# Technology Innovation: Mobility

## 1 Rolling Stock Aesthetics and Analysis-led Design for European Trains

Along with satisfying the railway operator's branding requirements, the exterior designs used when developing rolling stock for the European market also facilitate the development of exterior graphics by maintaining a common identity across Hitachi's trains in this market (the AT series), all of which share a conceptually similar external geometry. Meanwhile, fluid dynamics simulation is used in the design of rail car shape to improve aerodynamics (to reduce drag and aerodynamic noise). Hitachi has also reduced the size of the crashworthy structures developed to comply with European standards for collision safety without compromising their performance in a way that fits well with the streamlined front-end shape of the rolling stock.

For the train interiors, the design of features such as layouts, seating, ceiling lights, and luggage racks can easily be modified to suit the requirements of the railway operator. Hitachi has developed a virtual reality (VR) configurator system that can be used to assess designs from a passenger's perspective. To provide cabin interiors that passengers will find comfortable, analysis-led design utilizing thermal fluid simulation is used for air conditioning and heating.

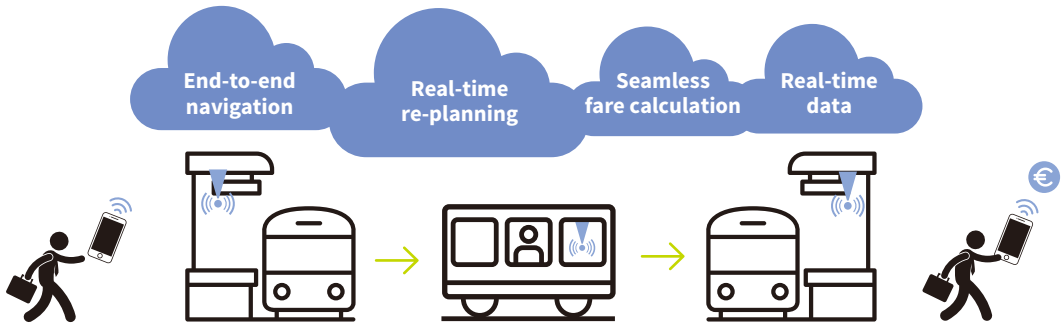
Hitachi was awarded the Imperial Invention Prize at the 2019 National Commendation for Invention for the design of the Class 800 high-speed train for the UK (Design Registration No. 1486294), the first time a design had won this award.

## 2 Digital Ticketing Solution for a Seamless Passenger Journey

Mobility as a Service (MaaS) has attracted a lot of interest from multiple service providers worldwide as it enables passengers to travel seamlessly using different modes of transport such as railways or buses. Hitachi has developed a solution that uses wireless communication technology to detect passenger journeys automatically as well as to provide cashless fare collection.

An important requirement of this solution is the ability to track passenger journeys accurately. Hitachi has developed a technology that uses passengers' smartphones to receive the information from low-cost wireless communication devices installed in vehicles and stations. The received data is then analyzed in real time to accurately determine passenger's location. This algorithm works accurately even in a complex wireless environment, such as inside a train, station, building, and so on. A trial of this technology is currently underway in Trento, in the northern part of Italy.


**1** Exterior design of standard rolling stock for European market




2 Overview of digital ticketing solution

This new solution allows passengers to travel using different modes of transport while requiring neither a pre-purchased ticket nor touching a pass at a gate. In the future, Hitachi intends to enhance this seamless travel experience by deploying this solution to public transport globally.

## 3 SiC Modules for Railway Inverters Able to Operate at High Temperatures

Hitachi is developing a sintered copper bonding technique for inverters that use silicon carbide (SiC) semiconductors that enables high-temperature operation. By permitting operation at temperatures of 175°C or more, the technique facilitates the miniaturization of inverters by increasing power module output density.

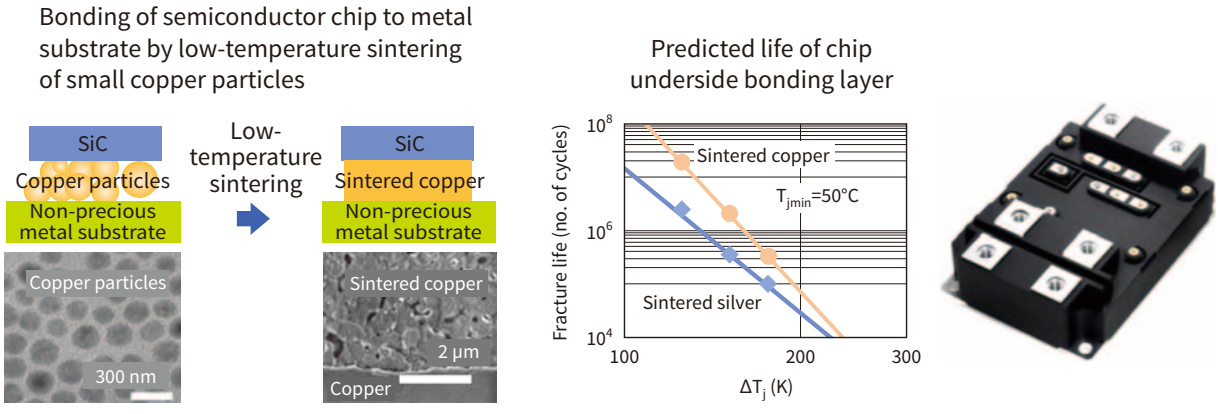
Sintered copper bonding uses copper particles to bond the semiconductor chip. A copper bonding layer is formed by using sintering to bind the copper particles together. Copper, compared to conventional solder and silver, has a high yield strength (an indicator of its resistance to fracture) of 0.2%, giving it a long fracture life even when operated at temperatures of 175°C or more. Sintered copper has good bonding performance for non-precious metals like copper and nickel, and also cuts costs because it does not require gold or silver plating of the electrode to which it is bonded.

At 47 kVA/cm$^2$, the output density of a full SiC power module (3.3 kV, 1,000 A) produced using sintered copper bonding was 25% higher than when past methods were used*. The intention for the future is to expand use of the technique to medium-voltage applications such as in the automotive sector.

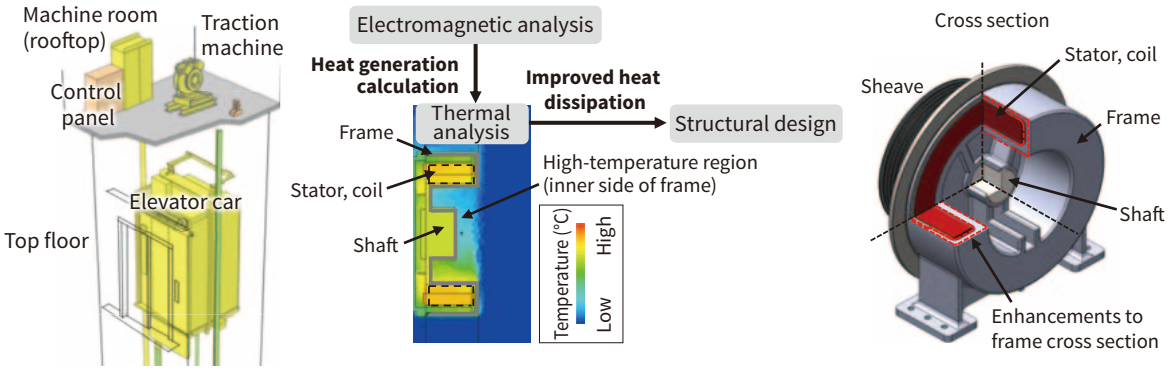
* As of May 8, 2019, based on research by Hitachi.

## 4 Miniaturization of Electric Motors for Elevator Modernization

Amid rising demand for the modernizing of elevators that have been in service for 20 years or more, Hitachi continues to expand its menu of modernization and maintenance options that deliver improvements in safety, comfort, and maintenance quality. The option of replacing only key components such as the control panel or traction machine while leaving the elevator itself in place is available for customers who want to




3 Life extension by sintered copper bonding (left and middle) and 3.3-kV/1,000-A full SiC power module (right)



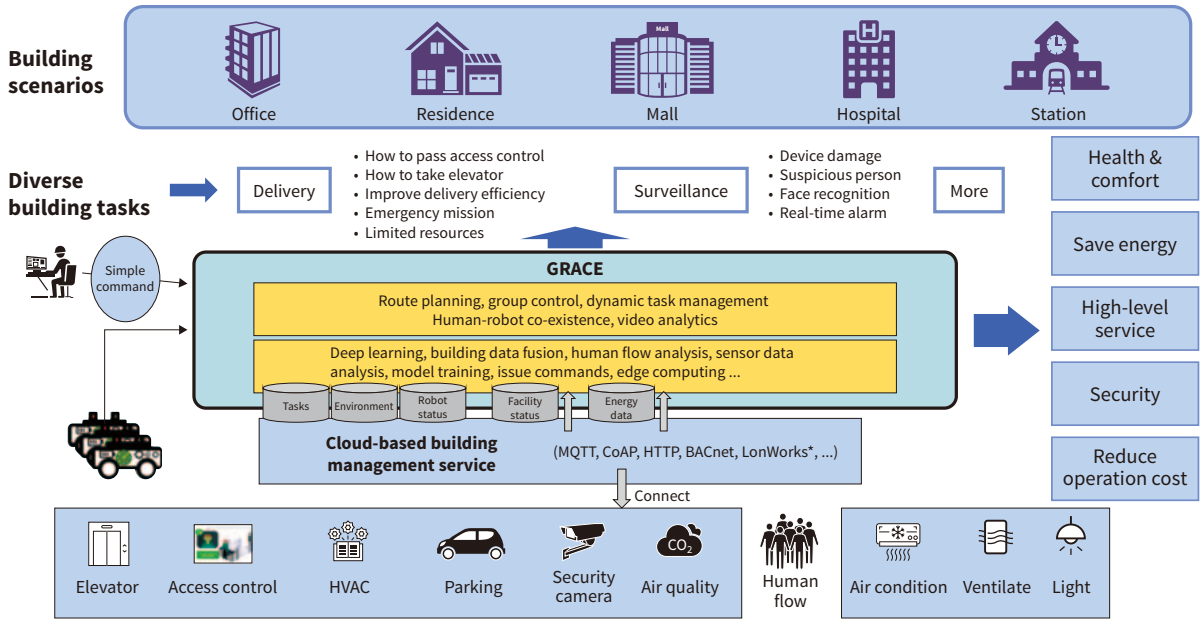

4 Miniaturization of traction machine for upgrade projects

shorten the time taken for this work, something that is in strong demand. However, it is impossible in some cases to fit a new traction machine into the machine room due to constraints such as weight or dimensions.

Recognizing this situation, Hitachi has developed a small and lightweight gear-less traction machine. The challenge when making the traction motor smaller is to improve cooling performance because of the larger amount of heat generated per unit of volume. To address this, Hitachi has developed a thermal analysis technique that can predict the internal motor temperature with high accuracy by considering the air flow around the traction machine and the conduction and radiation of heat by structural components, which have a major bearing on cooling performance. Structural design improvements were made by coupling this with an electromagnetic analysis to produce a small and lightweight traction machine for commercial release.

## 5 China Urban Area Building Service Comfort Solution

With the rapid development of urbanization, China faces the problems of an aging population, shortages of manpower, and rising labor costs. These have become a big challenge for urban services. It is increasingly difficult for building operators to provide residents with safe, convenient, and high-quality services. Since 2017, Hitachi (China) Research & Development Corporation (HCR&D) has been visiting office buildings, shopping




MQTT: message queuing telemetry transport CoAP: constrained application protocol HTTP: hypertext transfer protocol
BACnet: building automation and control networking protocol HVAC: heating, ventilating, and air-conditioning
* See "Trademarks" on page 151.

5 Illustration of expert recommendation solution

malls, and residential and park customers with partners, and has proposed the building service concept of "Gateway of Robots and Connected Environment" (GRACE) based on the rapid development of new smart building facilities and service scenarios.

There are many building service robot startups in China who want to go deep into the building service scene, but they often lack the ability to interact with building facilities (such as elevators, security gates, and air conditioners), and they are not familiar with the business logic of building services. The goal of GRACE is to help partners to connect with building equipment through task allocation, path planning, facility management, video analysis, human-machine coordination, and other technologies, and thereby to expand application scenarios for creating new Hitachi building businesses.

Since 2019, HCR&D has developed a GRACE prototype system through joint research with Hitachi Elevator (China) Co., Ltd. (HELC), Hitachi Solutions (China) Co., Ltd. (HSCN), and robot startups. A demonstration of GRACE in the HELC's Hitachi Innovation World showroom is providing a wide range of experimental environments for new building services creation.