# Activities in Overseas Transportation Business to Achieve the SDGs

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## 1. Introduction

Mitsubishi Electric Corporation has been expanding its overseas transportation business during the last 60 years with the mission of providing safe, secure, and stable transportation and comfort by constructing infrastructure in the global market. Through technological development, Mitsubishi Electric has satisfied various needs such as for compliance with local regulations, smaller and lighter equipment, energy-saving, and easier maintenance.

Today, global warming and other environmental issues are growing to be paid attention. In Europe, which is the center of railway systems and technologies, there are rising expectations for environmentally beneficial railways, which are also related to economic policies such as green recovery triggered by the COVID-19 pandemic. In addition, to enhance the competitiveness of the European railway industry, various technological development schemes such as Shift2Rail have been promoted with funds from the European Union (EU). There has been systematic technological development linked to the EU's railway policies, certification system, and development of standards, and these schemes and regulations have been expanded around the world. Since the UN adopted the SDGs at the UN General Assembly in 2015, aiming to build a sustainable society, various actions to create a decarbonized society and other actions have been taken.

Under those circumstances, Mitsubishi Electric established local production bases in Mexico, Australia, USA, China and India. In recent years, we invested Mitsubishi Electric Klimat Transportation Systems S.p.A. (MEKT) in Italy manufacturing air conditioning systems for railway vehicles, MEDCOM Sp. z o.o.(MEDCOM) in Poland providing solutions supporting public transport systems and power supply systems for industrial applications and EKE-Electronics Ltd. (EKE) in Finland which excels at train control and management systems and maintenance technologies. (Fig. 1)

This paper describes our contribution to sustainable development mainly through our technologies and cooperation with overseas manufacturers, along with the roles that Mitsubishi Electric will play in the global market in the future, while also examining the trend of the changing external environment.

## 2. Overseas Transportation Business of Mitsubishi Electric

The overseas transportation business of Mitsubishi Electric started with AC electric locomotives for the

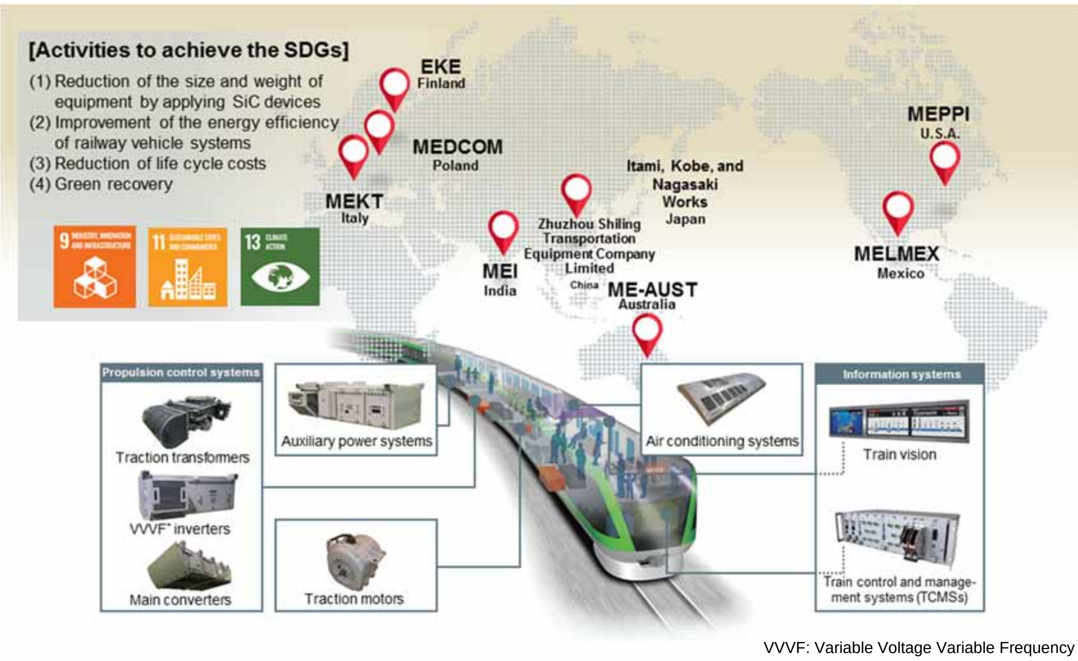



Fig. 1 Our global system that realizes synergy effects of technologies as a general electric machinery manufacturer

*Itami Works

Indian national railways in 1960, and expanded thereafter. We received orders for electric locomotives for the Spanish national railways in cooperation with a Spanish railway vehicle manufacturer. In the 1970s, we received orders for electrical equipment in Australia and Mexico and set up ME-AUST (1974) and MELMEX (1976) as local production sites. Later, we received orders for air conditioning systems for railway vehicles for the New York Metropolitan Transportation Authority in 1997 and orders for railway vehicle electrical equipment in 1999, which means that we fully entered the U.S. market by starting production there. In China, meanwhile, as the Chinese government rapidly expanded its urban transportation systems, we received orders for railway vehicle electrical equipment orders for Tianjin Line 1. Taking this opportunity, we participated in many projects in China and set up Zhuzhou Shiling Transportation Equipment Co., Ltd. in 2005 as a local production site. We re-entered the Indian market in 2001 by winning orders for Delhi's Metro and started local production in 2015 in response to growing demand for domestic production with an increasing number of self-financing projects. In Europe, in 2006, we received air conditioning system orders for railway vehicles for London underground for the first time. We acquired an Italian manufacturer of air conditioning systems for railway vehicles a fully-owned subsidiary in 2014 to start local production and made the products more attractive by combining their technologies with our air conditioning technologies. In the same year, we expanded our sales offices in Europe with the aim of boosting sales by combining railway vehicle electrical equipment with air conditioning systems. In 2015, we invested in MEDCOM, a Polish electrical equipment manufacturer, which has been providing solutions supporting public transport systems and power supply systems for industrial applications. MEDCOM has the state-of-the-art power electronics technologies as well as technologies for reducing size and weight, and has increased the competitiveness of its products by combining their technologies with our advanced technologies including power semiconductors. Most recently, in June 2020 we invested in EKE in Finland, which excels at train control and management systems and maintenance technologies, and we intend to rationalize the railway vehicle maintenance business in the future.

While expanding its global business, Mitsubishi Electric has been developing production sites for local production. Furthermore, to understand the latest trends in markets and quickly respond to customer requests, we have been forging alliances with overseas manufacturers. Under such initiatives, we will contribute to realizing the SDGs through supplying railway vehicle electrical equipment.

## 3. Technological Development Activities

This section describes cooperation with MEDCOM, EKE, and MEKT regarding technological development to achieve the SDGs.

### 3.1 Reduction of the size and weight of equipment by applying SiC devices

Mitsubishi Electric delivered propulsion control systems with hybrid SiC devices for metro vehicles in service operations in February 2012,(1) becoming the first in the world[1] to apply SiC devices to railway vehicles, and have since reduced the size and weight of equipment. We have also applied full-SiC devices to commuter train vehicles(2) and traction systems for Shinkansen vehicles. We have been working to reduce the size and weight of auxiliary power systems (APSs) in cooperation with MEDCOM by utilizing the low loss characteristics of SiC devices. For conventional APSs, transformers that are used to isolate the input circuits from output circuits account for a large proportion of the volume and mass of the entire system. Therefore, we focused on reducing the size and weight of transformers and developed high-frequency link type APSs with SiC devices. The high-frequency link type isolates the input circuit from the output circuit by combining a high frequency drive inverter, transformer, and rectifier as shown in Fig. 2. As an example, for the APS of 95-kVA

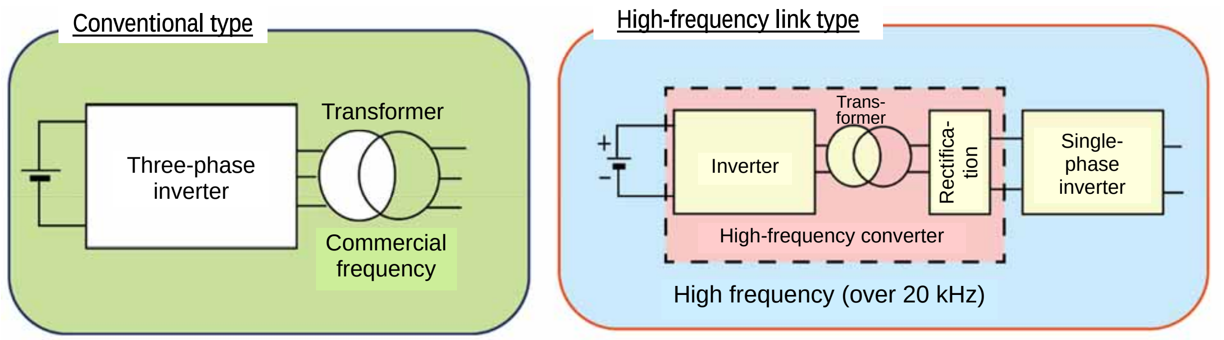



Fig. 2 Comparison of APS types

[1] As of September 27, 2012, researched by Mitsubishi Electric

Fig. 3 High-frequency link type APS with SiC devices

with SiC devices shown in Fig. 3, the volume was reduced by approximately 30% and the mass by approximately 60% compared to the conventional type with the same output capacity.

In addition to APSs, MEDCOM has developed propulsion control systems in which auxiliary power systems and battery chargers get combined as systems with SiC devices for E-BUS (electric bus). Figure 4 shows its appearance; such systems get installed on rooftops. SiC devices can reduce the loss by up to 30% compared to conventional types, allowing to extend the traveling distance on storage batteries and to reduce both the volume and mass by 40%. The on-ground battery chargers for E-BUS have gotten developed adding to on-board systems, which satisfy various needs with charging capacities ranging from 30 kW to 650 kW for boost charge.

### 3.2 Improvement of the energy efficiency of railway vehicle systems

According to the analysis of the loss that gets generated in the main circuit system for the conventional vehicle, the loss of the running resistance accounts for a large percentage, and the one from the inverter.(3) Which infers the low-loss SiC device application fails to decrease the loss of an entire system well enough. Thus, Mitsubishi Electric focuses on the performance curve of vehicles for the SiC device application. We combine SiC devices with low-impedance motors, which allow us to improve the amount of regenerated power with necessary brake forces ensured through the regenerated brake from the high-speed range. The combination improves the energy-saving effect of the entire vehicle systems. Besides, we have been implementing various measures for long train sets to reduce the energy use of the entire sets and optimize the configuration, such as controlling which units in a train set are used depending on the magnitude of the required tractive force for the train set, and another configuration in which the braking force is changed depending on the unit located in a train set to prevent the regenerative braking force from decreasing due to sliding. MEDCOM has been developing high-efficiency drive systems using supercapacitors for short train sets (e.g., light rail vehicles (LRVs)). For propulsion control systems for LRVs that repeatedly accelerate and decelerate frequently, supercapacitors that have lower internal resistance than storage batteries can get rapidly charged and discharged, which allows for the high-efficiency systems to contribute to energy-saving as well.

Fig. 4 APS/propulsion/charger combined system with SiC devices for E-BUS

### 3.3 Reduction of life cycle costs

Mitsubishi Electric and EKE supply train control and management systems (TCMSs) and remote train maintenance support systems to railway companies.

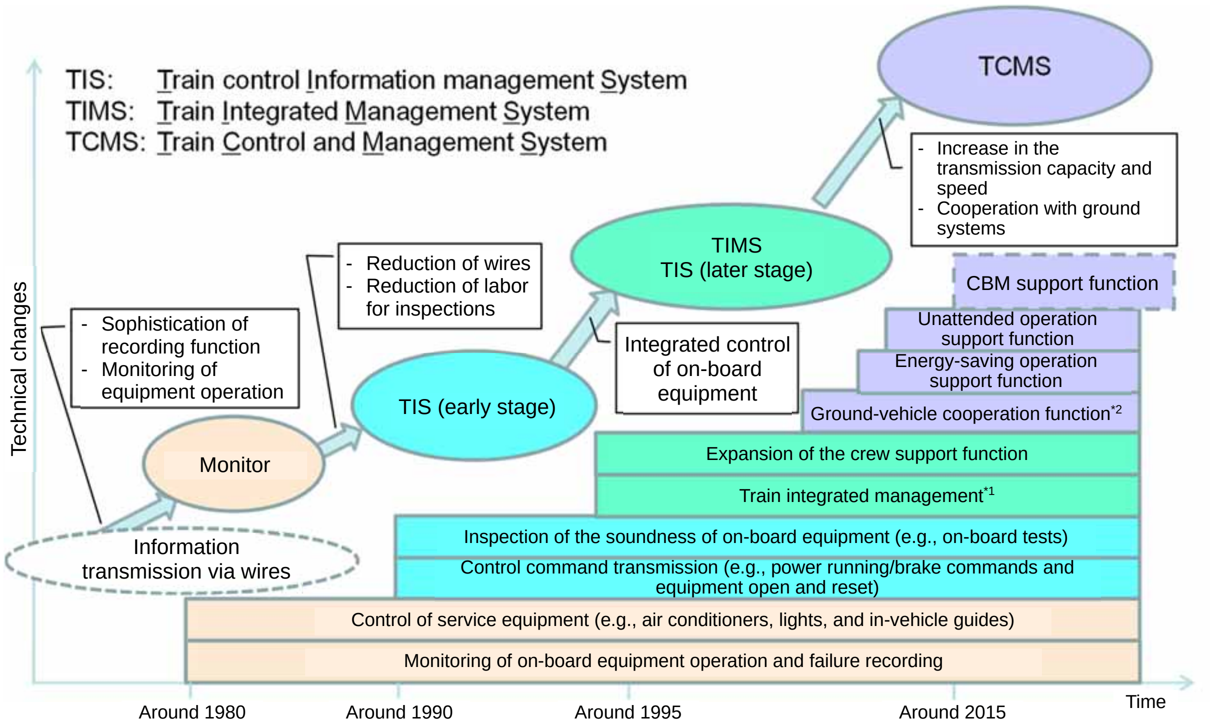
As shown in Fig. 5, TCMS serves as a brain of a train, providing various functions such as energy-saving driving support, maintenance support through communications with ground facilities (ground-train communication functions) and automatic train operation support, in addition to monitoring and control of on-board equipment. TCMS has a wide variety of applications in railway vehicles for safety and stable transportation.(4)

In recent years, there has been increasing demand for remote monitoring and condition based maintenance (CBM) of railway vehicles using digital technologies such as the Internet of Things (IoT) and big data, for achieving more labor-saving and efficient maintenance activities for railway vehicles. Mitsubishi Electric and EKE have been actively using technologies of both companies to reduce life cycle costs of railway vehicles, aiming to implement the TCMS-based CBM support functions shown in Fig. 5 and the remote train maintenance and CBM support system shown in Fig. 6.

The first stage is remote monitoring of on-board status, and this has already been commercialized as the remote train maintenance support system. This function sends on-board equipment status data collected by TCMS to ground systems through wireless communications, achieving real-time monitoring of on-board status. In the event of an on-board failure, this function allows ground operators and maintenance staff to check details of the failures and expedites the recovery operation.

In addition, this function also allows maintenance staff to remotely collect logs from on-board equipment and change parameters of on-board equipment, achieving labor-saving maintenance activities.

The second stage is visualization of on-board status. The operation data of on-board equipment collected by




*1: Train integrated management: Function to control electrical equipment in an integrated way so as to optimize the operation of the entire train set

*2: Ground-vehicle cooperation function: Railway vehicle maintenance support and train operation support functions by cooperation between ground systems and TCMSs

Fig. 5 Changes in functions of train control and management systems (TCMSs) of Mitsubishi Electric

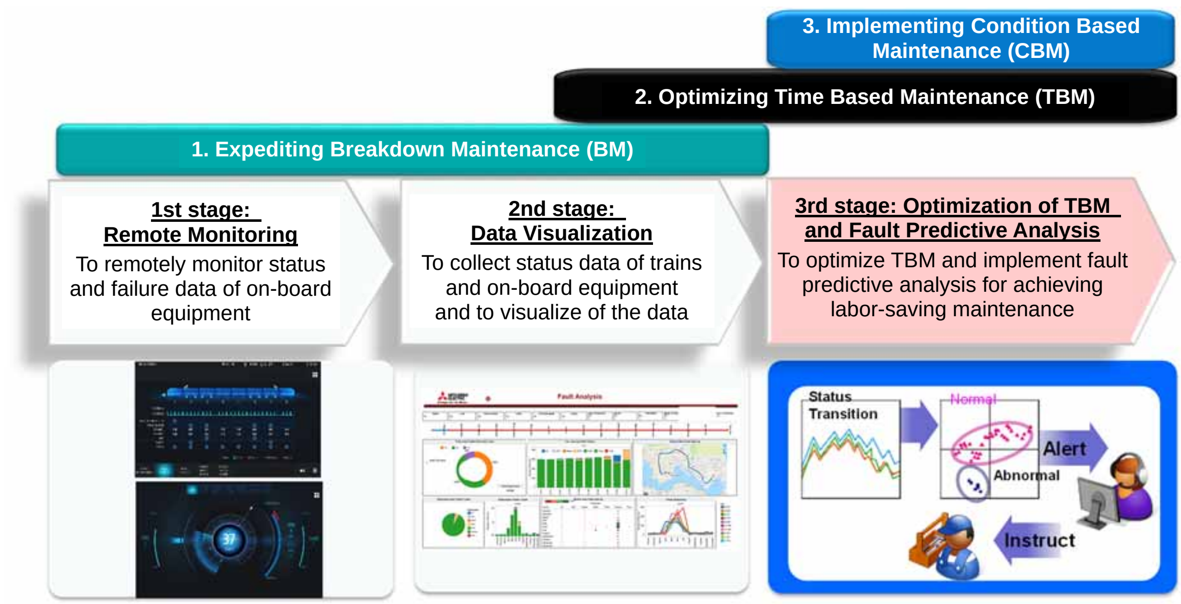



Fig. 6 Mitsubishi Electric's concept for Remote Train Maintenance & CBM Support System

TCMS is accumulated in a database, supplemented with information such as date and time, traveling location, train speed, and environmental conditions. This function statistically compiles the accumulated data from various aspects and visualizes their results, allowing ground operators and maintenance staff to analyze characteristics in operating conditions of on-board equipment and signs of failure occurrences.

The third stage is optimization of TBM and fault predictive analysis. This activity is to establish a mechanism for identifying trends of equipment degradation and irregular data among operation data of on-board equipment. This promotes reduction of downtime and optimization of maintenance cycles as equipment can be replaced prior to failure occurrences.

### 3.4 Green recovery

For air conditioning systems for railway vehicles, hydrofluorocarbon (HFC) which is an alternative of hydrochlorofluorocarbon (HCFC) or chlorofluorocarbon (CFC) refrigerants, such as R407C and R134a, are used and their global warming potential (GWP) is around 1,500. GWP regulations to combat global warming have been tightened, making it essential to switch to lower GWP refrigerants. Currently, targeting projects in Europe, we have been carrying out fundamental development of air conditioning systems with natural refrigerant $CO_2$ of GWP1 and considering reducing energy consumption by controlling the compressor inverters in addition to changing the refrigerant. We intend to release such air conditioning systems into the European market after commercialization development at MEKT and field tests in the market. In addition, the ventilation function provided by air conditioning systems of railway vehicles has attracted attention during the COVID-19 pandemic. As a temporary measure, the volume of air taken in from outside has been changed to increase the amount of ventilation. However, this increases the heat load too and impacts the performance of cooling and heating the air in the vehicles. To solve these problems, we are working on improving the ventilation function and energy efficiency as medium- to long-term tasks.

## 4. Conclusion

Amid the COVID-19 pandemic, needs in the railway sector are changing in various ways. At the Rail Summit held in Berlin in June 2020 under the sponsorship of the German government, various goals were cited: Double the number of railway passengers by 2030 and increase the frequency of railway services between all main cities to shorten the interval to 30 minutes in the future in order to make railways more convenient for users.[5] “Flight shaming”, which started in Europe in 2018, may have affected this trend. Mitsubishi Electric has obtained a supplier certification for communications-based train control (CBTC) for the New York Metropolitan Transportation Authority in the North American market. Therefore, we can help improve the transportation capacity and stabilize transportation by utilizing moving blocks. In addition, regarding Shift2Rail, various approaches using new technologies are essential to establish integrated platforms that offer sustainable transportation services. Digitalization, automation, telecommunications, and satellite services will be key for this purpose.[6] As a general electric machinery manufacturer, Mitsubishi Electric will work hard to contribute to the international community through its railway business by gaining the synergy effects of technologies across multiple businesses that specialized manufacturers cannot offer.

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