3 Functions making the railway LMS on INFORPISM platform possible

The Railway LMS on INFOPRISM platform enables five different functions—infrastructure operation and management, raw data management, usage data management, data relevance management, and data disclosure management—configured through the data provisioning, data management, and infrastructure layers indicated in Fig. 1. These functions make the solutions described above possible.

In addition to these five functions, Mitsubishi Electric is currently developing a traceability management feature in the data provision layer to connect the rolling stock and onboard equipment data. This kind of link is a necessary component to advance asset management in the future. This section outlines this traceability feature.

Each solution provided by Railway LMS on INFOPRISM associates and facilitates use of a wide range of data, such as engineering design, production, operational history, operational data, inspection, and maintenance data throughout the life cycle from the design and manufacture through operation and disposal of rolling stock and onboard equipment. A traceability management function links, manages and uses this plethora of information. First, the system converts and aggregates this diverse data across the entire operational history as a digital thread consisting of a database model that is able to create historically traceable links between multiple companies and manufacturers. These links drive operational efficiency and sophisticated asset management by supporting plans for total overall of onboard equipment and expediting the horizontal exchange of information about any mechanical issues (Fig. 4).

Data relevant to rolling stock includes data to manage each train formation, such as management, inspection and operational data as well as data to manage the equipment and systems, such as design, manufacturing, part replacement, and repair. Reviews that use thses data to assess the health of rolling stock and onboard equipment must include information on the train formations (location of onboard equipment)

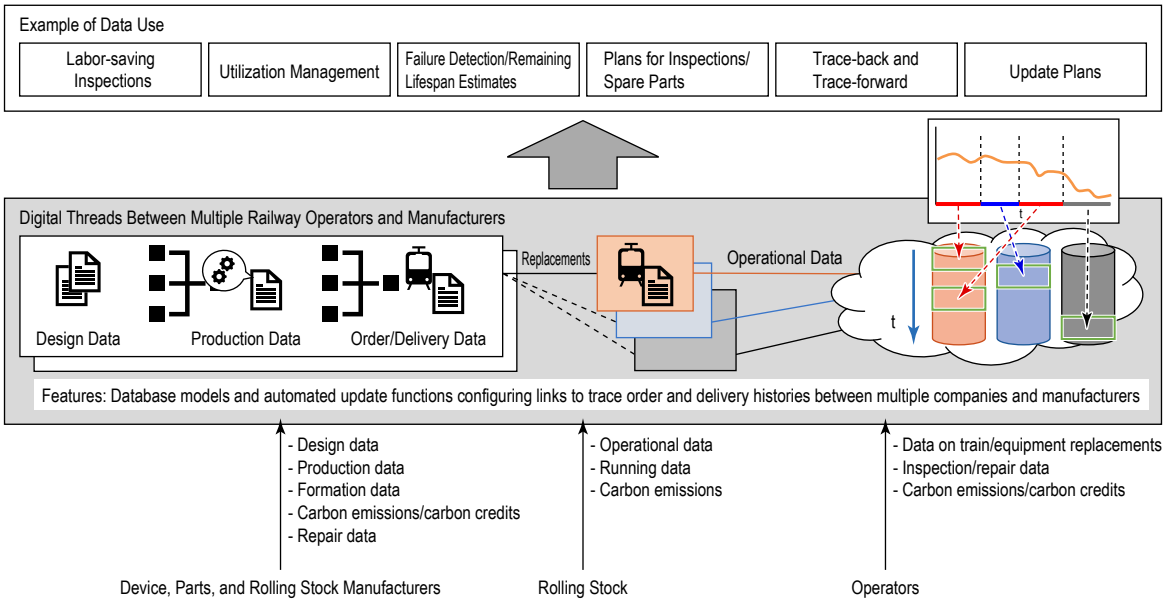

Fig. 4 Digital thread data among multiple railway operators and multiple manufactures with traceability management functions

and accurate data on the operational history of each piece of equipment. The traceability management function guarantees validity of operational histories and ensures access control through digital threads that use blockchain technologies. Currently, Mitsubishi Electric is in the process of evaluating and expanding the development of a prototype that primarily aggregates and uses operational history (onboard equipment data).

As outlined earlier, Railway LMS on INFOPRISM is provided as a solution to support the entire life cycle of rolling stock and onboard equipment in order to help continually build and forge partnerships between transport service users, railway operators, and companies involved in the industry in addition to contributing to sustainable railways. To achieve this goal, the platform must support initiatives to create and provide value from a broad range of data in cooperation of numerous companies and manufacturers.

4. Future Initiatives

4.1 Expansion of the railway maintenance solution

The future of railway maintenance will reform maintenance standards using operational equipment data, which should further drive TBM inspection efficiency through the labor-saving inspections described in Section 3.1.2 as well as other solutions. Moreover, the aggregation of operational data from equipment utilizing failure detection and monitoring as well as AI analyses will make CBM a reality.

4.2 Management optimization of all railway assets

The development of solutions to support the cooperative maintenance work to address equipment trouble takes advantage of data collected by condition monitoring systems that monitor failures as well as data about past equipment trouble in order to more rapidly determine the initial response. The traceability management function saves labor by acquiring data through automated data recognition and collection technology (automation), realizes the traceability of circuit boards, and advances links between equipment design and production data from manufacturers to help drive the efficiency of broad yet meticulous maintenance work. To solidify a foundation from this success, Mitsubishi Electric is collaborating with railway operators to innovate asset management solutions that help optimize management of all railway assets.

4.3 Innovations to bring about next-generation railway transport systems through the use of data

Next-generation systems will take a stance on data use that aims to integrate not only the railway and rail yard maintenance data currently available in the Railway LMS on INFOPRISM, but also operational monitoring; electrical and signal transmission; station monitoring; track, civil engineering and construction monitoring; sales; and a wide range of other data across railway operators. The objective of these innovations

is to develop a platform of next-generation railway transportation systems that offer energy savings, autonomous driving, and travel services plus higher efficiency throughout all railway operations. (Fig. 5)

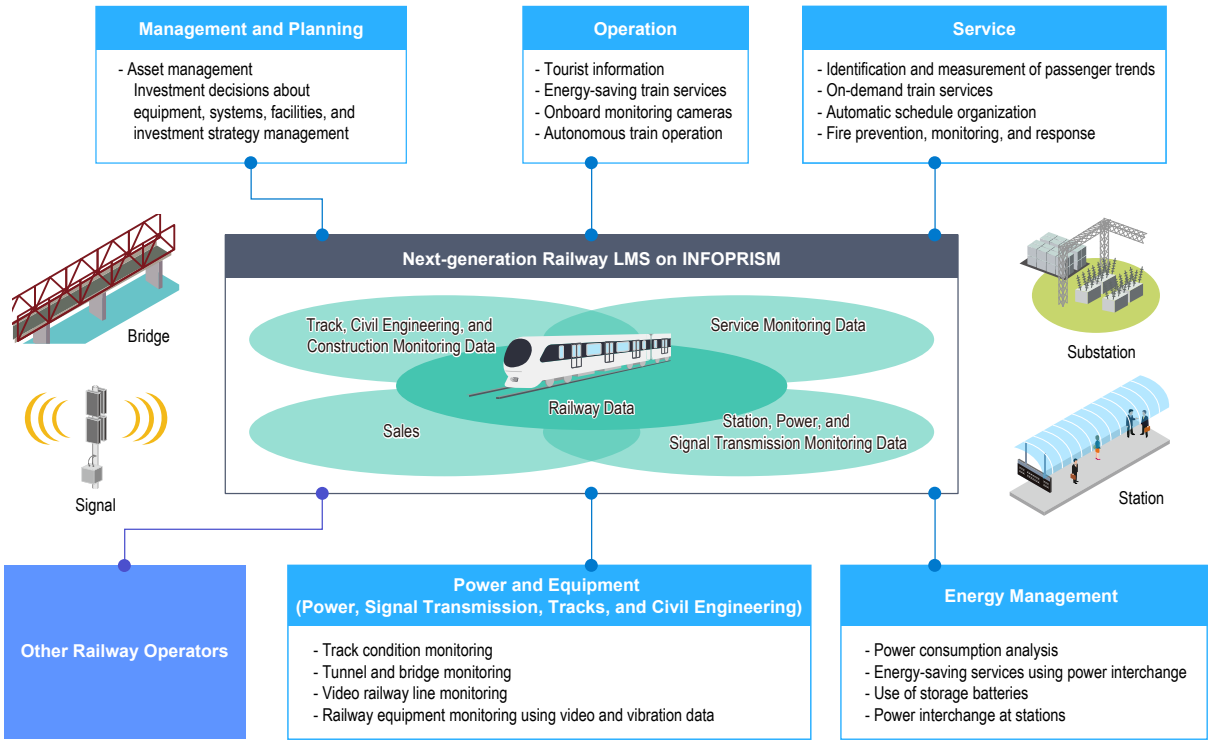

Fig. 5 Concept of structure of the next generation railway system with data utilization[1]

5. Conclusion

This paper has described the past development efforts, results, and future initiatives of the Railway LMS on INFOPRISM. Mitsubishi Electric leverages its expertise amassed in railway equipment and inspections thus far to further the development of railway maintenance solutions that visualize the condition of rolling stock, save labor on TBM and utilize operational equipment data in other ways as well as solutions coordinating maintenance work by utilizing maintenance data. Going forward, development of open platforms will work to add a lineup of equipment and inspection processes compatible with railway maintenance solutions and expand asset management solutions that help drive operational efficiency of all railway assets with the aim to expand and make possible the next generation of railway systems that can further capitalize on data. Through these developments, we will provide solutions to drive railway management efficiency and optimize and contribute to the sustainability of transportation businesses.

Reference

(1) Yokoshima, K., et al.: “LMS on INFOPRISM” Contributing to Efficient Train Maintenance Work and Stable Operation, Mitsubishi Denki Giho, 94, No. 12, 669-673 (2020)