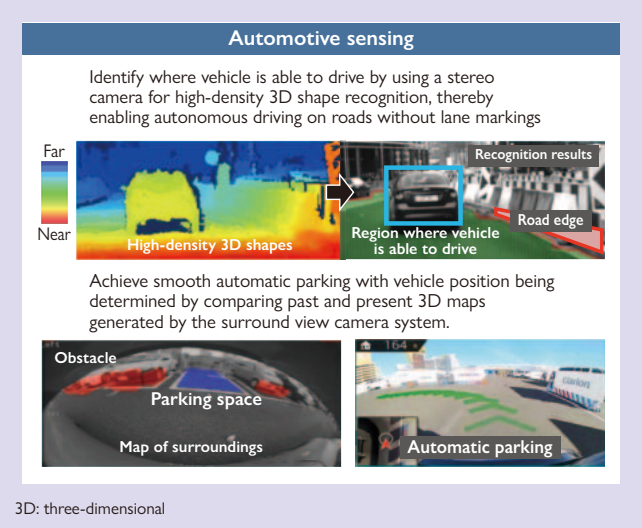
Technology Innovation

Urban

1 Recognition and Control Techniques for Enhancing Autonomous Driving

The market is seeing an acceleration in the development of automotive sensing technology aimed at realizing autonomous driving. Hitachi is also developing vehicle-mounted sensors that include stereo cameras and surround view cameras (peripheral cameras installed on the left, right, front, and rear for viewing the area around the vehicle). Autonomous driving has already advanced as far as automatic steering functions for lane-keeping on highways, and it is anticipated that the scope of application will expand beyond highways to include ordinary roads in the future. This means that a key challenge for sensors will be the ability to identify not only specific features such as lanes and other vehicles but also things like generic objects on ordinary roads or complex road layouts such as those at intersections.



3D: three-dimensional

1 Automotive sensing

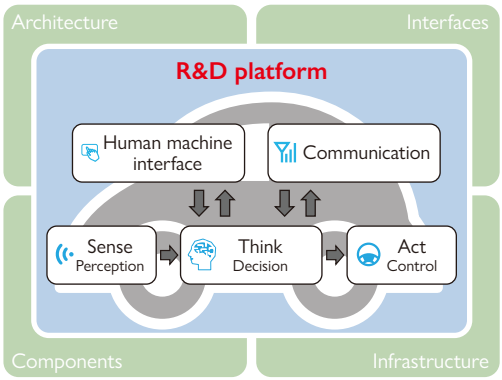
To implement automatic steering on ordinary roads, Hitachi has developed a stereo camera that uses a high-density three-dimensional (3D) point cloud to determine where the vehicle is able to drive and identify the shapes of arbitrary obstacles on the road. Similarly, to enable automatic parking with smooth vehicle steering, Hitachi has also developed a surround view camera system able to view the surroundings of the vehicle using fish-eye cameras, and that can determine vehicle position by comparing past and present 3D maps generated by these cameras.

In the future, Hitachi intends to use this technology to contribute to implementing practical autonomous driving that can be used on a wide variety of roads.

2 Collaborative Creation with Customers for Autonomous Driving through a Rapid R&D Platform

For collaborative creation with Business Units and customers, it is required to show Hitachi's technical capability in the field. However, even if we have innovative technologies, it is sometimes difficult to properly integrate them as solutions, for example when a customer demonstration is needed. Especially in automotive and mobility field, where the development period is normally longer than in other domains, this problem becomes critical. In order to achieve rapid prototyping in mobility field, Global Center for Social Innovation – Europe (CSI-EU) proposed an research and development (R&D) platform targeting demonstrations to customers.

The platform is aiming at the acceleration of vehicle-related software development for connected and autonomous test/demo



2 Overview of research and development (R&D) platform

vehicles of Hitachi. The platform provides reference architecture design, common interface definition, loosely-coupled software components, and infrastructure to develop and deploy components. Thus, the platform enables rapid development, automated deployment, and effective reuse of components.

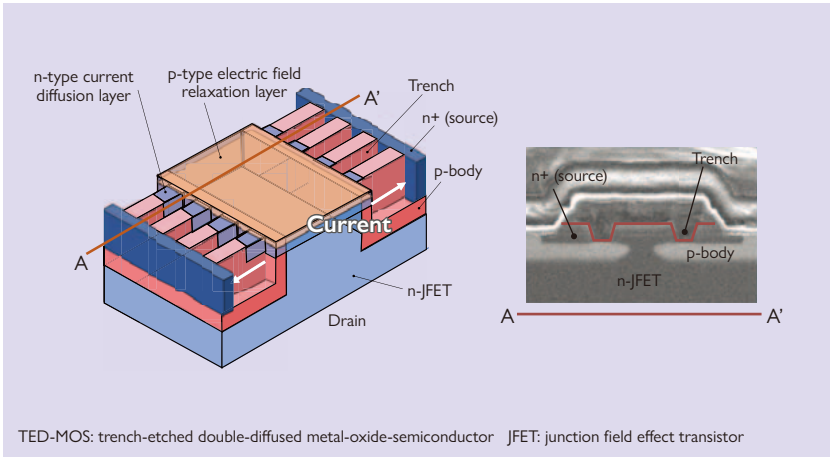
CSI-EU is already utilizing this R&D platform for collaborative creation with two European research projects, aDverse wEather eNvironmental Sensing systEm (DENSE) and HumanDrive. For both projects CSI-EU has implemented in its demo vehicles architectures based on this R&D platform and proposed to the internal sponsor and to partners/customers.

Now CSI-EU is further promoting the platform to other internal business entities including Hitachi, Ltd.'s Research & Development Group and Hitachi Automotive Systems, Ltd. With the R&D platform, entire Hitachi can gather and share its technologies and experience to enable collaborative creation with customers. Hitachi is planning to adopt the platform not only to automotive, but also other mobility fields such as rail, maritime, etc.

3 Highly Durable TED-MOS Design of SiC Power Semiconductor for Improving Energy Efficiency of Electric Vehicle Motor Drive

Hitachi has developed a new type of power semiconductor device called the trench-etched double-diffused metal-oxide-semiconductor field-effect transistor (TED-MOS) that uses a next-generation material silicon carbide (SiC) to help improve the energy efficiency of electric vehicles (EVs). The TED-MOS is an SiC metal-oxide semiconductor field-effect transistor (MOSFET) featuring a fin-shaped structure and avoids the problem of electric field concentration that affects other trench MOSFETs while also having a lower resistance than past double-diffused metal-oxide-semiconductor (DMOS) designs. Along with the electric field being further limited by an electric field relaxation layer in the central part of the device, a current diffusion layer has also been added to reduce resistance, reducing the electric field intensity by 40% and resistance by 25% compared to previous DMOS devices, resulting in 50% lower energy losses. This allows higher current densities to be used in EV applications.

In addition to the use of this new technology to improve the energy efficiency of EV motor drive inverters, Hitachi also intends to contribute to the creation of a low-carbon society by also utilizing it in various electrical converters used in social infrastructure systems.



TED-MOS: trench-etched double-diffused metal-oxide-semiconductor JFET: junction field effect transistor

3 Newly developed TED-MOS

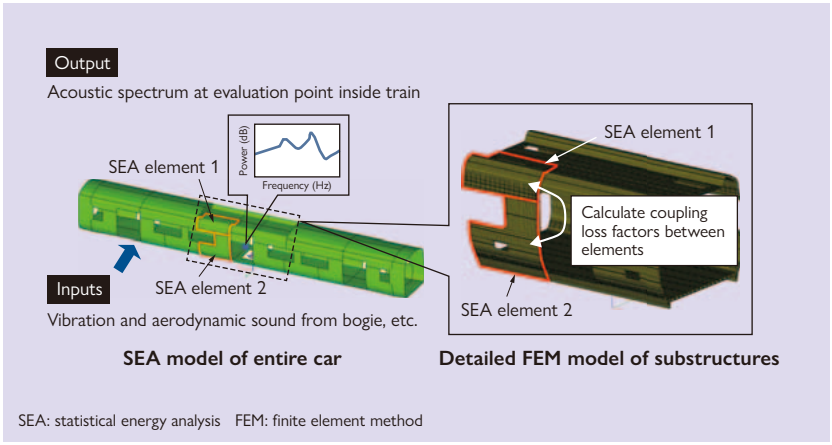
4 Interior Noise Prediction Technology for Rolling Stock

Achieving a quiet interior environment is an essential requirement for improving passenger comfort in vehicles such as railway rolling stock, which play an important role in public transportation. Unfortunately, innovations such as faster speeds and lighter weights tend to make the interior of trains noisier, raising the importance of noise prediction and reduction technology that can be used at the design stage. Noise prediction for large machinery

such as rolling stock has been using a technique called statistical energy analysis (SEA). SEA uses a full structural model that divides the vehicle into various structural elements and takes the vibration of the bogie and aerodynamic sound around the train as its inputs, calculating the spectrum of the sound that propagates through the structure of the carbody into the interior compartment.

The problem with SEA has been that the calculation requires coupling loss factors that indicate how much vibration propagates across the region where different structural elements are connected with each other, and that the practical way to obtain these coupling loss factors has been by conducting tests on actual rolling stock. To overcome this, Hitachi has developed a way to build SEA models of an entire railway car by using a detailed finite element method (FEM) model of parts of the structure that include these contact regions. This is then used to calculate the coupling loss factors.

In the future, Hitachi intends to use this method to help develop rolling stock that achieves high levels of performance in conflicting requirements such as quietness and light weight.



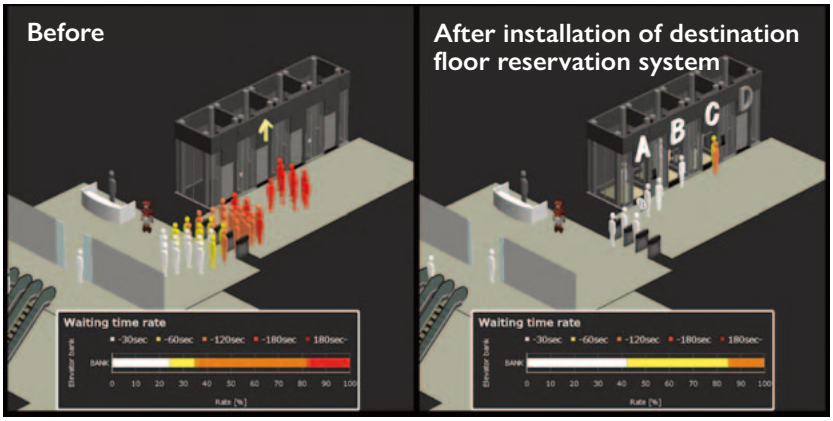
4 SEA model of railway car that utilizes a detailed FEM model of substructures

5 Simulation of People Flow that Includes Elevators to Enable Trouble-free Access Inside Buildings

Hitachi has developed a technique for simulating people flow to assist with elevator installation planning. The technique models building facilities such as elevators and security gates to predict the movement of people who use these facilities from the building entrance until reaching their office desk. The results can be presented as an intuitive and easy-to-understand three-dimensional animation.

The figure shows results from an example application of the technique in which it was used to compare conventional elevators with elevators that are equipped with a destination floor reservation system. Whereas delays occurred at the security gate for the conventional elevators, this was avoided when the destination floor reservation system was introduced as people were sent in different directions after passing through the gate depending on their intended floor.

This use of people flow simulation provides a way to show the consequences of changes to building facilities or layouts and helps with the design of suitable building facilities, making it easier to communicate the issues across different interested parties at the design stage.



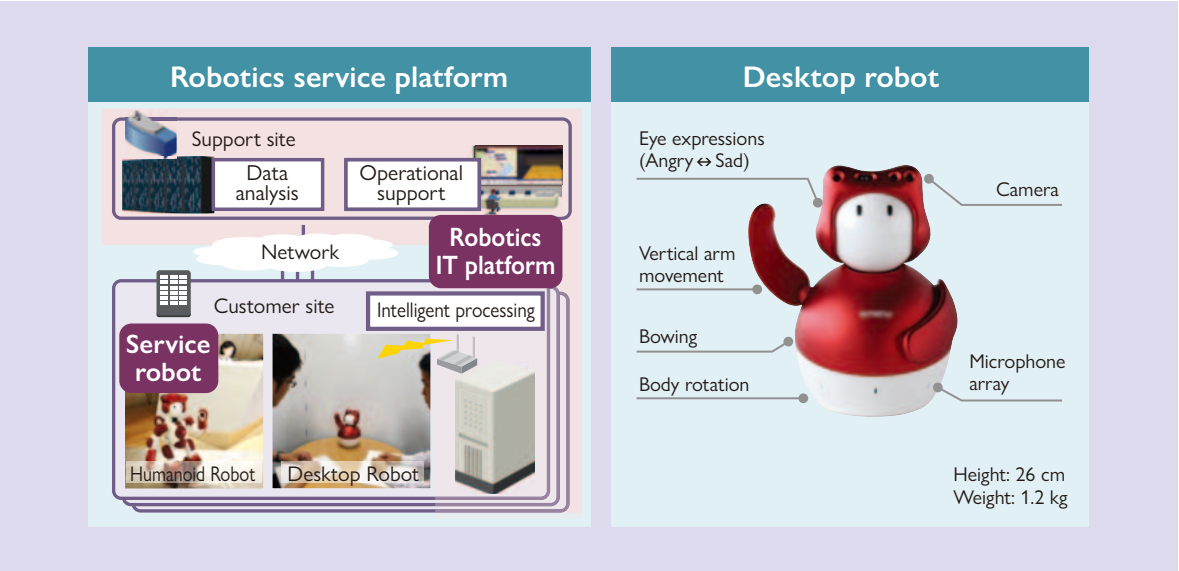
5 Assessment of benefits of installing destination floor reservation system

6 Robotics Service Platform

Hope is being placed on the creation of a super smart society that utilizes robotics and artificial intelligence (AI) as a way to resolve the societal issues raised by things like the aging population and low birth rate. In response, Hitachi is engaging in collaborative creation with customers to create new service businesses that make use of robotics.

Trials are being conducted in preparation for the commercialization of Hitachi's humanoid robot and robotics IT platform developed in 2016, with work also proceeding on functional improvements. Hitachi is also engaging in new robot development that connects to the robotics IT platform to expand the range of services to be offered. One such is the development of the desktop robot for use on counters or meeting room tables, for example. The robot is intended to be low-cost, being designed specifically for desktop communications without any traveling functions. Development efficiency was also improved by having it operate on the same robotics service platform as the humanoid robot.

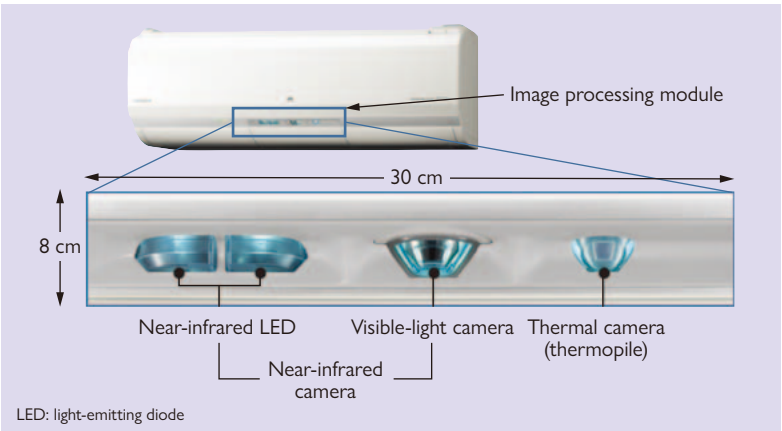
Along with the creation and expansion of robotics service businesses in parallel with further trials, future plans also include the creation of new digital solutions that use data collected by robots.



6 Robotics service platform and desktop robot

7 Image Processing Module for Home Air Conditioner

Hitachi has developed an image processing module for combining comfort and energy efficiency in home air conditioners. It provides an individual recognition function that uses a camera to detect each person in the room and determine how long they remain there. By using this length-of-stay information to predict changes in how hot or cold each person is feeling, the module can maintain comfort by making changes to the air flow before the person begins to feel uncomfortable. It is also equipped with a thermal



7 Image processing module for home air conditioner

camera to obtain the temperature distribution of the room and near-infrared light-emitting diode (LED) technology, contributing to the energy-efficient operation of the home air conditioner by using these to determine the conditions in the room, such as the location and shape of furniture and the temperature of the ceiling, walls, and windows, and then efficiently circulating cool or warm air.

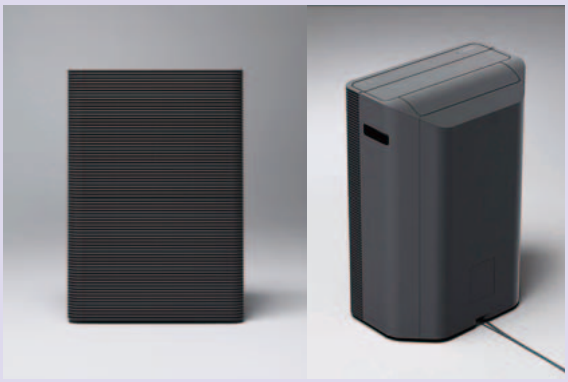
8 Design Enhancement for Home Appliances "Hitachi meets Design" Project

The Global Center for Social Innovation – Tokyo operated by Research & Development Group of Hitachi, Ltd. is engaged in a design innovation project with Hitachi Appliances, Inc. called "Hitachi meets Design" that is linked to the "design value creation" statement put out by Hitachi Appliances in February 2018. To achieve a new level of design quality that is highly competitive in the market and in tune with upcoming social trends, the project is undertaking pre-emptive developments and has formulated a design philosophy of "Less but Seductive: objects that appear restrained at first glance and yet exert a fascination on people." The intention is to incorporate designs that embody this concept into products progressively.

Along with in-house improvements to enable the company on its own to achieve a level of design quality that is significantly higher than what has gone before, it is also working with well-known designers from outside Hitachi who are in sympathy with this philosophy and developing special models that bear their names. The first project to be undertaken as part of this collaboration involves the launch in February 2019 of an air purifier by the world-renowned designer, Naoto Fukasawa, that is intended for the global market. This will be followed by a collaboration with a notable European designer.

Hitachi intends to refresh its home appliance designs by pursuing innovation, targeting designs that put users in mind of their beauty as well as their ease of use each time the product is encountered, and that will remain in use for many years as a familiar and much appreciated part of their daily lives.

This top loading washing machine for the Asian market was the first product to emerge from in-house design improvement work. It has its controls on top of the glass lid and incorporates numerous features for ease-of-use, with operation designed to suit laundry practices in the target market.



This air purifier designed by Naoto Fukasawa for the global market was the first of the collaborations with designers from outside Hitachi. It features clean lines, with the front panel being made up entirely of air intake louvers, and can be mounted in the corner of the room to help achieve better air circulation.

8 Top loading washing machine for Asian market that is the first product to emerge from in-house design improvement work (top), and an air purifier for the global market that is the first of the collaborations with designers from outside Hitachi (bottom)