

Management and Technology Innovation in Rail Industry as Social Infrastructure for Improved Quality of Life

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SUMMARY East Japan Railway Company has created new businesses such as life-style business and information technology business on the basis of railway business for sustainable growth. These businesses generate and provide synergy to one another effectively because each business is autonomous decentralized system based on diversified infrastructure. The infrastructure includes not just structure but management, technology, operation and maintenance: we call this “MTOMI Model.” The MTOMI Model is the key concept of JR East’s businesses and can generate JR East’s ecosystem.

key words: autonomous decentralized system, MTOMI Model, infrastructure, ecosystem

1. Introduction

Transportation as social infrastructure must grow sustainably for improved quality of life because it plays an important and indispensable role in society. In particular, public transportation centered on railway service significantly reduces traffic congestion thanks to its large capacity and small latency. It is also superior environmentally and reduces trip time, thus greatly contributing to economic growth and regional development.

JR East has created new businesses such as life-style business and information technology (IT) business in addition to railway business for sustainable growth through management and technical innovation. These businesses generate and provide synergy to one another, and each model of the business is considered to be autonomous decentralized system. JR East’s ecosystem consists of a combination of the businesses and the autonomous decentralized systems. The ecosystem can be achieved by diversified infrastructure including not just structure but management, technology, operation and maintenance. This ecosystem and sustainable innovation in transportation can raise people’s quality of life.

At the beginning of this paper, characteristics of JR East, and relationship between infrastructure and international competitiveness are described as background. Then the important concept of JR East’s ecosystem, “MTOMI Model”, is presented. After that, JR East’s innovation examples and ecosystem are explained. Finally, the importance of sustainable innovation is described in conclusion.

2. Characteristics of JR East

2.1 Outline of JR East

JR East’s rail system infrastructure operates and maintains various categories of rail transport, including Shinkansen, metropolitan, suburban and regional railways as shown in Fig. 1. More precisely, JR East has the following seven characteristics:

1) Vertical structure

JR East owns all its railroad infrastructure, operates it and maintains it as a fully integrated railroad enterprise which includes all types of infrastructure, such as stations, rolling stock, track, electric power supply, signals, IT systems, and related business.

2) Horizontal structure

JR East owns and operates all categories of rail transport such as five Shinkansen lines, metropolitan and regional railways with a 7,474 km network. As an integrated rail network, it is both convenient and comfortable for customers.

3) Business structure

JR East also manages life-style businesses utilizing station space, shopping centers, hotels etc. Revenue from such non-transportation was more than 30% of total revenues of the JR East Group in FY2013 as shown in Fig. 2.

4) Micropayment

JR East owns a micropayment infrastructure. This is the first IC card ticketing system in Japan, introduced in the Tokyo metropolitan area in 2001 as “Suica,” whose name is an ab-

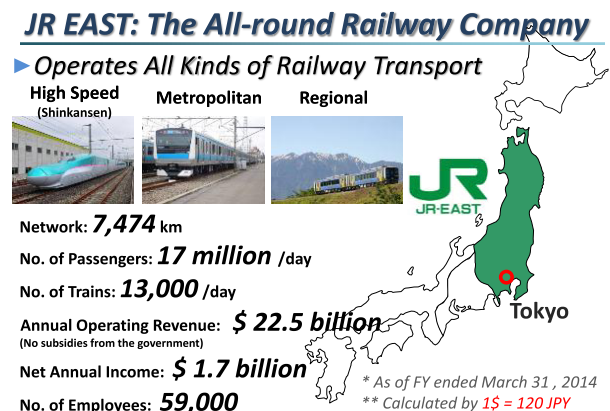


Fig. 1 Outline of JR East.

Manuscript received July 24, 2015.

Manuscript revised November 16, 2015.

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DOI: 10.1587/transcom.2015ADI0001

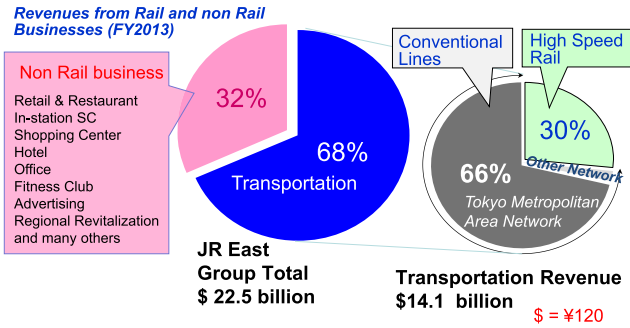


Fig. 2 Business structure.

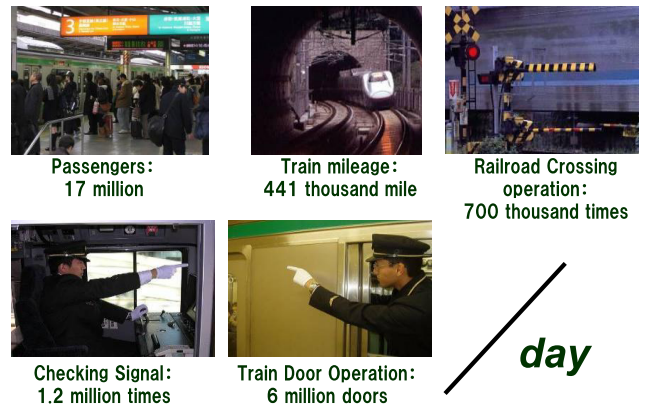


Fig. 4 Quantitative features in JR East.

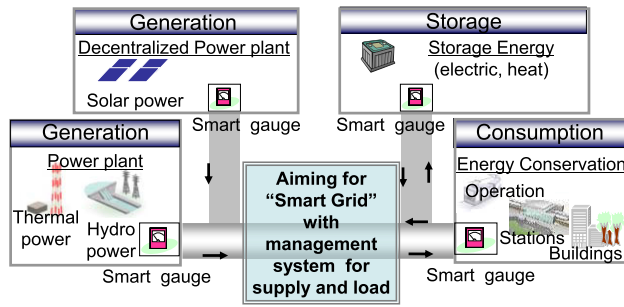


Fig. 3 Energy chain.

breiviation of "Super Urban Intelligent CARd." In 2004, JR East launched a micropayment service (e-money) based on an IC fare card system, and has disclosed IC card standards to other transportation companies. The total number of IC card holders is about 100 million and transactions per day total 130 to 150 million, where transaction implies single trip with IC, IC commuter pass, or e-money. The processing time is 0.2 seconds for passing through automated passenger gates.

5) Energy chain

JR East produces and consumes its own energy, being on both the "supply" and "demand" sides. The company owns two electric power plants, power lines substations etc. One power plant is hydroelectric and the other thermal. Power is used by stations, trains, shopping centers, retail shops, hotels, offices and other facilities (Fig. 3).

6) Rolling stock chain

JR East implements all stages in the life cycle of rolling stock, from philosophy and concept to development, design, manufacturing, operation, maintenance, feedback for new development, recycling, etc.

7) "Two WITHOUTS"

JR East has not received any subsidies from central or local governments since privatization in 1987, and has not raised fares or charges except for consumption tax increases since then.

2.2 Quantity Changing the Quality

In 2012, total operating distance of rails worldwide was almost 2.9 trillion passenger-km, with Japan's rails account-

ing for 9% [2]. However, the number of passengers carried by train in the world was almost 30.7 billion with Japan accounting for about 29%. Thus, it can be said that railways in Japan carry more passengers per kilometer than those in other countries.

Quantitative features in JR East are shown in Fig. 4. The number of passengers (17 million per day), and high expectations from users and society in general have improved the quality of railways in Japan, such as higher frequency, larger capacity as well as safer, more punctual, and quicker service. More precisely, in terms of frequency, JR East operates Shinkansen trains at 4-minute headway maximum and conventional trains at 2-minute headway. In terms of capacity, a single train in JR East can carry 3 to 4 thousand passengers. In terms of safety, the most important among the five qualities, Shinkansen fatalities have remained at zero since 1964 when Shinkansen operation started. In terms of punctuality, average time delay per Shinkansen train from 2009 to 2013 was only 46 seconds including case of natural disasters. In terms of quickness, an automated ticket gate reads and writes fare data on "Suica" in 0.2 seconds. JR East must sustain and/or improve these five qualities simultaneously. Consequently, quantity changes the quality.

Suica, or IC ticket cards, can be mentioned as another example of the fact that "quantity changes quality." Suica users were few in 2001 when Suica was introduced. Paper-based tickets were chiefly being used at that time. The number of Suica users has been increasing gradually since then, and presently more than 90% of passengers in the Tokyo metropolitan area use Suica, including "Mobile Suica" in which passengers can use a smart phone or cell phone as a ticket card instead of an IC card.

Supposing 100% of passengers have and use IC cards, ticket-vending machines or money would not be needed. Therefore, new space can be generated in place of the area of current vending machines and the burden and cost of using money could be reduced. Various possibilities in diversified use of space can be created. For example, as in Ueno station, the necessity of ticket-vending machines has decreased thanks to the wide use of Suica. Thus the space of some ticket vending machines has been converted to commercial

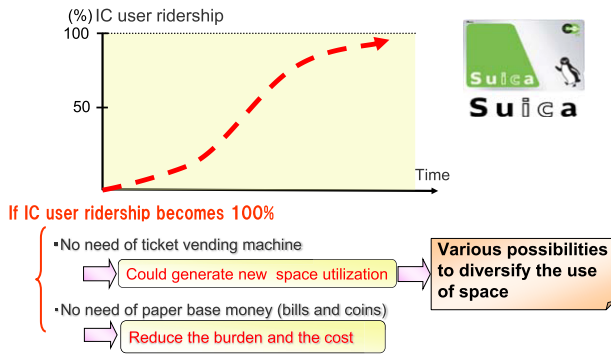


Fig. 5 Potential of Suica.

space. Use of space in stations will be completely restructured in the near future (Fig. 5).

3. Infrastructure and International Competitiveness

3.1 What is “Infrastructure?”

In the narrow sense, infrastructure is a general term of what forms a base for social economy and production such as roads, ports, rivers, railways, information and communication facilities, sewage systems, schools, hospitals, parks, public housings, etc. Also, infrastructure can be said to be structure that configures the base of economic activity and social life. There are two meanings in this context. One is an industrial base such as dams, roads, ports, power plants, communication facilities, and so on. The other is facilities for common welfare such as schools, hospitals, parks, etc.

In a broader sense, infrastructure can be perceived by the three following viewpoints: (1) Infrastructure system for abundance, (2) Infrastructure that integrates control technology for efficient facilities and flexible operation with information technology for improved value and services, (3) Infrastructure that integrates dissimilar resources and services in response to individual customer needs. The first one has the two following meanings: i) Something that enables people to choose resources and services for a better quality of life, ii) Efficient use of resources and services from the standpoint of customers.

3.2 Diversity of Definition of Infrastructure

In railway industry, there are two major definitions of infrastructure. One is an infrastructure that does not include train operations, or “two-tiered system;” and the other is an infrastructure that includes train operations, or “vertical integration” of infrastructure, operation and maintenance. Many European railway companies are the former (Fig. 6), and many Japanese railway companies are the latter (Fig. 7). JR East not only owns land, structure and rolling stock, but also operates and maintains them to provide customers and society with selectable resources and the integrated technology and service.

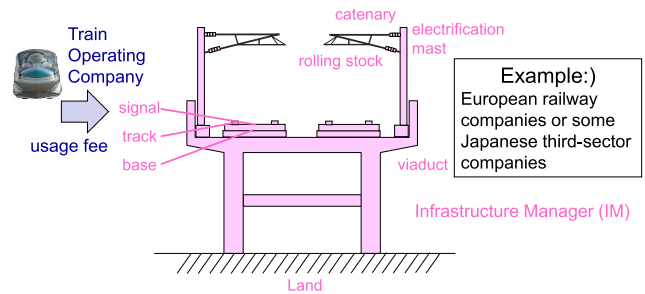


Fig. 6 Two-tiered system.

Vertical Integration of Infrastructure and Operation, Maintenance

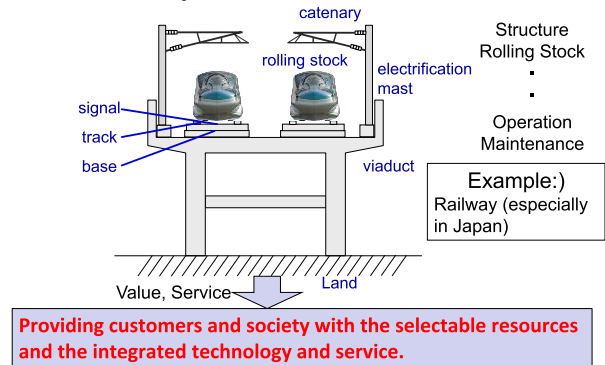


Fig. 7 Vertical integration.

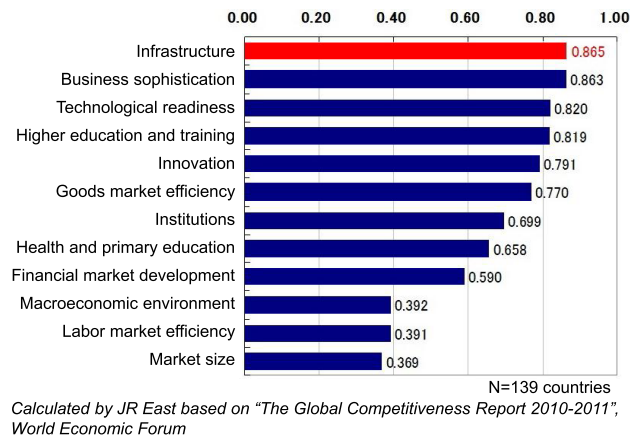


Fig. 8 Determination coefficients in the global competitiveness index.

3.3 International Competitiveness

According to “The Global Competitiveness Report 2010-2011” (Fig. 8), infrastructure ranked at the top in determination coefficients in the global competitiveness index out of twelve factors, such as business sophistication, technological readiness, higher education and training, innovation and others. Therefore, infrastructure is most important to a nation’s global competitiveness.

As mentioned in Sect. 3.2, vertically integrated infrastructure, including operation and maintenance, provides so-

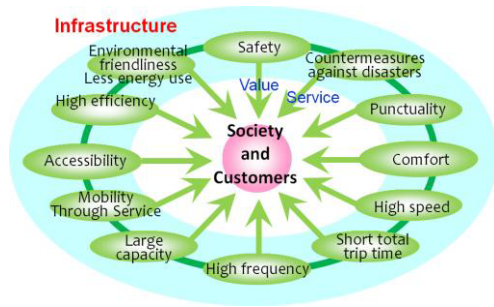


Fig. 9 Infrastructure providing value and services to society and customers.

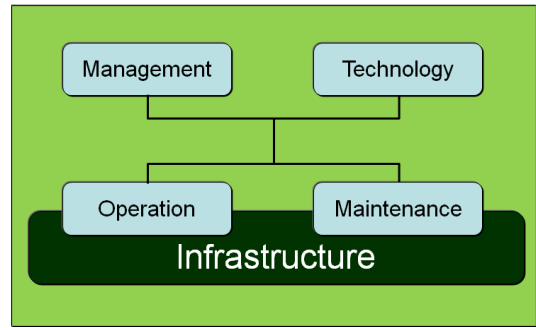


Fig. 11 MTOMI model.

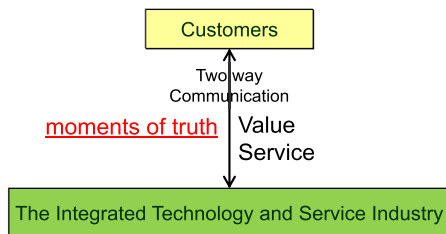


Fig. 10 Relationship between customers and the integrated technology and service industry.

city and customers with values and services such as safety, comfort, large capacity, etc. as shown in Fig. 9.

4. MTOMI Model

4.1 What is “Service?”

Service is provided to customers from the integrated technology and service industry based upon customers’ demand. Therefore, two-way communication exists between customers and the industry as shown in Fig. 10. “Service” is totally different from “product goods” as it is produced and consumed simultaneously, cannot be stocked, has no distributable sample, is not replaceable, or is not uniform.

Moments at which customers and employees encounter each other are called “moments of truth” [1]. Quality of service and the company are evaluated at this moment. Hospitality is the important mutual relationship between customers and well-disciplined employees. Hospitality is only realized at the moment of truth. If it fails, it cannot be corrected or changed.

4.2 MTOMI Model

What is the integrated technology and service industry that provides excellent value and service to society and customers in these “moments of truth?”

JR East is a vertically integrated company owning infrastructure that includes operation, maintenance, management and technology. Figure 11 shows the relationship among these elements and is newly dubbed the “MTOMI Model” based upon initials of each element (Management,

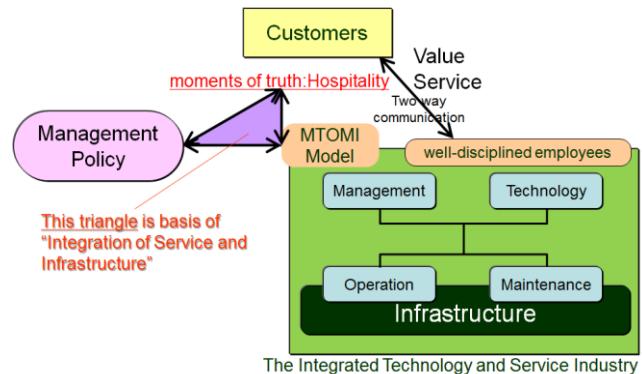


Fig. 12 Integration of service and infrastructure.

Technology, Operation, Maintenance, Infrastructure).

As shown in Fig. 12, the MTOMI Model provides values and services to customers, society and nations in the moments of truth through well-disciplined employees. The integrated technology and service industry also owns its management policy for service, “Integration of Service and Infrastructure” is achieved based upon the three elements such as MTOMI Model, Management policy and Moments of truth.

5. Innovation of Railway

5.1 What is “Innovation?”

Innovation is not only the invention of a new technology, but also new ideas and concepts creating new value to make a big change in society. JR East could not have existed without “innovation”. Typical examples of innovation in JR East are mentioned as follows.

5.2 Suica

Suica is an IC card with which passengers can pass smoothly ticket gates. “Smoothly” means passengers do not have to insert their cards in a slot, and all they need to do is pass their cards over a card reader/writer at the gate. The system was first introduced in the Tokyo metropolitan area as the first transport IC card system in Japan, in 2001. Coverage was expanded to Tohoku and Niigata areas later. Because



Fig. 13 Suica.

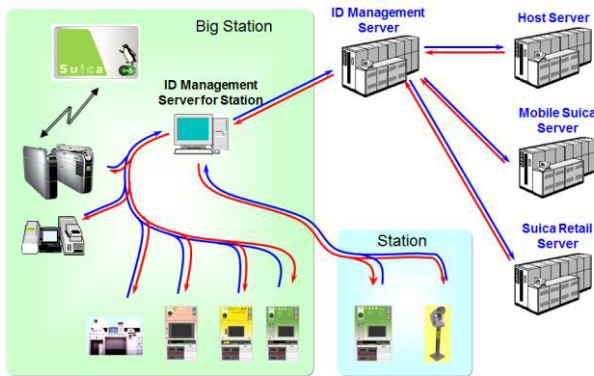


Fig. 14 Autonomous decentralized system for Suica.

the Suica IC card standard has been disclosed to other transportation companies, many railway companies have adopted the same IC card system as Suica. Consequently, mutual service has expanded with nine other participating transportation IC cards, including JR West's ICOCA and PASMO (major private railway companies in the Tokyo metropolitan area) and others. The total number of the ten transportation IC cards reached about 100 million in 2015.

Regarding function, micropayment function and Mobile Suica that passengers can use their smartphones or cell-phones instead of Suica cards were added in 2004 and 2006, respectively. Presently, Suica can be used not only as stored fare and micropayment but as commuter pass, "Green Car" ticket and facility identification purposes. In addition, Mobile Suica can be used as Shinkansen ticket not only for JR East but also for JR Central. Transaction time is 0.2 seconds and the system processes 130 to 150 million transactions per day (Fig. 13). Suica system is such a large-scale system that we adopted an autonomous decentralized system (ADS) concept for online expansion, fault tolerance and on-line maintenance, as shown in Fig. 14.

As mentioned above, Suica is one of the most important technological innovations including many new ideas, concepts and technologies. Beyond that, Suica can be called an innovation because it has created new value to make big changes in people's life-styles.

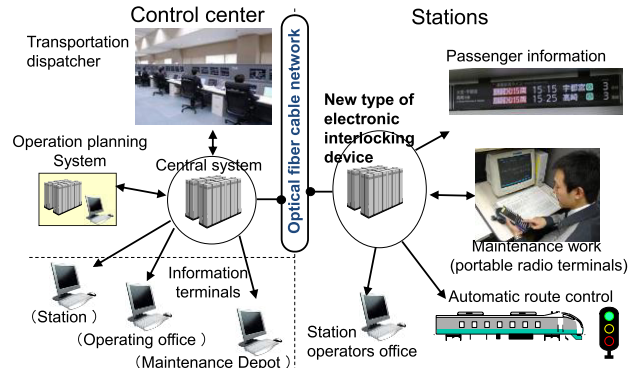


Fig. 15 Autonomous decentralized system for ATOS.

5.3 ATOS

ATOS, whose name is an abbreviation of "Autonomous decentralized Transport Operation control System", is a large-scale train operation system for the Tokyo metropolitan area in JR East. This system was first introduced in Chuo Line between Tokyo and Kofu in 1996, later expanding to 21 lines in Tokyo metropolitan area. This system introduced the ADS concept with allocating general-purpose computers for station facilities at stations in order to control trains in extremely high-density lines and achieves automatic route control for the purpose of providing reliable transportation, raising customer service levels, sharing train information, and improving safety and maintainability. Previous train operation systems using Centralized Train Control (CTC)/Programmed Route Control (PRC) were ideal in terms of control and operation but didn't work well when size becomes extremely large due to its limitation in computer processing capacity. Because ATOS introduced ADS concept, it consisted of subsystem area by area, and thus works within the limitations of computer processing capacity (Fig. 15).

5.4 Shinkansen

Shinkansen, the high speed train firstly introduced in 1964, is an innovation as well. JR East raised the top speed of commercial Shinkansen train to 320 km/h in 2011, and now passengers can travel from Tokyo to Shin-Aomori within three hours.

The next target speed is 360 km/h, although several issues are yet to be solved. The three major issues are classified as 1) Safety and reliability, 2) Sustainability and 3) Ride comfort. Among these, wayside noise is the one of the biggest challenges in increasing speed. As Hokkaido Shinkansen operation will start in 2016, higher speed and technologies for that are anticipated. (Fig. 16)

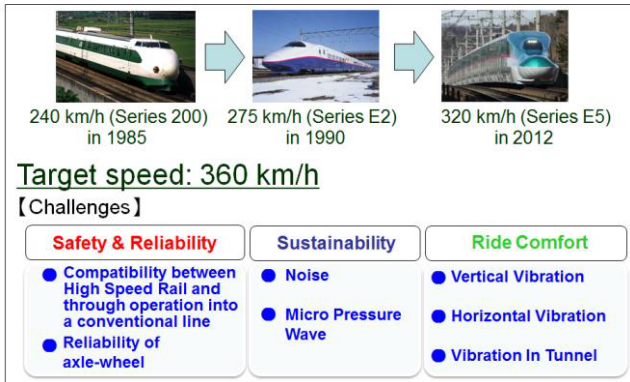


Fig. 16 Shinkansen running at 320 km/h.

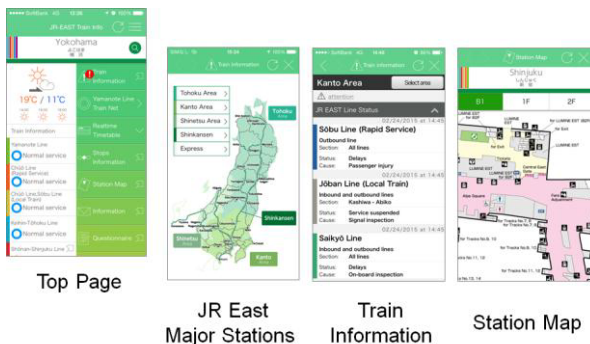


Fig. 17 Screenshots of JR East train info.

5.5 Utilizing ICT

5.5.1 JR-EAST Train Info App

1) Overview

“JR-East Train info” App (JR-EAST App) is JR East’s smartphone’s free app for both iOS and Android. The concept of this app is “Everything about JR-EAST railway in one app.” You can easily view JR East train status and station facilities on your smartphone. JR-EAST App is available in both Japanese and English. The Japanese version was launched on March 10, 2014 and more than 1.2 million have been downloaded as of July, 2015. English version was just launched on March 20, 2015.

2) Contents of JR-EAST App

User interface design is most important for smartphone apps. We took great care in designing the top page. Station information is displayed at the top and the nearest station automatically appears by global positioning system. You can choose from around 150 major JR East stations. Weather and train operation information for fifteen major JR East railway lines can be seen at all times on the left side. On the right side, you can view the information you need; Train Information, Yamanote Line Train Net, Departure Information, Stops Information, Station Maps, and others (Fig. 17).

Train Information is for viewing information on train

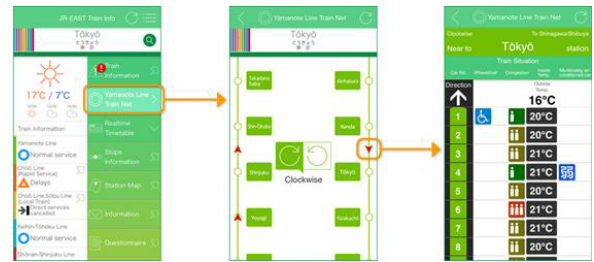


Fig. 18 Screenshots of Yamanote line train net.

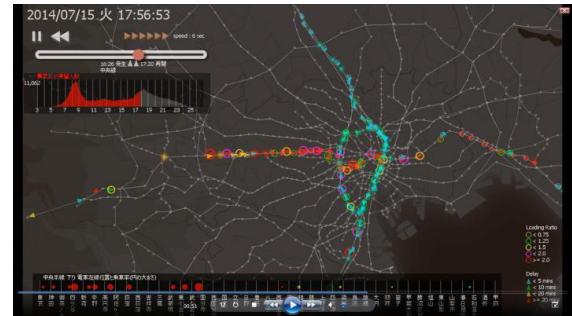


Fig. 19 Screenshot of big data analysis.

service. Details are available by selecting a specific area. Yamanote Line Train Net is a featured function of the JR-EAST App. You can view the real-time positions of Yamanote Line trains and carriage conditions (congestion and temperatures for each car) in real time as shown in Fig. 18.

Departure Information provides information on trains departing from Tokyo, Shinjuku, Ueno and Shinagawa in real time. This information is the same as the electric signboard displaying train departures in stations. Stop Information shows possible routes departing from the stations displayed on the top page and stops along the routes. Station Maps has detailed station information on maps.

5.5.2 Big Data Analysis

JR East already has a huge amount of data in its daily railway operation. We have train operation data, Suica data, ticket data and more. The data volume was too huge to analyze several years ago, but now we can analyze thanks to technological progress, computation, database, storage, AI (Artificial Intelligence) and also gathering various data by utilizing IoT (Internet of Things) technology.

Figure 19 shows one example of big data analysis, visualization of train location, congestion and delay information using data of automated gate, passenger load and train location.

We also established an “Analysis and Security Center” in our headquarters on April 1, 2015 to catch up on social and technological trends as shown in Fig. 20.

5.6 Energy and Environmental Strategies

JR East is emphasizing development of energy and environ-

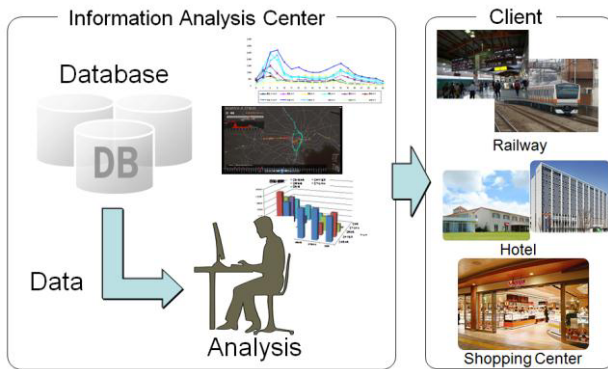


Fig. 20 Analysis and security center.

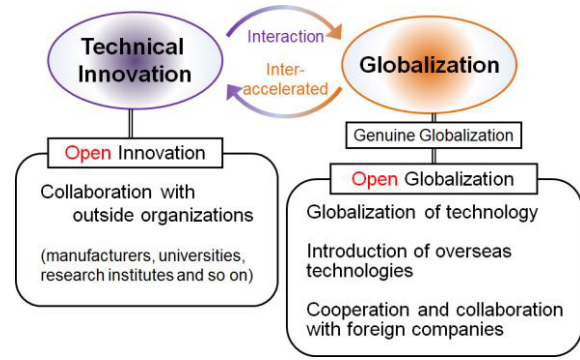


Fig. 22 Interrelation between technical innovation and globalization.

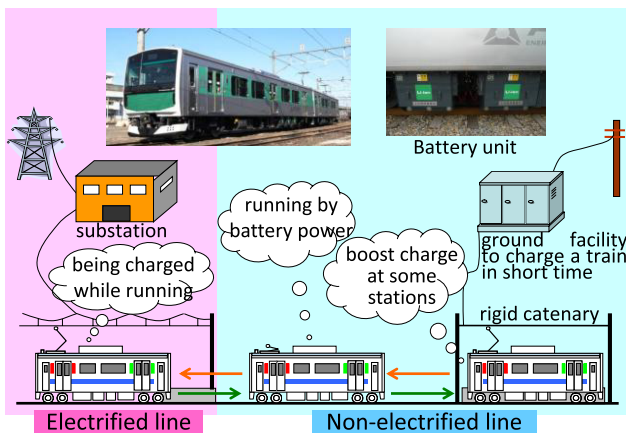


Fig. 21 Battery-powered hybrid railcar “ACCUM”.

mental strategies appropriate for Japan’s long-term power shortage problems due to the earthquake of 2011. Our R&D activities are focused on renewable energy sources, energy conservation, and smart grid technology for railways. One example, the catenary and battery-powered hybrid railcar “ACCUM”, is shown in Fig. 21. This system reduces the environmental impact in non-electrified sections. Our future dream is to do away with the catenary.

5.7 Technical Innovation and Globalization

In addition to strengthening infrastructure, technical innovation is essential for globalization and strengthening international competitiveness. The relationship between technical innovation and globalization is shown in Fig. 22. Technical innovation and globalization have a synergistic relationship. In other words, technical innovation is accelerated by globalization, which consists of the globalization of technology, introduction of overseas technologies and cooperation and collaboration with foreign companies. Conversely, globalization is accelerated by technical innovation in which open innovation, collaboration with outside organizations such as manufacturers, universities, research institutes and others, is essential.

6. JR East’s Ecosystem

JR East has created various new businesses and systems based upon the MTOMI Model for transportation. We have diversified and developed businesses from transportation, life-style, IT-Suica, to overseas business by taking full advantage of the MTOMI Model. These businesses generate and provide synergy to one another. Each model is considered to be autonomous decentralized system, and so JR East’s ecosystem is a combination of the businesses and those autonomous decentralized systems.

Using Suica as an example, it was launched in 2001 merely as a service for train fare payment to reduce maintenance cost. Although Suica could only be used in the Tokyo metropolitan area at first, we have expanded the system to Sendai and Niigata. Suica is also compatible with JR West’s ICOCA card and with the PASMO card issued by private railways in Tokyo area because we have disclosed the IC card standard to other transportation companies. We achieved elimination of the psychological burden of purchasing tickets at every transfer between operators and transport modes.

Suica e-money service was started at station kiosks in 2004. Suica can also be used as e-money for purchases at convenience stores, shopping centers, and other places around town. Suica is an autonomous decentralized system and social infrastructure that creates new services. From the description above, Suica is an example of the application of MTOMI Model for transportation (Fig. 23).

7. Conclusion

Today, the management environment surrounding us is rapidly changing. As shown in Fig. 24, the changes are typically classified into three categories. The first one is changes in society and the economic environment. Nowadays, economic crises such as Lehman’s collapse and Euro crisis instantly propagate to other areas in the world. In addition, domestic society is shrinking, especially in Japan with its low birth-rate and aging society. The second category is changes in management and technology environment such as the advance of globalization and development of information and

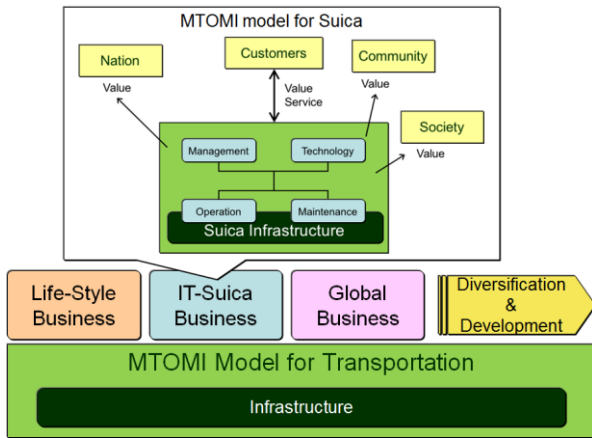


Fig. 23 JR East’s ecosystem.

1. Changes in society and the economic environment

- ① Instantly propagating economic crisis (Lehman’s collapse, Euro crisis, and so on...)
- ② Shrinking domestic society (low birth-rate / aging society) (in Japan)

2. Changes in management and technology environment

- ③ Advance of globalization
- ④ Development of ICT (Information, Communication and Technology)

3. Changes in natural environment

- ⑤ Severe issues on environment (CO2, Climate change, and so on...)
- ⑥ Increase of natural disasters (earthquake, typhoon, and so on...)

Fig. 24 Rapidly changing management environment.

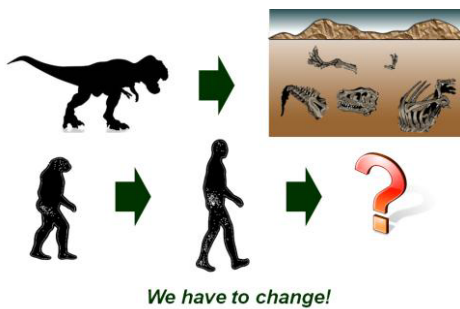


Fig. 25 Environment surrounding us—rapidly changing world.

communication technology. The third category is changes in the natural environment. There are severe issues in the environment such as CO2 emission and climate change. Natural disasters such as earthquakes and typhoons have increased as well. In this rapidly changing management environment, we have to respond to the changes through the accumulated technological strength of the rail industry. As with dinosaurs, it is not the strongest of the species that survives, nor the most intelligent, but rather the one most adaptable to change (Fig. 25).

JR East has a 28-year history since its privatization. It is neither merely a railway company nor a transportation

JR East is; Neither merely a railway company nor a transportation company
An Integrated Technology and Service Industry

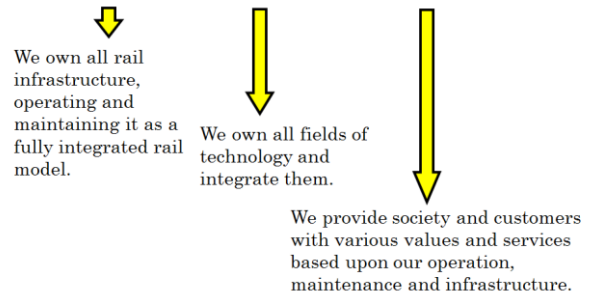


Fig. 26 Domain of JR East.

company. It is an integrated technology and service industry (Fig. 26). In this context, “integrated” means JR East owns all the infrastructure of railway, operation and maintenance as full integrated rail model. “Technology” means that JR East owns all the fields of technology such as operational engineers, rolling stocks, signaling systems, communication, tracks, electric house supply engineer, architecture, construction engineers, etc. “Service” means that JR East provides society and customers with values and services based upon infrastructure with operation and maintenance.

Railway as infrastructure can sustainably innovate itself. The sustainable innovation of railway can keep raise the quality of life.

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- [2] UIC, “International Railway Statistics 2012,” 2012.



Masaki Ogata Vice Chairman of East Japan Railway Company (JR East). He joined the Japanese National Railways in 1974, and afterward joined JR East in 1987. After having experienced various management positions, he joined the Executive Directors as Director at the Transport and Rolling Stock Department in 2002, Executive Vice President in 2008, and the current position in 2011. Also he was elected to President of UITP (International Association of Public Transport) in 2015.