Development of Technology for Safe Goods Distribution for Use in Small Package Delivery

Along with greater corporate social responsibility in recent years, the logistics industry is being called to adopt more sophisticated ways of making driving safer by using information from vehicles on the road. To achieve this, Hitachi is developing various smart mobility services tailored to the needs of logistics operators by combining information from various sources, including from onboard devices and information about drivers, and using it for analysis and diagnosis. Clarion Co., Ltd., meanwhile, is developing advanced onboard devices to satisfy particular requirements, using over-the-air updating techniques jointly developed with Hitachi. This article describes work on developing technology for goods distribution that supports both safe driving and improvements to service levels in the logistics industry.

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1. Introduction

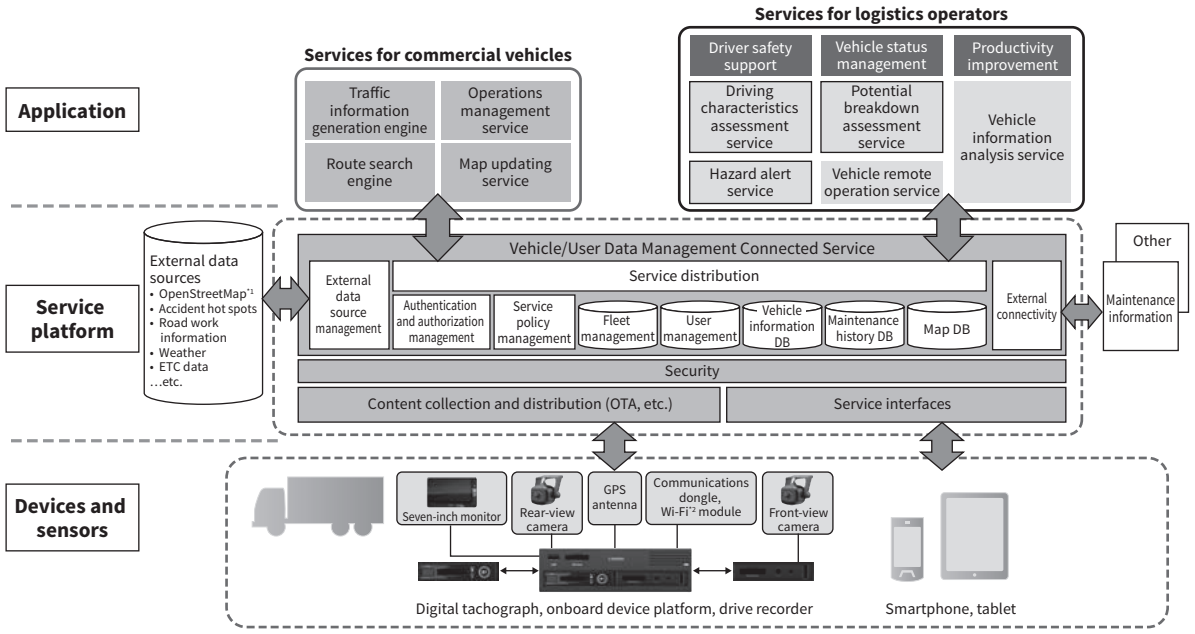
It is anticipated that the logistics industry will experience an increase in the volume of deliveries to ordinary consumers as a result of the growth in the electronic commerce (e-commerce) market (from 12 trillion yen in FY2015 to 20 trillion yen in FY2019[(1)]) and increased consumption, imports, and exports due to the tariff liberalization included in the Trans-Pacific Partnership (TPP). Moreover, with consumer needs becoming more diverse and some e-commerce businesses seeing delivery services as a way to differentiate themselves from competitors, the service levels expected from logistics operators are also rising even higher, including agreed-time deliveries, immediate deliveries, and frequent deliveries of small quantities of goods.

Within the industry itself, meanwhile, there is a shortage of drivers due to the aging population and low birthrate. The government response to this has included the introduction of a new "semi-medium vehicle license" for drivers 18 years and older that permits them to drive vehicles of between 3.5 t and 7.5 t. Along with recruiting the number of drivers needed to achieve the level of service expected of them, logistics operators are also taking steps to prevent accidents caused by inexperienced drivers.

It is in this social environment that Hitachi has launched smart mobility services that support these initiatives by utilizing big data obtained from vehicle

Figure 1 — Overview of Smart Mobility Services

The diagram shows an overview of services for use by various types of business operators that collect data acquired from onboard devices and other smart devices.



ETC: electronic toll collection system OTA: over the air DB: database GPS: global positioning system

*1 OpenStreetMap is a registered trademark of the OpenStreetMap Foundation.

*2 Wi-Fi is a registered trademark of the Wi-Fi Alliance.

operations. This article describes work Hitachi is doing on services for vehicles that help make driving safer, and on onboard devices that feature the flexibility to add functions as needed.

2. Smart Mobility Services

To help drivers to drive safely, Hitachi provides smart mobility services that collect vehicle information (including vehicle speed, distance traveled, acceleration, location, and video) and driver information (including driving time, work performance, and near-miss accidents) from sensors located in onboard devices or smartphones, and then combine this information for analysis and diagnostics. The services include issuing an audible warning to drivers when approaching a dangerous location, and assessing and advising drivers on accident risk based on their driving performance. Hitachi also provides services to meet the needs of commercial vehicles and logistics operators (including route search, fleet management, and map updating) (see **Figure 1**).

2. 1
Services for Commercial Vehicles

Businesses that operate commercial vehicles such as buses, taxis, or trucks need navigation systems that incorporate a higher level of traffic information than those supplied to the general public.

Hitachi provides a service for sending information to vehicles, including map content and congestion updates, that is generated based on things like changes in location data collected in real time, information posted on social networking services (SNSs), and video collected by drive recorders.

2. 2
Services for Logistics Operators

Businesses that use delivery trucks typically have many vehicles and many drivers and require ways of improving service levels and preventing accidents.

The following are typical examples of such services provided by Hitachi.

(1) Hazard alert service

This service displays the location of driving hazards on a map, shares this information between drivers,

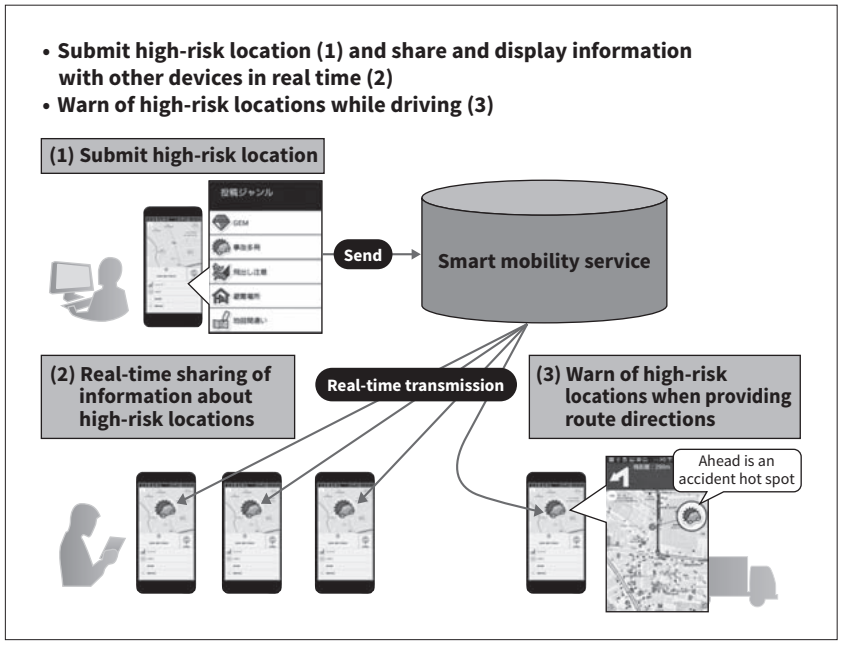


Figure 2 — Flowchart for Hazard Alerts
The system works by sharing information on map locations identified as being high-risk via the service and using it to issue alerts.

and issues an audible alert from the onboard device to warn the driver. Drivers can also mark the map with the location of places where they know they may need to brake suddenly or where there is some other form of accident hot spot, and receive a verbal warning when the vehicle approaches one of these locations.

To provide these warnings to the driver at an appropriate timing, it is necessary to manage information about the location, which in the past would have been represented simply using coordinates, by linking it to an accurate position on the map. This is done using the highly accurate vehicle positioning techniques that Clarion already incorporates into the car navigation systems it supplies to vehicle manufacturers.

It is also possible to set thresholds for various sensors such that, when the conditions are satisfied, information about the hazard and its location is sent from the onboard device to the service to automatically record the location and type of event on the map (such as locations where the vehicle needs to suddenly slow down or stop). The recorded information is shared via the map so that other drivers can see it in real time (see **Figure 2**).

(2) Driving characteristics assessment service

This service provides assessments and advice by applying support vector machine (SVM)[*1] learning to large amounts of driving information from drivers who have experienced accidents to identify driving behaviors that correlate with a history of accidents.

Accidents can be prevented by identifying drivers with a high probability of causing an accident and providing tailored driving guidance. Compared to past methods that did not use records of past accidents (instead using their own thresholds such as the number of times the driver accelerated rapidly), the use of machine learning enables accurate assessments of driving characteristics (see **Figure 3**).

(3) Potential breakdown assessment service (yet to be deployed)

Hitachi has plans to deploy a potential breakdown assessment service for highlighting vehicle breakdown risks based on machine learning techniques from Hitachi's Research & Development Group and data from customers on vehicles and their maintenance histories.

The service can predict the failure of car parts with high accuracy by using machine learning techniques that have been developed for fault diagnosis in industrial equipment, namely vector quantization clustering (VQC)[*2], SVM, and dynamic Bayesian networks (DBN)[*3].

Vehicle breakdowns are a critical problem for delivery operators, with major operators handling vehicle maintenance for themselves. Performing maintenance

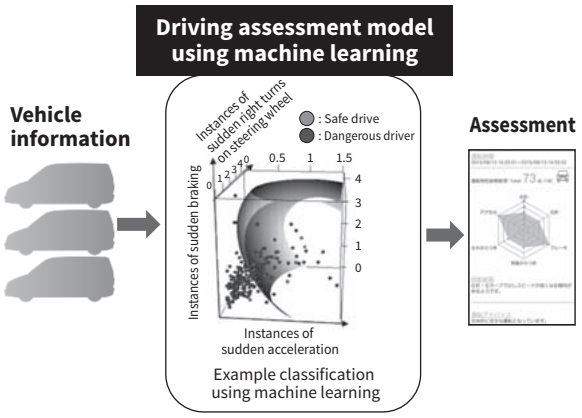
*1 SVM: A technique for classifying operational data using a model that has undergone supervised learning with data for normal and abnormal conditions.
*2 VQC: A technique for rapidly assessing operational data by comparing it against a model generated from data representing normal conditions.
*3 DBN: A technique for using conditional probabilities to infer the causes of abnormalities from operational data.

Figure 3 — Overview of Driving Characteristics Assessment

This service uses Hitachi's proprietary driving characteristics assessment engine and a technique for determining acceleration to assess a driver's risk of an accident.

Driving behaviors that correlate with a history of accidents

	Factor	Description
1	Sudden acceleration	Number of instances per hour of forward acceleration of more than 0.2 G
2	Sudden braking	Number of instances per hour of deceleration of more than 0.2 G
3	Sudden left turns at intersections	Number of instances per hour of lateral acceleration of more than 0.25 G (a left turn is identified as being a change in orientation by −30° or more)
4	Sudden right turns at intersections	Number of instances per hour of lateral acceleration of more than 0.25 G (a right turn is identified as being a change in orientation by +30° or more)
5	Erratic driving in direction of travel	Standard deviation of acceleration or deceleration in each 30-s interval
6	Erratic driving in lateral direction	Standard deviation of lateral acceleration in each 30-s interval



before a breakdown occurs can boost utilization and reduce operating costs (see **Figure 4**).

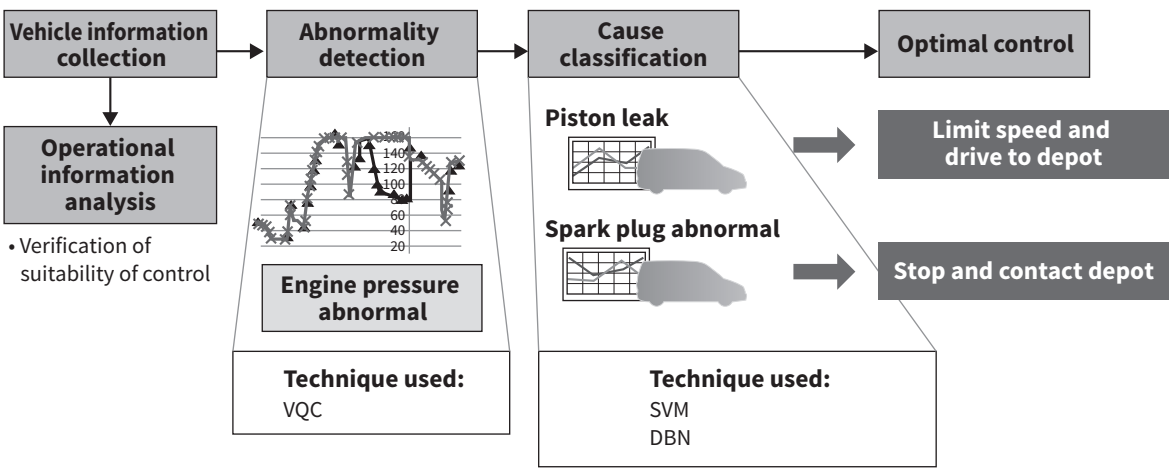
3. Onboard Device

The long operating life of commercial vehicles, typically ten years or more, means that they need to be able to adapt to changing business requirements. In the past, when vehicles were retrofitted with cameras or other hardware, or needed software updates, performing the upgrade required removing the onboard device from each vehicle.

Clarion's onboard device uses an over-the-air (OTA) function (for updating programs via the mobile communications network) developed jointly with Hitachi to enable applications to be added or upgraded as needed after installation in the vehicle. The adoption of an open source operating system (OS) that is widely used on smart devices also facilitates the development of applications for functional upgrades without being locked into a specific vendor. It also

Figure 4 — Proprietary Algorithm Used in Potential Breakdown Assessment for Identifying Abnormalities

By using machine learning to predict faults, the algorithm can detect problems that previous methods based on thresholds would fail to identify.



VQC: vector quantization clustering SVM: support vector machine DBN: dynamic Bayesian network

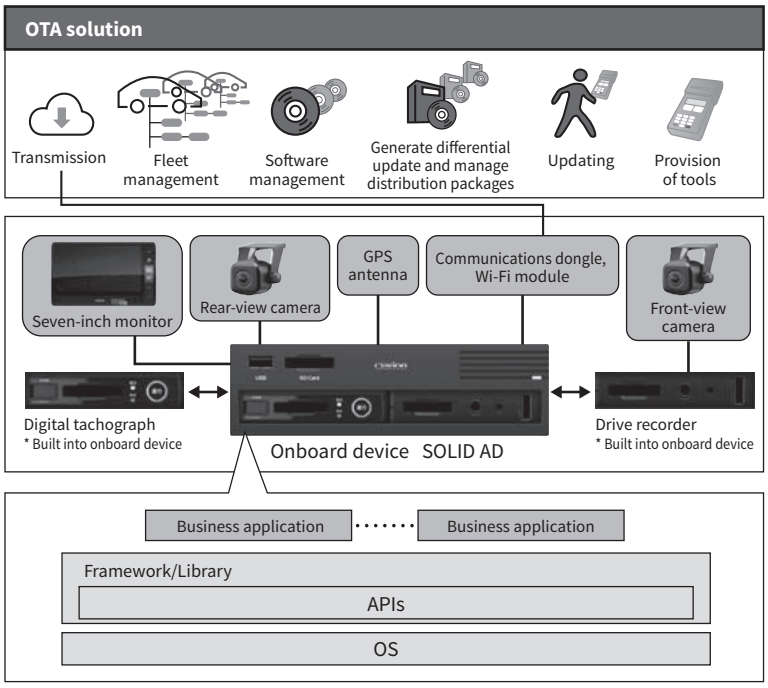


Figure 5 — Overview of OTA Solution for Onboard Devices

The diagram shows how the logical configuration and OTA updating of software is performed for onboard devices.

allows those functions that can run standalone on a smart device to be used on vehicles that lack an onboard device.

3. 1
OTA Installation and Updating of Software

The onboard device developed by Clarion uses a highly reliable remote updating technique developed for upgrading vehicle control software to install or update the OS or application software via the mobile network. This means that software of various types can be installed or updated as required after the onboard device has been fitted, including the installation of OS security patches, driver software for retrofitted hardware, and functional upgrades or operation enhancements for business applications (see **Figure 5**). Moreover, the use of a backup data area for software updates ensures that software installation and updating can be completed safely and reliably, even under the unique conditions that occur in vehicles, such as power supply fluctuations when starting the engine.

3. 2
Application Development

The onboard device is based on open source technology, using an application platform that is in widespread use. A development kit is available for those customers who need to build their own applications. This provides an environment in which applications for the onboard device can be implemented using an application programming interface (API).

4. Providing Value to Staff, Business Operators, and Society

Figure 6 shows the value that using these smart mobility services provides to driving staff, business operators, and those aspects of society that relate to motor vehicles.

For drivers, the services can operate directly to prevent accidents while also providing indirect support for safe driving by suggesting efficient delivery routes, thereby allowing them to feel more relaxed about delivery times.

For business operators, the ability to install and update the onboard device software as needed means that they will be able to add functions in a timely manner to keep up with requirements that change over time. They can also look forward to putting the information collected about vehicles and drivers in the cloud to use in new businesses.

For society, Hitachi believes that, in addition to fulfilling a social responsibility for devising safety

Value for drivers	Value for business operators	Value for society
• Use hazard alerts to eliminate accidents • Reduce driver impatience by providing more efficient delivery routes • Help new drivers by providing directions and maps	• Install or update functions on onboard devices as needed using OTA updating • Identify potential vehicle breakdowns so that maintenance can be performed • Develop new businesses based on the collection and use of information in the cloud	• Fulfill social responsibilities by devising advanced safety measures • Help with driver shortages by supporting their driving • Reduce environmental load by assessing driver performance to encourage economical driving

Figure 6 — Providing Value to Staff, Business Operators, and Society

Use of the smart mobility services provides value to drivers, business operators, and society.

measures, the services can also provide value in forms that include responding to driver shortages and helping protect the environment by assessing how economically vehicles are being driven.

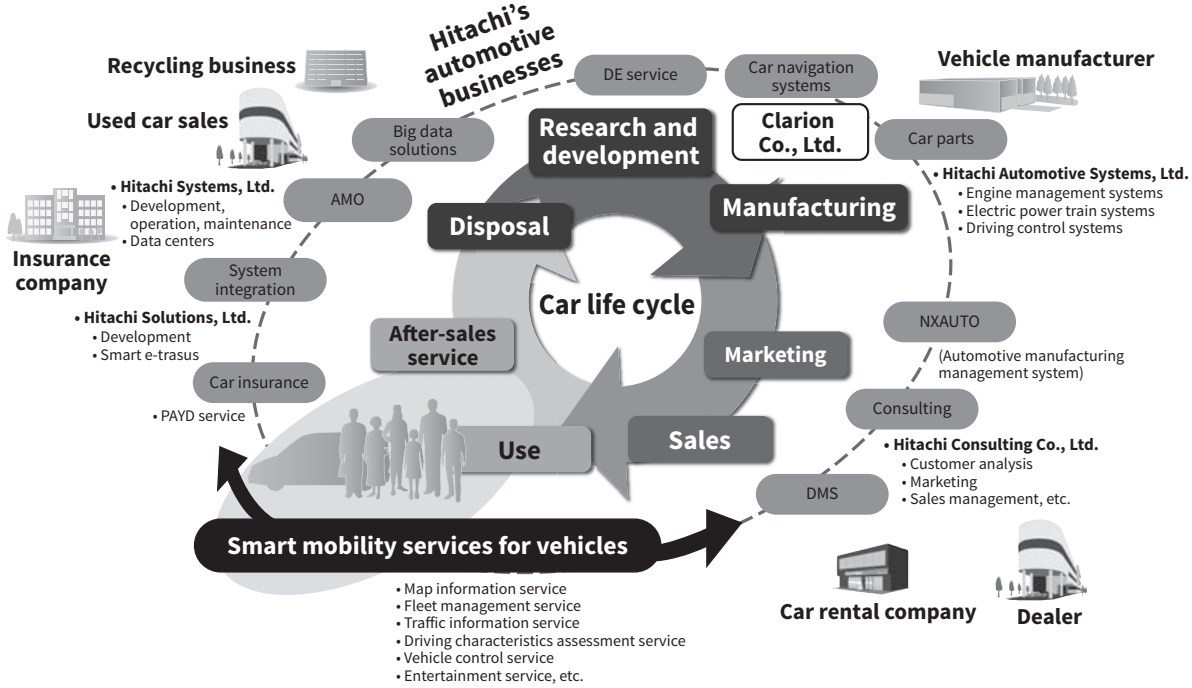
5. Conclusions

As of 2016, there were approximately 78 million vehicles in use in Japan[2]. There is also a plan to implement close-following driver-less vehicle convoys on highways in 2020[3]. In the near future, when greater use will be made of the Internet of Things (IoT) and automated driving will become a reality, it is anticipated that techniques for the collection and analysis of big data acquired from vehicles as they drive will become even more important.

Hitachi expects to put the data collected by these smart mobility services to use, not just in these current services, but also in all aspects of the car life cycle where its businesses operate (see **Figure 7**). In a variety of areas that relate to motor vehicles, Hitachi intends

Figure 7 — Overview of Hitachi's Automotive Businesses

Hitachi provides services for various aspects of the car life cycle.



AMO: application management outsourcing PAYD: pay as you drive DE: digital engineering DMS: dealer management system

to develop its automotive businesses with high added value in the form of leading-edge services by combining its information technology (IT) and operational technology (OT) and by linking data together.

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