Hitachi Rail Innovation

Future Rail Services Driven by Digital Technologies

In recent years, Japan's rail sector has been experiencing stagnating transport revenue along with difficulties in transferring skills to new workers as a massive wave of older workers reaches retirement age. But the industry may be able to tap into hidden growth potential by responding to new demands such as inbound demand and the increasingly diverse attitudes of today's rail users. Recent growth in the IoT and other digital technologies may be a key factor in the creation of new services to meet these demands. To suggest one possible approach for a rail industry experiencing a dramatically changing business environment, Hitachi has studied and conceptualized possible future rail services by approaching them from a stripped-down perspective that ignores technical restrictions, regulations, and other incidental obstacles. The company will work on creating these future rail services through collaborative creation projects while responding to rail service operator needs.

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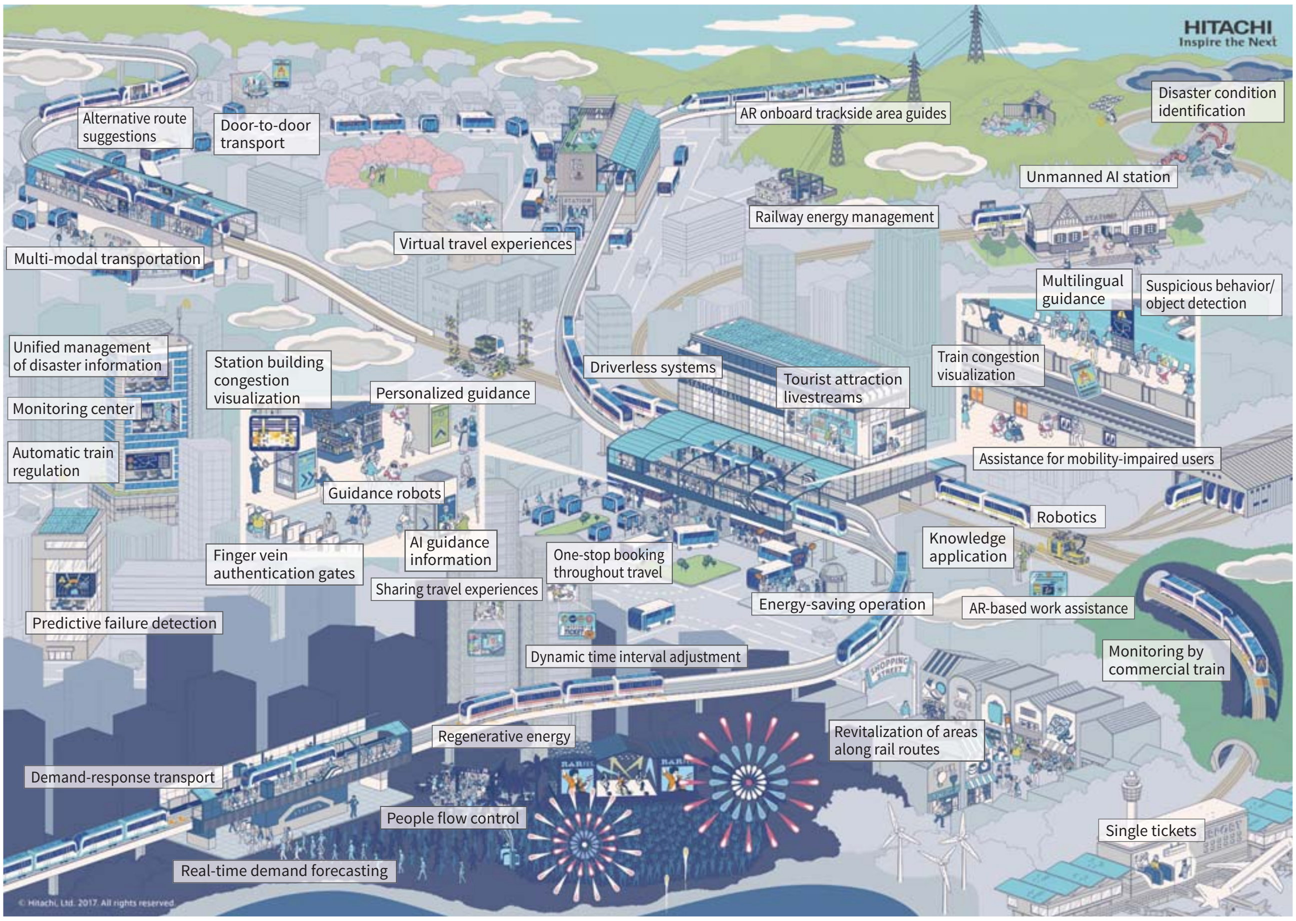
1. Introduction

Over its roughly 140-year history, Japan's rail system has evolved from steam locomotives to diesel and electric trains. Accidents have provided valuable lessons for improving safety, speeds have increased with the opening of the Shinkansen and other high-speed services, and transport capacities have been increased in urban areas. The rail industry has grown in tandem with Japan's population growth and high economic growth, but with Japanese society now reaching a period of maturity, the environment surrounding the rail industry is changing.

The rail sector has recently been facing several new challenges—stagnating transport revenues and workforce shortages caused by Japan's falling population, aging tunnels, bridges, and other infrastructure, and the need for counterterrorism and energy-saving efforts[(1), (2)]. But at the same time, the industry may be able to tap into hidden growth potential by responding to new areas of demand. This growth could come from rising numbers of tourists from overseas, the rise of social media and the sharing economy, and increasingly diverse attitudes among today's rail users[(3), (4)].

The recent rise of the Internet of things (IoT) and other digital technologies has been striking. New digital technologies have enabled new services in fields

Figure 1 — Conceptual Overview of Future Services Described in This Article
Twelve digital technology-driven solutions will create rail services that address the challenges and needs of people and society.



AR: augmented reality   AI: artificial intelligence

as diverse as finance, manufacturing, and medicine, and they are now reaching the point of also being able to address the rail sector challenges and needs mentioned above.

As a comprehensive rail solutions provider, Hitachi has responded with the presentation and collaborative creation of digital technology-driven solutions designed to address the issues and needs of Japan's rail service operators. Conceptualizing approaches to future rail services, it is confident that its solutions can help rail service operators grow.

2. Future Rail Services Driven by Digital Technologies

Now that Japan's society has reached a period of maturity, the rail sector requires new growth that is adapted to market changes in addition to the ongoing growth it generates by continuing to do what it has always done. Using PEST analysis*1, Hitachi has analyzed approaches to future rail service growth by formulating the three concepts described below.

(1) Improving reliability

Safe and secure transport is the cornerstone of the rail sector, and a higher priority than ever for a society that has reached maturity. Along with using new technology to address issues such as workforce shortages and aging equipment, it is important to continue providing stable transport while ensuring safety over a wide range of areas including train and station building interiors.

(2) Aiding regional and national development

Rail service operators have a close connection to recent societal challenges such as environmental protection, energy-saving efforts, dealing with

*1 Political, economic, sociocultural, and technological (PEST) analysis is used by companies when creating management or business strategies to identify how the company is currently affected by its external environment, and to predict how the company will be affected by it in the future.

Table 1 — Solutions Behind Future Rail Services
Hitachi's 12 solutions are classified into three concepts and five categories as shown below.

Category	Solution \ Concept	Improving reliability	Aiding regional and national development	Adapting to increasingly diverse attitudes
Smart transport	1. Demand-response transport	✓		
	2. Multi-modal transport	✓	✓	
Smart navigation	3. Sensor-driven passenger assistance	✓		
	4. Disaster rail information guidance	✓		
	5. Personalized guidance		✓	✓
Ticketing services	6. One-stop booking throughout travel			✓
	7. Single tickets			✓
Smart maintenance	8. Smart maintenance	✓		
Other	9. Station urban development		✓	✓
	10. Railway energy management		✓	
	11. Pleasant travel spaces			✓
	12. Creating opportunities for travel			✓

mobility-impaired users, and regional revitalization. While some challenges can be overcome by single rail service operators working alone, wide-ranging and complex challenges can only be overcome through the coordinated efforts of multiple companies and industries. The rail industry's approach to growth needs to become more responsive to the public and society at large.

(3) Adapting to increasingly diverse attitudes

New services are needed to meet the needs of increasingly diverse attitudes and lifestyles, and the increasing number of visitors to Japan from overseas. The rail industry can respond to demand and enable growth by creating services that meet diverse needs. These services could include ticketing services designed for universal ease of use, information services every user can understand, and services that provide rail-based experiences.

3. Solutions Behind Future Services

Hitachi has derived several digital technology-driven solutions to implement the three concepts it has formulated for future rail services. There are 12 solutions in five categories (see **Table 1**).

Figure 1 provides a conceptual oveview of the future services it describes.

This section provides an overview of four solution categories: smart transport, smart navigation, ticketing services and smart maintenance.

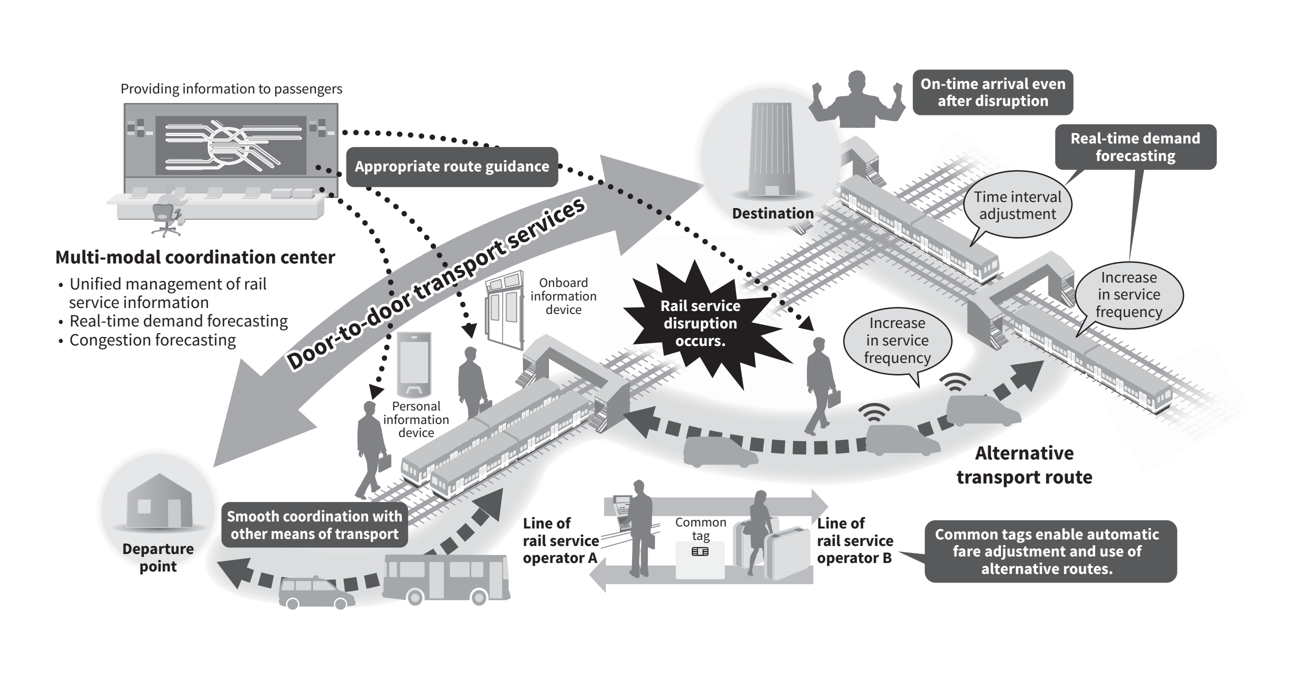
3. 1 Smart Transport

It can sometimes be difficult for today's timetable-based transport services to respond to sudden changes in passenger demand. And, while individual operators are working on rationalizing their timetables, convenience is still a challenge for secondary transport services and smooth transfers between collaborating operators.

The next generation of transport services to be created will include services that ensure flexible transport capacities tailored to demand, and services providing door-to-door transport from departure to arrival point (see **Figure 2**). To ensure that transport capacities are tailored to demand, the services will set a basic timetable and automatically adjust the number of trains, train cars, and train arrival/departure intervals in response to real-time demand fluctuations. These services are expected not only to improve rail users' travel experiences, but also to be effective at rationalizing rail service operator transport costs.

Door-to-door transport services will be provided by using a central unified system to identify the service conditions of all the transport service operators in the city, so that rail, bus, and other transport services can

Figure 2 — Future Smart Transport Services
Door-to-door transport services provided from departure point to destination point will closely link rail service operators.



be operated based on real-time passenger demand forecasts. If transport service is disrupted, alternative routes can be increased to ensure that transport service operators can collectively provide enough transport capacity to meet the total demand. Passengers can be helped to travel smoothly from departure point to arrival point by providing them with appropriate route information according to the current service and congestion conditions.

Driverless systems are one of the elemental technologies that can be used to create these services. Driverless systems have several benefits such as reducing labor costs and improving safety by eliminating human error. As an additional benefit, they also enable transport service operators to respond to increases or decreases in service demand without staffing restrictions.

Hitachi is developing technology that uses sensors installed in stations to analyze and visualize station congestion levels. It lets operators automatically optimize the number of train services they provide in response to increasing or decreasing passenger numbers. The technology is currently being examined in a proof of concept overseas(5).

Providing services that ensure transport capacity tailored to demand and provide door-to-door transport between each passenger's departure and arrival points will improve the convenience and travel experience for rail users.

3. 2
Smart Navigation

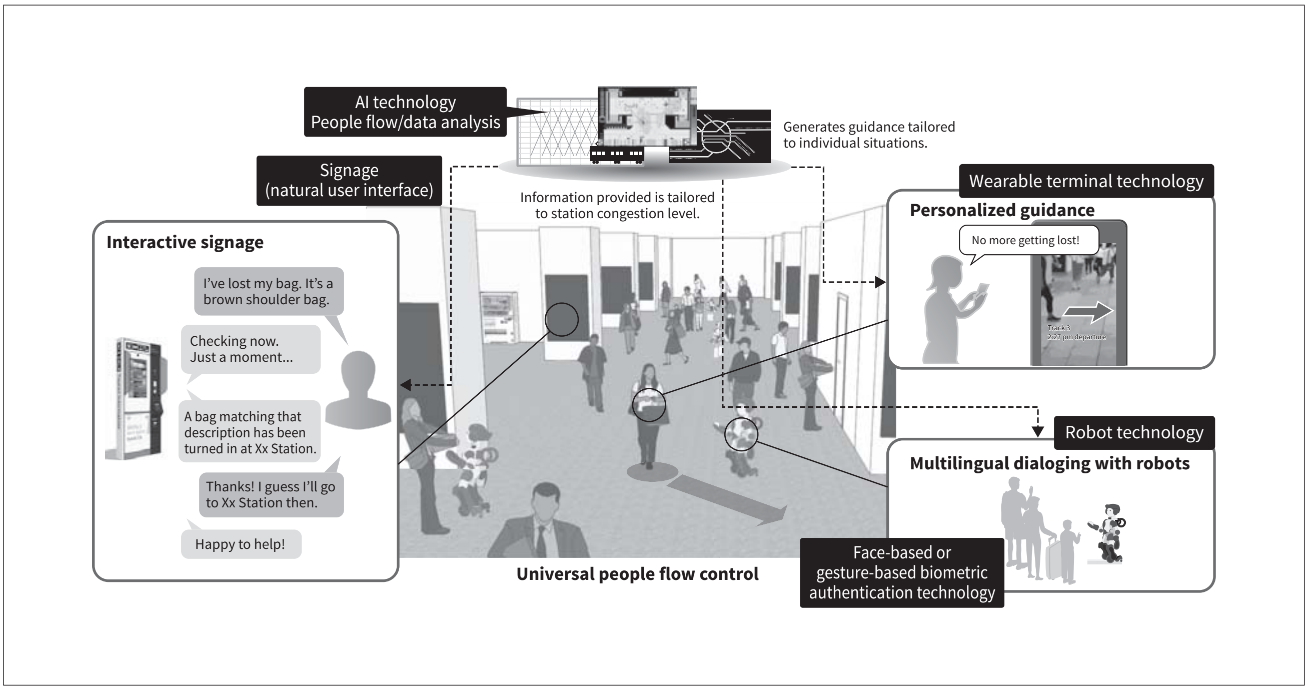
With foreign travelers, seniors, and other transport users each requiring different information, demand for tailored guidance and support is increasing. Some users have expressed dissatisfaction with issues such as the congestion and lack of information provided to passengers when transport service is disrupted. Next-generation services will use robots and advanced sensor technology to provide guidance tailored to individual passengers at times of both normal service and service disruptions (see **Figure 3**).

Using mobile robots and interactive signage, guidance services for individual users will be able to provide the optimum information whenever needed, even when no station staff members are present. Robots will use cameras and sensors to detect users' expressions and physical characteristics. They will provide the guidance service needed by each individual user in a multilingual, interactive format.

In addition to robots, sensors and cameras mounted in station buildings and trains will also provide

Figure 3 — Future Smart Navigation Services

Smart navigation services will provide passengers with individualized information.



individual user support by analyzing information in real time to detect users who may need assistance such as wheelchair users. Artificial intelligence (AI) applications will use the analysis results to determine how and by whom each user should be handled. When needed, the applications will assist passengers by alerting staff or robots of the need for a rapid on-site response.

When transport service is disrupted by heavy rain or a natural disaster, information such as alternative routes and service resumption forecasts will be provided in a manner that meets individual passenger needs. Changes in transport service plans that were previously done manually will be automated to enable the rapid creation of service resumption plans that minimize the impact extent. Disorder during transport service disruptions will be reduced by providing these changes rapidly and in a manner adapted to the needs of individual users.

Hitachi is proof-of-concept (PoC) testing customer service and guidance services provided by its EMIEW3 interactive humanoid robot in commercial facilities and other public spaces. The company also completed a service that gives users a timely view of the level of congestion in a train station by sending images from cameras inside the station building (manipulated to protect privacy) to an app on the user's smartphone[(6), (7)].

Services meeting the needs of individual passengers will be created by providing individuals with guidance and assistance, and by finding ways of reducing disorder during transport service disruptions.

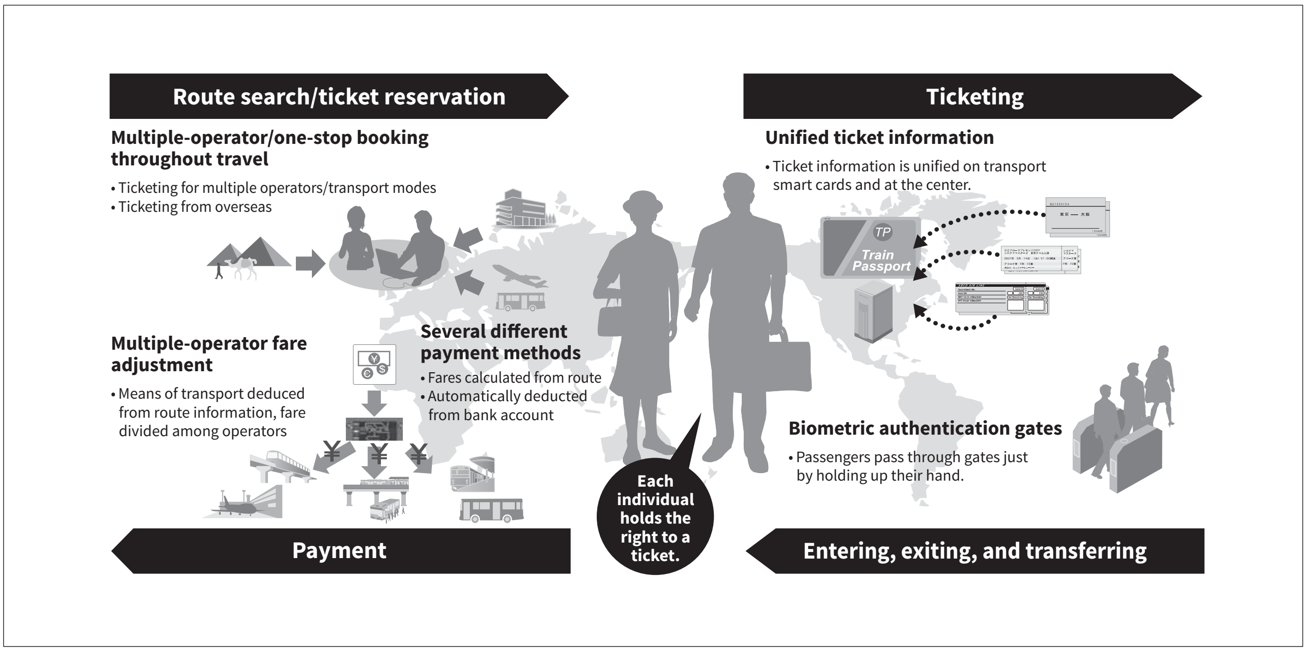
3. 3
Ticketing Services

To increase the convenience of processes ranging from reserving tickets to boarding and payment, next-generation ticketing services will provide single tickets that can be used for rail service operator services as well as for planes, buses, and every other means of transport (see **Figure 4**).

When making reservations, users will be able to purchase any ticket from the same vendor whether they are in Japan or overseas. This system will eliminate the need to deal with multiple agents or access multiple websites. Fares will vary dynamically to balance supply and demand, with both users and rail service operators benefiting from flexibly set prices.

Information about purchased tickets will be managed in a unified manner by a host center, linked to personal information such as credit card information. These advances will eliminate the need to issue tickets

Figure 4 — Future Ticketing Services
One-stop booking services will let passengers reserve and buy multiple-operator tickets for travel on multiple-operator routes with just one ID.



printed on conventional physical media. Once passengers have registered their finger vein pattern or other biometric information with the center, they will be admitted through finger vein authentication gates without having to carry a physical ticket.

Entrances for boarding commuter trains and other means of transport not requiring a reservation will have gates that record each passenger passing through them. The host center will automatically calculate the travel route and applicable fare, which will later be deducted from the passenger's bank account. When travel includes transport services provided by multiple operators, the fare owed to each operator will be calculated automatically.

Using a host center to manage ticket information and personal information in a unified manner will enable passengers to use every form of transportation with the aid of technology such as biometric authentication.

3. 4
Smart Maintenance

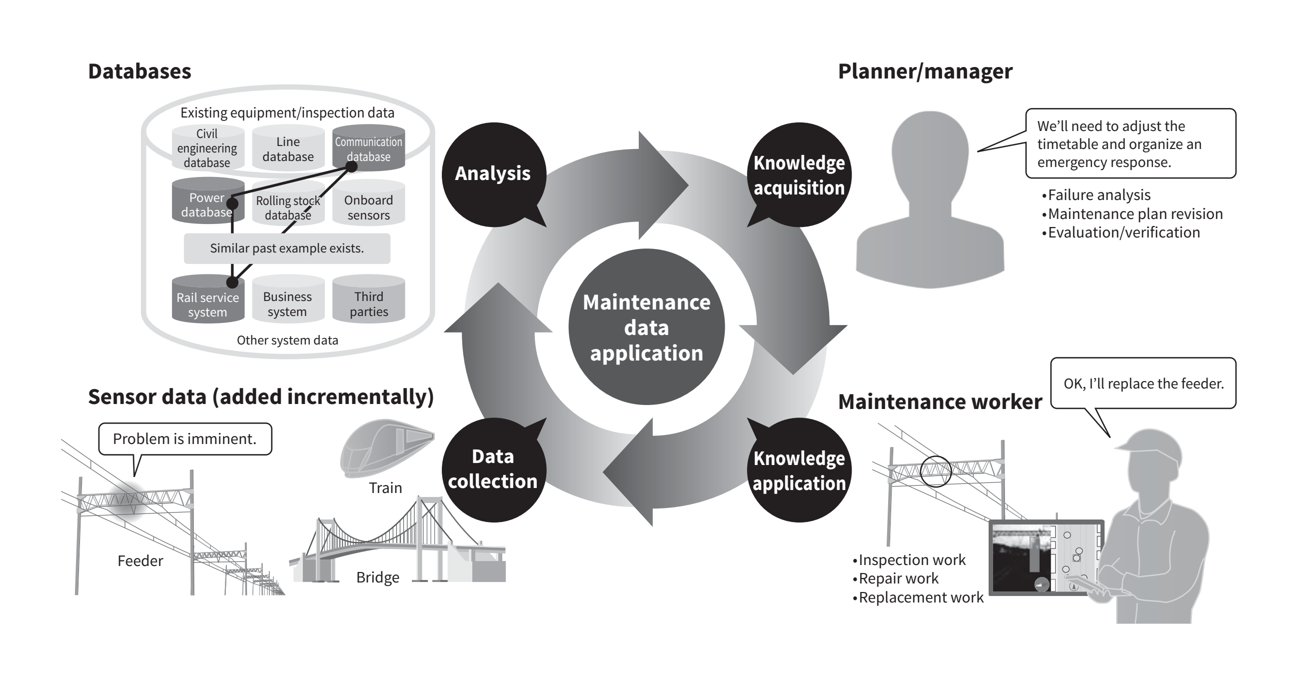
Maintenance on trains, tracks, and other equipment accounts for a large share of rail service operator expenses. Analysis of operators in Japan has shown that maintenance accounts for about 30% of all operator business expenses. Increasing maintenance work efficiency has also become a key challenge in recent years due to the problems of aging equipment and workforce shortages. To respond to these challenges, maintenance efficiency will be improved by assisting sites through robotics, more efficient inspection work, inspection data application, and knowledge acquisition for skills training (see **Figure 5**).

The use of sensors mounted on trains and equipment to monitor conditions in real time can make inspections more efficient by reducing costs relative to manual inspections and enabling more frequent inspections. Subsequent manual maintenance work can be made easier by using alarms to identify problem locations, and using collected information to create intuitive and easy-to-understand visualizations.

Analyzing collected information enables predictive failure detection for trains and equipment, ensuring maintenance is done at the right time. Using a condition-based maintenance (CBM)*2 approach can prevent accidents while enabling repairs soon after problems occur, before they turn into major failures. But since CBM is not appropriate for all train parts and equipment, maintenance efficiency can be

*2 Also known as status-monitoring maintenance. An approach that accounts for degradation states and failure risks to ensure that maintenance is done before failures occur or service life ends.

Figure 5 — Future Smart Maintenance Services
Smart maintenance services will increase maintenance efficiency by creating cycles for maintenance work improvement.



increased by combining CBM with the conventional time-based maintenance (TBM)[*3] approach.

To assist skills transfer, knowledge can be acquired by collecting and creating visualizations of information tacitly understood by experienced workers. Various maintenance operations have conventionally relied on the expert perception and judgment of experienced workers. Examples include hammering tests to detect problems and comprehensive failure evaluations made using several different types of data. Creating visualizations of these advanced operations will enable them to be done by inexperienced workers.

To assist sites, labor-saving solutions will be created to adapt to the declining workforce. Examples will include the use of robots designed to save labor and ensure worker safety, and the use of tablets or wearable terminals for knowledge applications.

These solutions will improve maintenance quality, while also cutting costs and saving labor by improving efficiency.

*3 Also known as periodic maintenance. An approach in which maintenance is done at fixed time intervals.

4. Conclusions

Hitachi has presented its future rail service concepts to several rail service operators, and received a generally sympathetic response toward aspects such as rail industry growth and improved user convenience. The concerns raised about services included the need for collaboration among multiple operators, and the lack of a clear return on investment. But ongoing efforts to propose and present Hitachi's service concepts have led to several collaborative creation projects.

The future rail service concepts suggest future approaches to rail services, so the solutions presented in this article are not all necessarily in their final form. As solutions are created, they will evolve along with advances in technologies and the processes of collaborative creation with rail service operators.

As a comprehensive rail solutions provider, Hitachi will continue to work on collaborative creation projects to make its future service concepts a reality, while responding to the needs of rail service operators.

References

1) Ministry of Land, Infrastructure, Transport and Tourism, “Annual Report of Railway Statistics,” (2014) in Japanese.
2) Ministry of Land, Infrastructure, Transport and Tourism, “Transport Policy White Paper” (2015) in Japanese.
3) Japan Tourism Agency, “Consumption Trend Survey for Foreigners Visiting Japan” (2016).
4) Nomura Research Institute, Ltd., “Changes in Japanese Values and Consumption Behavior Seen in NRI Questionnaire Survey of 10,000 Consumers,” (2015) in Japanese.
5) Hitachi News Release, “Ansaldo STS Signs MoU with Metroselskabet for Proof of Concept of New Dynamic Headway Solution Leveraging Hitachi Technologies for Copenhagen Metro” (Jun. 2017), http://www.hitachi.com/New/cnews/month/2017/06/170609c.pdf
6) N. Matsukuma et al., “Using People Flow Technologies with Public Transport,” Hitachi Review, 66, pp. 145–149 (2017).
7) Hitachi News Release, “Tokyu Corporation Officially Launches ‘Eki-Shi-Vision’ In-station Camera Image Delivery Service — Conveying Timely Understanding and Views of Station Congestion Conditions, Utilizing Hitachi’s Image Recognition Technology —” (Sep. 2016), http://www.hitachi.co.jp/New/cnews/month/2016/09/0915.pdf in Japanese.

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