

Automotive Systems

1 ECUs for Autonomous Driving

Hitachi Automotive Systems, Ltd. has commercialized stereo cameras for use in Subaru Corporation's EyeSight* and electronic control units (ECUs) for advanced driver assistance systems (ADASs) such as ProPILOT*, an autonomous driving technology designed for highway use in single-lane traffic that is installed on the Nissan Serena* made by Nissan Motor Co., Ltd. The company is also working on developments aimed at autonomous driving, which is expected to be a key technology for future public mobility.

As ECUs for autonomous driving require a higher level of processing performance together with the ability to support advanced security and ever larger and more complex software, developments by Hitachi Automotive Systems

include the use of field-programmable gate arrays (FPGAs), software platforms with excellent portability and scalability that support application plug-in, and over-the-air (OTA) techniques for the wireless updating of software.

With the aim of becoming a system supplier for autonomous driving systems, Hitachi is also developing a wide variety of other ECUs required for vehicles capable of advanced autonomous driving, including gateway units that manage onboard and external communications and security, telematics control units for external communications, and high-definition map units. (Hitachi Automotive Systems, Ltd.)

* See "Trademarks" on page 148.

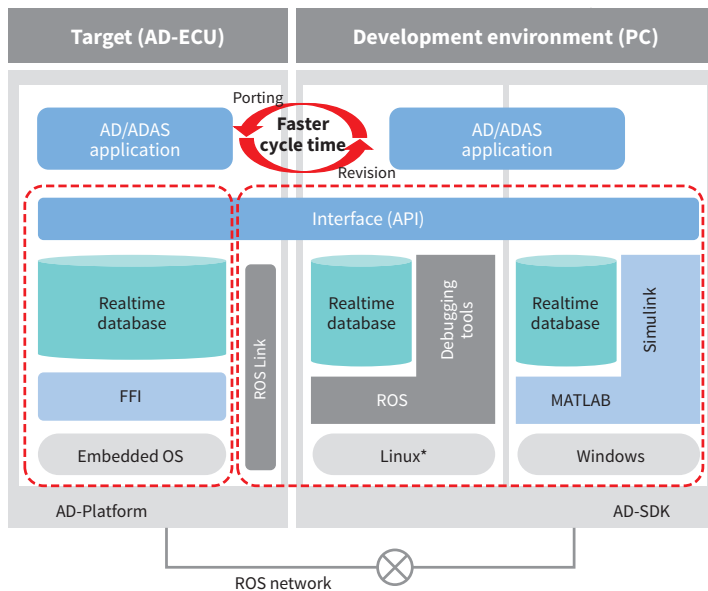
2 Platform for Autonomous Driving ECUs

As autonomous driving systems become more advanced, the rapid increase in development workload due to the increasing size and complexity of autonomous driving applications is posing a challenge. Accordingly, in partnership with Hitachi Solutions, Ltd., Hitachi Automotive Systems has developed an ECU platform for autonomous driving that improves the efficiency of application development.

A feature of the platform is that it includes a real-time database that provides centralized management of data from exterior sensors, maps, and other sources and can store or retrieve data at speeds in the order of 10 μ s, and an application programming interface (API) that applications can use to access these data. It also provides a dedicated software development kit (SDK) with development environments for a robot operating system (ROS) accessed via this API, and for model-based development using



1 ECU for level 3 autonomous driving (top) and security gateway ECU (bottom)



AD: autonomous driving OS: operating system FFI: freedom from interference
 * See "Trademarks" on page 148.

2 Overview of platform for autonomous driving ECUs

MATLAB^{*} and Simulink^{*}. Performing development using the same API as the platform facilitates the porting of applications to ECUs and as a result, increases development efficiency. (Hitachi Automotive Systems, Ltd.)

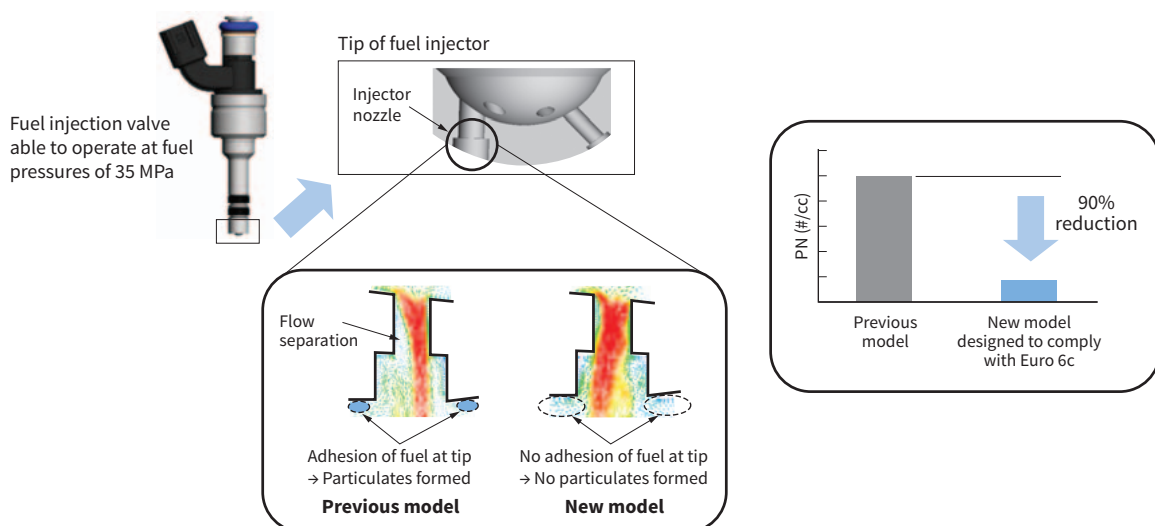
* See "Trademarks" on page 148.

3 Clean Exhaust Technology for Direct-injection Gasoline Engines

The downsizing of turbocharged direct-injection gasoline engines is being adopted as a way to protect the environment and reduce carbon

dioxide (CO₂) emissions. In response to the need for lower particle number (PN) levels in the emissions from direct-injection gasoline engines, as stipulated in regulations such as Euro 6c, Hitachi Automotive Systems has developed a fuel injector that can satisfy strict regulations.

Past research has indicated that a high PN is caused by the adhesion of fuel in the vicinity of the injector holes. Furthermore, simulation of the flow through the fuel injector valve indicates that separation of fuel flow in the injector nozzle extends as far as the nozzle outlet, disrupting the flow and dispersing the fuel. This leads to adhesion around the injector nozzle.



3 Simulation of fuel flow in injector nozzle

Accordingly, Hitachi Automotive Systems has succeeded in limiting fuel adhesion by using simulation to determine a fuel flow path design that minimizes flow separation. Engine testing has demonstrated that this significantly reduces PN compared to previous models. Other features of the new fuel injector are an ability to inject fuel at high pressure (35 MPa) and that it is not prone to increases in PN due to changes over time. By supplying this technology to vehicle manufacturers around the world, Hitachi Automotive Systems intends to help protect the environment by making gasoline engine emissions cleaner.

(Hitachi Automotive Systems, Ltd.)

4 Autonomous Driving Simulator

As autonomous driving systems become increasingly complex in the future, their safety testing will need a very large number of test cases. It is recognized that there is a limit to verifying these systems using actual vehicles as the primary means of safety testing. Hitachi Automotive Systems has developed technology for autonomous driving simulators that perform safety testing by operating the autonomous driving systems in a virtual computer space. The system is based on commercial software.

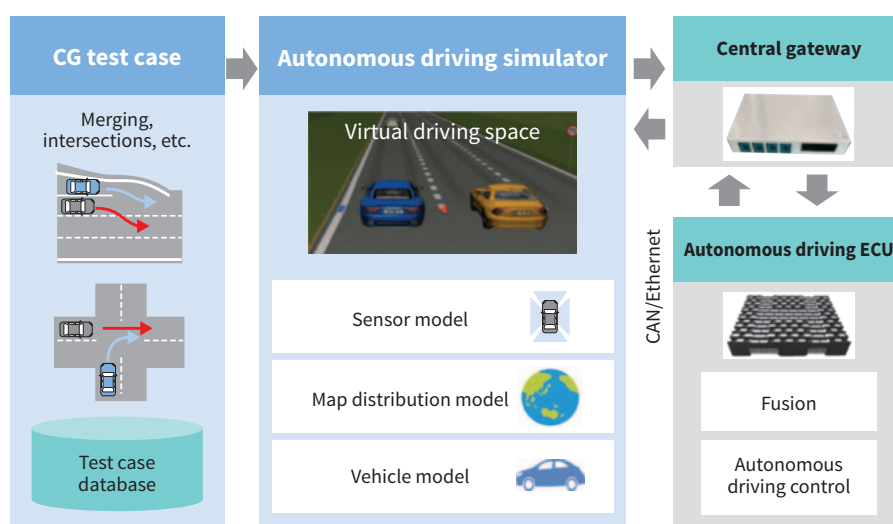
An autonomous driving simulator drives a virtual vehicle along a virtual test track in a

computer and sends the sensor data to an autonomous driving ECU. The autonomous driving ECU uses this data as a basis for recognition and judgement, then sends back the vehicle control signals to the autonomous driving simulator to simulate the resulting vehicle behavior. This enables dangerous test cases as well as the rapid development and quality improvement of autonomous driving systems. Along with supplying products such as the autonomous driving ECU and sensors, Hitachi Group also intends to provide evaluation testing environments that support the development of autonomous driving systems.

(Hitachi Automotive Systems, Ltd.)

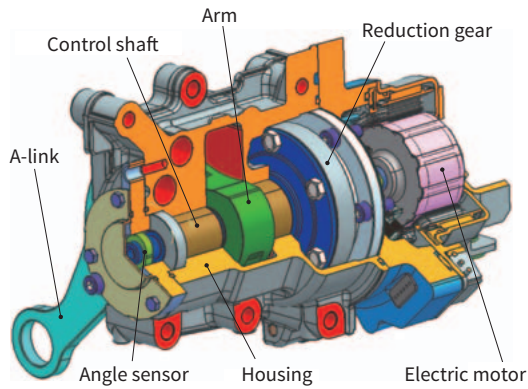
5 Continuously Variable Engine Compression Ratio System

Although higher compression ratios are one way to improve engine efficiency, they also result in knocking under sudden acceleration or on steep inclines. On the other hand, high torque can be delivered while minimizing knocking by reducing the compression ratio and using a turbocharger, but this has the downside of lower fuel economy. One way to deal with this conflict is to adopt a variable compression ratio (VCR) by shifting the top of the piston stroke (top dead center) to vary the volume ratio. Whereas the pistons in a conventional engine are connected to the crankshaft by conrods, VCR works by



CG: computer graphics CAN: controller area network

4 Block diagram of autonomous driving simulator



5 Cross-section of VCR actuator

fitting a link (called an “A-link”) where the control rod joins to the crankshaft that can be moved by an actuator, thereby providing a continuously variable top dead center. Hitachi Automotive Systems has developed and taken responsibility for manufacturing a VCR actuator made up of an electric motor and reduction gear.

As use of VCR makes it possible to achieve both the fuel economy of a naturally aspirated engine and the output of a turbocharged engine, the technique is extremely useful when turbocharging is used to downsize engines for higher efficiency. The company aims to have the technology adopted more widely in the future. (Hitachi Automotive Systems, Ltd.)

6 Semi-active Suspension with Internal Solenoid Valve

Hitachi Automotive Systems commenced the mass production of semi-active dampers in

2011, since then price competition has become more intense, in part due to their wider adoption on small vehicles. In response, with the aim of increasing sales and market share, the company has developed a second generation of solenoids intended to reduce the cost and boost the performance of the proportional solenoids used for control valves.

The main features are as follows.

- (1) Lower material costs and easier assembling achieved by adopting a solenoid design that uses stainless steel cylinders.
- (2) Lower cost and higher performance of 10% increased driving force achieved through use of magnetic field analysis to predict driving force.
- (3) Construction of a process-closed-line using robots to eliminate labor required for preparation of material parts and assembly.

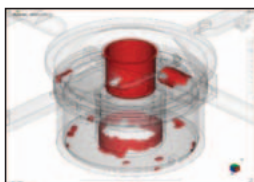
As well as succeeding at retaining customer orders through lower costs, in terms of manufacturing, the development also resulted in the construction of a production line that is not dependent on people and is capable of capacity expansion.

The development of second-generation solenoids and the establishment of new globally standardized processes with a higher level of quality assurance will be key selling points for future sales growth, with potential for the technology to be utilized in built-in solenoids for which there is growing demand.

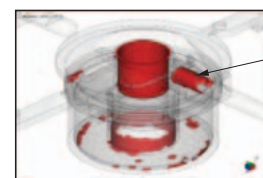
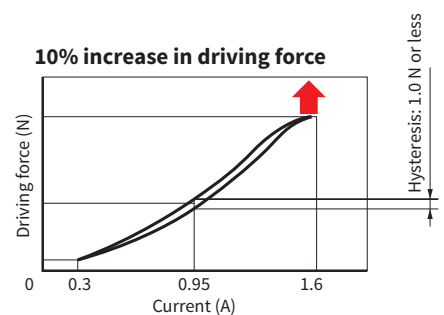
(Hitachi Automotive Systems, Ltd.)



Optimization of size and driving force using magnetic field analysis and hydraulic simulation

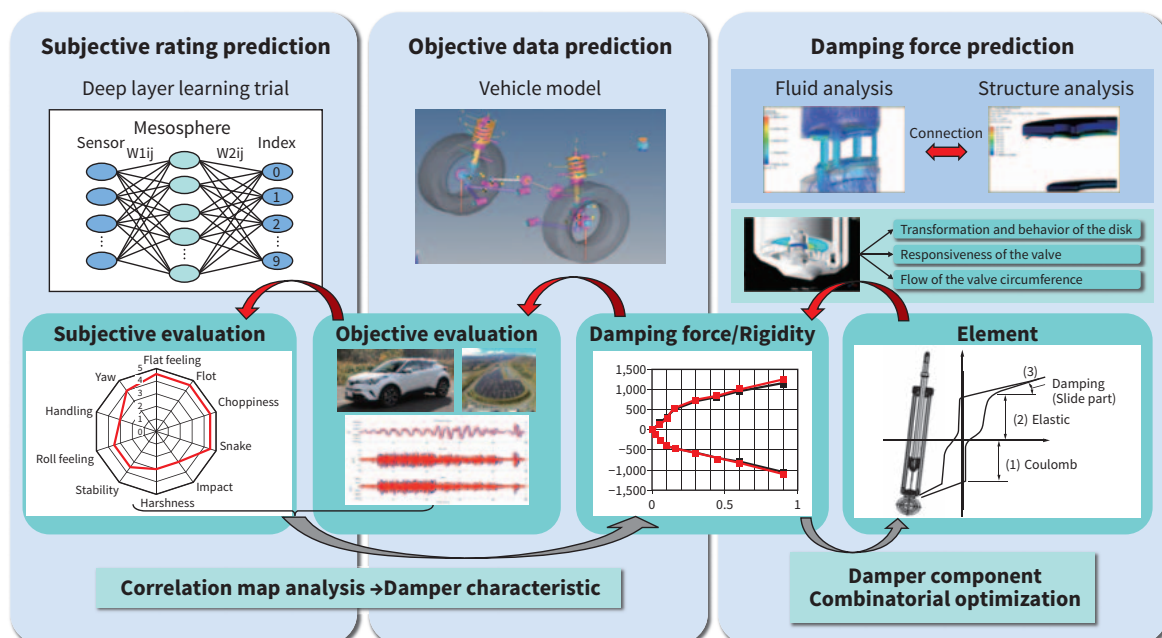


Mold coil seal design using plastic forming analysis



Shown with harness jacket welded in place

6 Use of analysis for optimized design and mold coil seal design



7 Damper development technology that achieves analysis-based evaluation of ride comfort

7 Analysis-based Damper Development

Dampers contribute to ride comfort and handling, being attached between the vehicle body and wheels where they are used for damping body and wheel motion. Dampers with a good feel ensure that the vehicle reliably behaves as the driver intends, provide a supple response to road inputs, and improve passenger comfort.

Small deviations in the components of a damper have a large effect on the vehicle's ride comfort. However, because the assessment of ride comfort depends to a large extent on subjective driver impressions, the practical improvements to ride comfort have involved the ongoing improvement and alignment of the individual components based on subjective evaluations.

With the aim of adopting analysis-based ride comfort improvements, Hitachi Automotive Systems is working on developing a set of techniques that cover the prediction of subjective evaluations, vehicle behavior, and damping force. The establishment of these prediction techniques has expanded the scope of performance evaluation by simulation, and succeeded in improving performance and in reducing the number of prototype manufacturing and testing iterations by estimating both vehicle behavior based on the requirements from subjective

evaluations and the damping characteristics and component parts needed to achieve this. (Hitachi Automotive Systems, Ltd.)

8 Mass production of Lithium-ion Battery for Hybrid Vehicles and Expansion to Range of Vehicle Models that Use the Battery

Hitachi Automotive Systems has developed a small and lightweight lithium-ion battery module with high reliability and had it adopted by a wider range of vehicle models.

By using cylindrical battery cells with high performance and reliability that have been developed through past applications and combining these cells with the circuit board used to detect battery cell voltage in a single plastic



8 Lithium-ion battery module

housing, the new battery module has been made approximately 35% lighter and 37% shorter in height than the previous model. With Hitachi's past experience and the ease of installation made possible by the lighter weight and smaller size being highly regarded by customers, the range of vehicle models that use the modules has progressively expanded to include the Solio* and Swift* models from Suzuki Motor Corporation.

In the future, Hitachi intends to continue contributing to advances in electric vehicles by strengthening its range of lithium-ion batteries and other electric power train products.

(Hitachi Automotive Systems, Ltd., Hitachi Vehicle Energy, Ltd.)

* See "Trademarks" on page 148.

9 NXV977D, Next-generation IVI Platform

The NXV977D is a navigation system that uses a new software platform and was developed to be the base model for Clarion Co., Ltd.'s planned integrated HMIs.

There are few functional differences between the commercially available navigation systems from different vendors, and the trend in recent years has been toward high-resolution audio and large screens with high image quality.

Along with existing models that offer fully digital reproduction of high-resolution audio, Clarion has equipped the NXV977D with a

24-bit/1.677-million-color full-color display that delivers richer video images on its large 9-inch high-definition (HD) liquid crystal display (LCD) screen.

Clarion has also developed a proprietary graphics engine to enhance human-machine interface (HMI) functions. While existing HMIs consolidate a wide variety of display and operation on the same screen, quad view (which splits the screen into four regions) provides not only a 7-inch display area as on previous models but also splits the remaining screen area into three regions, giving users a choice of whether to display navigation, audio, tools, and smart-phone integration functions on the main screen (offering a total of nine screen combinations).

This software platform can also provide a similar HMI on the physically separate screens inside the vehicle [meters, head-up display (HUD), rear-view monitor, and so on]. (The platform uses Linux 3.10 and has received GENIVI* certification.)

The adoption of proprietary development templates and frameworks has reduced the amount of work required for module development, and the NXV977D has improved software reusability to facilitate the addition of new functions. It has already been used for a variety of proof of concept (PoC) developments. (Clarion Co., Ltd.)

* See "Trademarks" on page 148.



9 Quad view with capability for displaying a variety of functions and information on the same screen