[iii] Connected Car Technologies and Services to Realize Comfortable Transportation Society

Connected Car Platform Supporting Mobility Operators in Shift to EVs

In pursuit of digital transformation and carbon neutrality, the shift to EVs is accelerating across various industrial sectors with aims that include generating value and enhancing the efficiency of mobility operations. This raises practical issues, such as how to use data to maintain free-flowing logistics and how to manage battery charging and range-constrained EVs. Hitachi Group supplies IoV platforms that provide a common foundation for addressing the challenges faced by mobility operators and is working to build an ecosystem and value chain through collaborative creation with customers and other partners. Through these initiatives, it intends to create new value that is safe and secure as well as carbon-free by promoting the use of data for digital transformation.

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1. Introduction

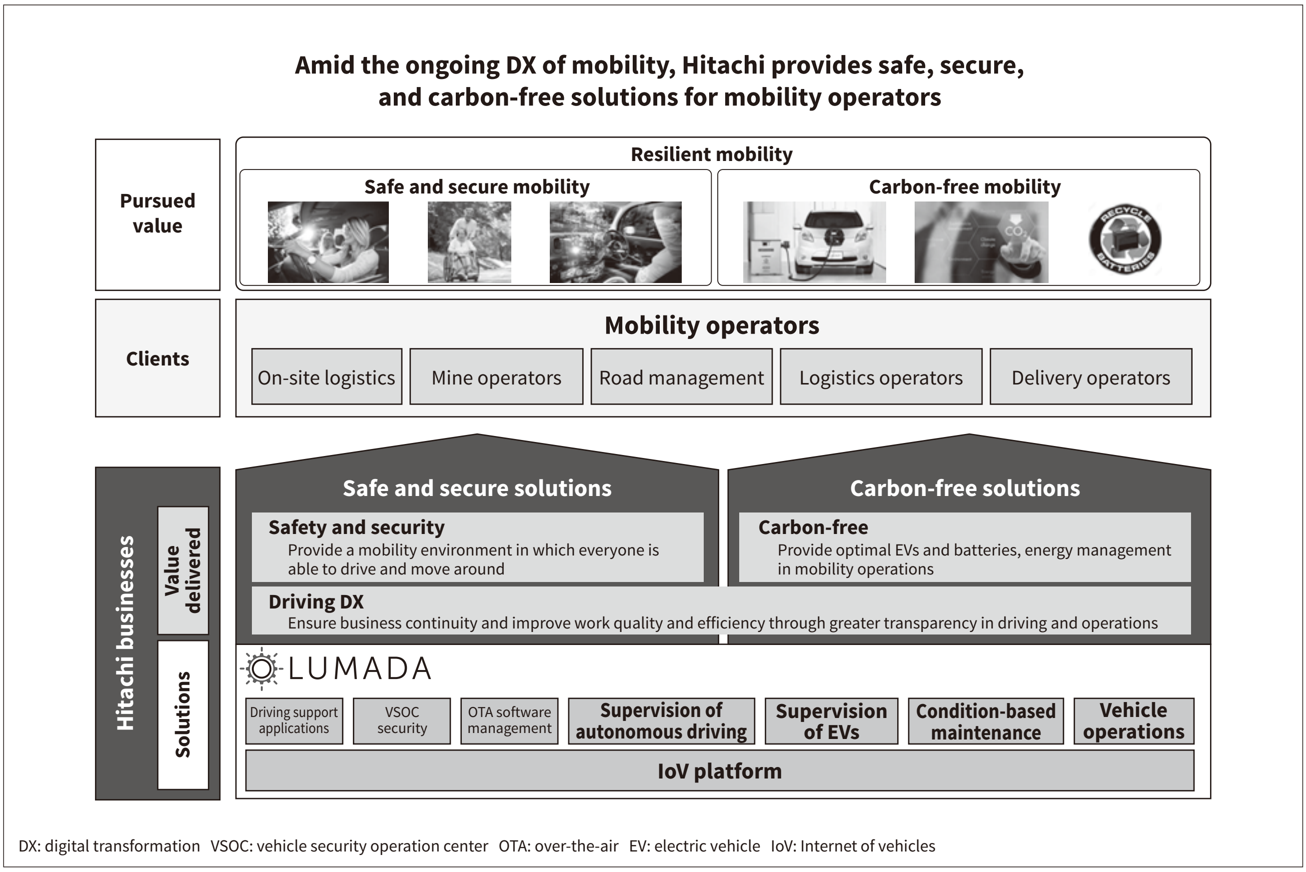
The world of mobility has been undergoing a major transformation over recent years, encompassing both technical and structural changes such as the spread of connected cars, advances in advanced driver assistance system (ADAS) and autonomous driving (AD) technology, and the wider adoption of electric vehicles (EVs). More recently, the transportation of goods by commercial vehicles for delivery and other purposes has been rising rapidly as a means of enabling contact-less sales to help prevent the spread of COVID-19[1].

Through collaborative creation with other business operators, Hitachi is seeking to launch new ventures in this period of mobility transformation by providing new solutions that offer safety and security and enable carbon-free operations. In this context, Hitachi defines "mobility operators" as businesses that either use commercial vehicles for logistics and delivery or operate them within defined areas such as waterfronts, industrial sites, or mines. This article describes new digital solutions that Hitachi has created for these mobility operators.

Two particular issues that Hitachi has identified as confronting mobility operators over recent years: (1) How to maintain safety and security, and (2) How to address environmental concerns (see **Figure 1**).

(1) To maintain safety and security, Hitachi Astemo, Ltd. supplies vehicle-based solutions for applications such as ADAS and AD[2]. Hitachi, Ltd., meanwhile, supplies solutions for mobility operators that provide safety and security through more efficient vehicle control and management, collecting digital data from vehicles by linking them to the cloud[3]. What is of particular value to mobility operators is the use of solutions in their own specific sphere of operations (such as large privately owned sites, ports, or industrial plants). This is because vehicle control and management become more efficient in such settings where regulations are more relaxed, and where they are able to install their own sensors around the site or on roads. Solutions like this that promote the use of data for digital transformation (DX) are described in chapter 2.

Figure 1 — Safe, Secure, and Carbon-free Solutions for Mobility Operators
Hitachi has consolidated its suite of Lumada-branded mobility solutions on an IoV platform and made it available to mobility operators to provide them with solutions for achieving safety and security as well as carbon-free operations.



(2) To address environmental concerns, Hitachi Astemo supplies electronic control units (ECUs) for EVs that help achieve carbon-free operations. Hitachi, Ltd., meanwhile, supplies services for mobility operators that promote carbon-free practices through the collection of digital data from commercial EVs linked to the cloud. Example services include data management to analyze and track degradation in lithium-ion battery performance and the cloud-based, real-time analysis and display of charging and discharging information. These solutions for mobility operators are described in more detail in chapter 3.

What both types of solutions have in common is that they deliver value to mobility operators through the collection and analysis of digital data from vehicles. Hitachi refers to these as Internet of vehicles (IoV) platforms, bundling solutions to deliver services that suit a wide range of scenarios. This IoV platform is described in more detail in chapter 4.

2. Promoting DX through Data Utilization

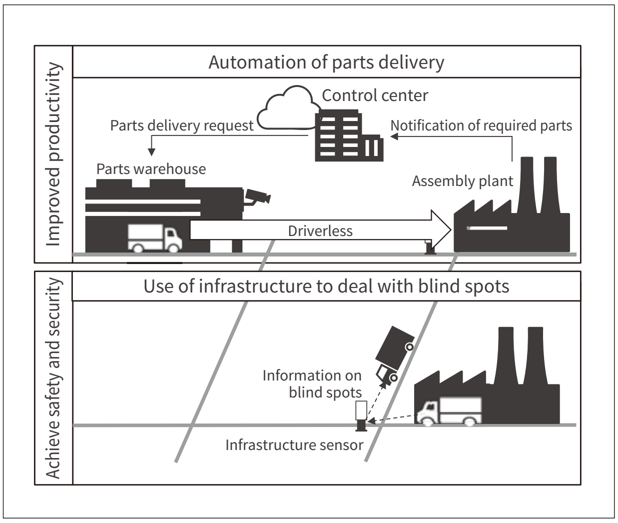
Work sites such as plants, ports, and road construction face problems with long driver waiting times, driver shortages[4], and the maintenance of safety and security. Practical attempts to address these problems include the artificial intelligence (AI) terminal[5] and i-Construction* [6] initiatives of Japan's Ministry of Land, Infrastructure, Transport and Tourism. Hitachi is achieving safety and security and improving the productivity of mobility operators that work in these areas by providing them with services based on the use of autonomous vehicles that are integrated into the infrastructure. These mobility operators are able to install their own sensors within their particular sphere of operations (private property such as plants, ports, at road construction sites, etc.). Compare with public roads, this allows them to set up their particular site in whatever way best suits their requirements and, by doing so, tailor their DX to their own circumstances.

Services that use autonomous vehicles are delivered through interoperation between various different components, namely the vehicles, control center, and infrastructure sensors. The control center uses location and status information collected from vehicles to calculate and track the route for each vehicle. Infrastructure sensors are fixed sensors such as light detection and ranging (LiDAR) that are installed on the roadside. They can improve vehicle safety by providing information about areas not visible to the driver

* i-Construction is a registered trademark of the Director-General of the National Institute for Land and Infrastructure Management, Ministry of Land, Infrastructure, Transport and Tourism in Japan.

Figure 2 — Value Delivered by Services for Operating Autonomous Vehicles at Industrial Sites

A service for operating autonomous vehicles at industrial sites can both improve productivity by automating the delivery of parts and maintain safety and security by utilizing the surrounding infrastructure in vehicle operation to make up for blind spots in their vision.



(vehicle blind spots). Similarly, information about obstacles collected by these infrastructure sensors can be used for route optimization by forwarding it to the control center so that the center's dynamic vehicle routing calculation can take account of any roads that are impassable. The updated routes are then distributed to the vehicles themselves. The IoV platform acts as a hub for collecting and distributing information from these various components and provides a way to achieve rapid service development and delivery when offering services tailored to specific worksites.

One example might be the use of trucks for transportation between a warehouse that stores parts and an assembly plant that assembles them into products. This involves assigning a driver, specifying which parts are needed at the assembly plant, obtaining the parts from the warehouse, and then transporting them to the plant. The autonomous vehicle service would automate the notification of which parts are required and the transportation of parts. When the control center receives information about which parts are needed at the assembly plant, it uses a driver-less autonomous vehicle to transport them from the warehouse to the plant. Data can also be used to optimize the timing of when a request for parts delivery is issued. Hitachi uses the automation of these processes to improve operators' productivity and uses autonomous driving that works with the surrounding infrastructure to provide safety and security along the delivery route (see **Figure 2**).

3. Solutions for Mobility Operators that Achieve Carbon-free Operation

Greater use is being made of commercial EVs to help achieve carbon-free operation. As commercial vehicles are used much more than passenger vehicles, the distance they can travel on a full battery charge decreases over time due to battery degradation. This means that batteries need to be closely managed to maintain vehicle utilization. Hitachi solutions for mobility operators[7] in the logistics and delivery businesses support the lifecycle management of their commercial EVs, delivering social, environmental, and economic value through a combination of: (1) lithium-ion battery lifecycle management (LiB-LCM), (2) condition-based maintenance (CBM), and (3) electric vehicle operation (EVO) management (see **Figure 3**).

(1) In the case of battery management, the aim is to reduce the load on the environment by using a rapid degradation assessment technique for lithium-ion batteries[8] to monitor battery state of health (SOH) on a daily basis and use this to determine how best to manage the customer's EV batteries. Achieving this requires integrated management of the EVs, batteries, and daily operations, including by specifying which batteries to use based on EV schedules and specifying how batteries are to be charged in a way that

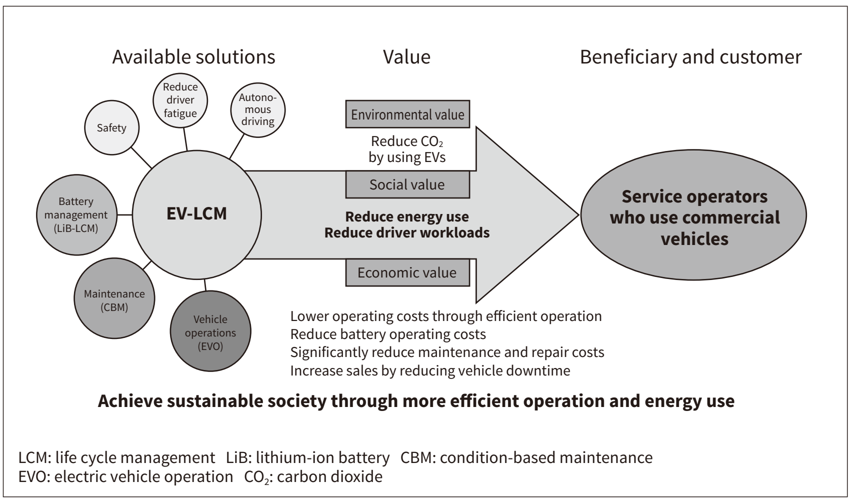
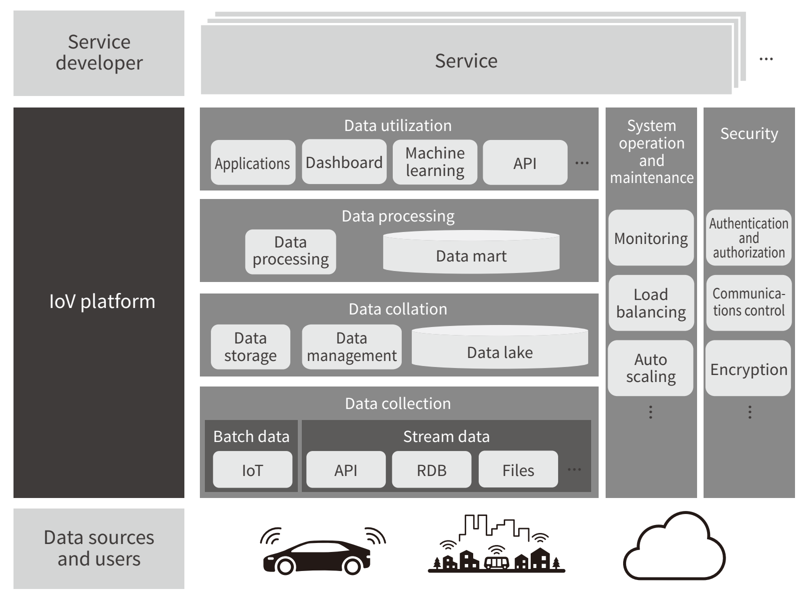


Figure 3 — Solutions for Mobility Operators

Hitachi solutions for mobility operators in the logistics and delivery businesses support the lifecycle management of their commercial EVs, delivering social, environmental, and economic value through a combination of: (1) LiB-LCM, (2) CBM, and (3) EVO.

Figure 4 — IoV Platform Functions

The IoV platform includes a suite of functions for the collection, collation, processing, and utilization of data together with common functions for system operation, maintenance, and security.



API: application programming interface IoT: Internet of Things RDB: relational database

minimizes degradation. To allow for interoperation with existing operational systems, the IoV platform includes support for a wide variety of diagnostic and control techniques.

(2) CBM aims to improve utilization by operating EVs in a highly efficient manner to reduce costs, cut maintenance overheads, and minimize vehicle downtime. This is done using machine learning, collecting EV data that can be used to identify potential faults on a daily basis to avoid loss of utilization due to unexpected faults putting EVs out of service. Depending on the severity and suddenness of the potential faults of interest, the EV data can be collected either in real time via a communication link or on a batch basis at the end of a day's work. The use of machine learning to warn of potential faults can reduce the risk of such unexpected faults by modelling normal conditions and then interpreting any deviation as indicating the presence of an abnormality. Achieving higher fault warning accuracy requires the selection of an appropriate machine learning model based on the EV year and model. The IoV platform supports this management of data and of machine learning models.

(3) The aim of EVO management is to reduce the risk of a flat battery and reduce charging costs by selecting vehicle routes that curtail the consumption of EV battery power. In some cases, an EV may consume less battery power by following a flat route rather than a shorter alternative that includes hilly terrain, as might be recommended by a car navigation system. EVO management can also prevent regenerative power from going to waste due to a full battery by recommending vehicle routes that take account of regeneration on downhill sections. On the other hand, treating the reduction of daily battery use as the sole criterion risks driver costs being higher if it results in the vehicle travelling longer distances. Rather, what is required are measures that extend average battery life over the long term through interoperation with operational systems to enable use of batteries with reduced charging rates.

Through this lifecycle management of EVs, the IoV platform supports the overall optimization of operations.

4. Definition and Role of the IoV Platform

Amid the transition from the previous hardware-centric approaches of the past to a service-centric model, mobility (the movement of people and goods) in the era of the connected car has over recent years come to be closely intertwined with a variety of other areas, including safety, the environment, logistics, and commerce(9). Supplying diverse services to these various different sectors will require the collection and use of a wide range of data, encompassing users, energy, and insurance as well as data on vehicles and traffic, and its transformation into value(10).

On the other hand, highly reliable and efficient system development is a challenge that needs to be overcome when providing connected car services that use data collected from these various different data sources. This is an area where arrangements with other market participants for the sharing and utilization of data have yet to be established. For example, data is collected from an extensive range of data sources that include onboard or externally attached vehicle sensors, infrastructure such as electronic toll collection (ETC) and EV chargers, and IT systems such as those for scheduling. Any personal information in the collected data must be protected and there is a need to support a wide variety of different forms of data, from kilobyte-order real-time data to gigabyte-order batch data. Moreover, services are provided to a range of different users, including vehicles, infrastructure, IT systems, and people(11). Service developers, for example, are always needing to consider whether their systems can adequately handle data of different types, such as the storage of probe data that is collected in large quantities and with high frequency or the high-speed processing of large amounts of camera data.

To facilitate the reliable and rapid development of a variety of different services, the IoV platform provides the core systems for collecting and utilizing data from various data sources. This includes a suite of functions for the collection, collation, processing, and use of data together with common functions for system operation, maintenance, and security (see **Figure 4**). The functions define system development tools and reference architectures for a variety of service formats based on knowledge acquired from connected car services supplied by Hitachi. For example, the service developer starts by selecting the service template, security rank, and other resources for the service it plans to build on the IoV platform. The next step is to consider how to implement the system with reference to the chosen architecture, and customizing the system development tool parameters to create a system that is appropriate for the intended service. By using the IoV platform as a means of ensuring best practice in the core systems for connected car services, this approach enables the rapid and highly reliable development of a variety of mobility services.

5. Conclusions

This article has explained how services for mobility operators are operated and has described an IoV platform that provides a common resource for overcoming the associated challenges. By using this IoV platform for collaborative creation with customers and other partners to establish an ecosystem and value chain, Hitachi intends to contribute to the creation of value through DX and the use of data.

References

1) Japan Institute of Logistics Systems, "Impact of the Spread of the Novel Coronavirus on Logistics and Supply Chains" (Jan. 2021) in Japanese, https://www1.logistics.or.jp/news/detail.html?itemid=400&dispmid=703
2) T. Shima et al., "Fundamental Technologies Driving the Evolution of Autonomous Driving," Hitachi Review, 65, pp. 426–432 (Nov. 2016).
3) K. Sakurai et al., "Connected Car Solutions Based on IoT," Hitachi Review, 67, pp. 72–78 (Jan. 2018).
4) Ministry of Land, Infrastructure, Transport and Tourism, "Comprehensive Physical Distribution Policy (FY2017–2020)" in Japanese, https://www.mlit.go.jp/seisakutokatsu/freight/seisakutokatsu_freight_tk1_000128.html
5) Ministry of Land, Infrastructure, Transport and Tourism, "Formulation of Specific Targets and Processes for Realizing an 'AI Terminal' that will almost Eliminate the Wait in Front of Gates at Container Terminals by the End of FY2023." (Mar. 2019) in Japanese, https://www.mlit.go.jp/report/press/port02_hh_000142.html
6) i-Construction in Japanese, https://www.mlit.go.jp/tec/i-construction/index.html
7) Hitachi High-Tech Corporation, "Life Cycle Management Solution for Lithium-ion Batteries," https://www.hitachi-hightech.com/global/products/advanced/lcm/
8) D. Komatsu et al., "Degradation Model Considering Electrolyte Dry-out Factor of Lithium Ion Battery and Lifetime Prediction of Combined Battery System for Automotive Application," IEEJ Transactions on Industry Applications, 139, pp. 689–698 (Aug. 2019) in Japanese.
9) Ministry of Land, Infrastructure, Transport and Tourism, "Mobility Revolution: The First Year of Innovation in Mobility" in Japanese, https://www.mlit.go.jp/common/001294520.pdf
10) Ministry of Land, Infrastructure, Transport and Tourism, "Guidelines for MaaS-related Data Linkage Version 2.0" in Japanese, https://www.mlit.go.jp/sogoseisaku/transport/content/001399363.pdf
11) Ministry of Internal Affairs and Communications, "Towards Realization of Connected Car Society" in Japanese, https://www.soumu.go.jp/main_content/000501374.pdf

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