BUSES

Overall Trends

1 Japanese Buses and Automotive Technology in an Era of Transformation

Automotive technology which developed following the invention of the internal combustion engine, is said to be coming to a major turning point. The underlying factors include not only the omnipresent issues of securing the oil resources that fuel internal combustion engines and preserving the environment, but also rising social expectations inspired by innovative advances in IT solutions. By virtue of the essential role of automobiles as an instrument that supports the day-to-day lives of people and logistics throughout the world, a transformation of automotive technology seems likely to affect the lives of all people beyond anything ever imagined. Beyond the technological advances, a change in the mindset of the people using it to its full extent is also required.

Changes such as these are making themselves felt in all categories, including international and domestic markets, production and consumption resources and, for production resources, trucks and buses. This article takes the perspective of the technological changes and expectations that are gradually affecting automobiles worldwide to presents an overview how this affects the situation of buses in Japan and of the attendant technological adaptations.

1. 1. Current Status of the Pressing Issue of Driver Shortage

Finding drivers is the most urgent and greatest challenge facing the Japanese bus industry. Driver shortage is also a critical problem in the truck industry, with the solution of improving employment conditions leading to a decrease in truck operating hours. The resulting impact on logistics is becoming a social issue. Similarly, the effects of driver shortage in the bus have become noticeable to users.

The direct cause of the shortage of drivers to support truck and bus operations is the low absolute number of driving license holders. In the truck industry, the licensing system was partially revised, and a new license for light-duty trucks used for home delivery or other collection-and-delivery services has been created but, with the stipulation of a passenger capacity of 11 or more people, a heavy vehicle license is always mandatory to drive a bus, regardless of the size of the vehicle.

The people holding the Class 2 heavy vehicle class license required to drive a bus for business purposes is getting older. There were 920,000 holders of Class 2 heavy vehicle licenses in 2017, with people 65 or older falling into the elderly category making up 45% of that total. The broader 50-and-above age range includes over 720,000 license holders, representing 78% of the total. Put another way, only a 22% minority of license holders are 49 or younger. These license holders include who are driving trucks for business purposes. The average age of truck drivers is in the mid-40s, while bus drivers have a higher average age of 50, illustrating how much further the aging of bus drivers has progressed. Successfully finding young drivers will determine the future of bus transportation.

Bus driver income is tied to operator profitability, which means that no improvement can be expected unless the number of users starts to rise. Moreover, recent major bus accidents have led to calls to more rigorously limit on-duty hours and ensure rest time, and worries over securing the necessary staff is an ongoing concern for people involved in bus operations. Long-distance route buses, with their larger per-person price than ordinary urban transit buses, are the mainstay of bus operator profits, but long-distance operation requiring a second driver make it difficult to increase the number of trips, and cases of canceling such operations altogether has also been observed. As ordinary routes are subject to measures such as reducing the number of buses, closing the route on weekends, or setting earlier times for the last bus, the shortage of drivers is affecting user convenience.

The aging of the population is increasing the appreciation of the role of buses in society. Similarly, as dependence on buses increases due, for example, to young people no longer getting licenses, the issue of a driver shortage causing the continued efforts to be in vain is a situation that cannot be ignored, in particular from the perspective of the social infrastructure. Some major bus operator executives have pointed out the danger of a labor bankruptcy if nothing changes. This situation is drawing attention to the hiring of non-Japanese workers and automated driving technologies.

1.2. Safety Education for People with No Bus Driving Experience

In response to the decrease in license holders and the aging of Class 2 heavy vehicle license holders, some bus operators have been looking at the possibility of hiring non-Japanese workers. More realistic measures involve many operators expanding the scope of driver hiring. The past application requirements of experience driving a heavy-duty vehicle has been eliminated in favor of hiring people without experience, having them acquire a Class 2 heavy vehicle license in-house, and providing training. A growing number of bus operators are also increasing their efforts to hire women drivers.

The shortage of drivers means that the number of drivers with little experience will increase, and this will have an impact on bus technologies. Bus manufacturers have been making models with torque converters or electronic control mechanical transmissions (AMTs) that allow two-pedal operation (AT vehicles) and cases of operators introducing vehicles for driver trainings stand out.

Japanese-made buses, which were the last line of defense for manual transmission vehicles (MT vehicles) until a few years ago, are seeing a rise in the proportion of AT vehicles spearheaded by urban buses, followed by AT vehicles becoming mainstream for heavy-duty sightseeing buses.

Vehicles for driver training reflect the changes in the hiring environment. The unraveling of the assumption of prior experience underlying past driver training now requires an approach targeting inexperienced drivers that involves objectively collect data on how they drive to encourage safe and economical driving. This includes monitoring how the driver's gaze moves, thorough checks for safety both in and out of the vehicle, and other functions unique to buses, where some passengers stand (Figs. 1 and 2). The question of imparting safe and energy-efficient driving habits is common to all operators, but with the need to address specifications on an individual basis and the mounting costs of analysis or other equipment, few operators can introduce full-fledged training vehicles. Nevertheless, they retain significance in terms of demonstrating a commitment to hiring and safety.

Fig. 1 Example of Vehicle Used for Safe Driving Training (Kintetsu Bus)

Fig. 2 Quantifying Bus Driving Operations as Data to Encourage Safe and Economic Driving

Fig. 3 A Dedicated Bus Driving Simulator Has Been Developed

Similarly, the high number of safety checks required by transit bus operation has led to the development of dedicated bus driving simulators to cultivate driver experience. Rain, snow, and other weather conditions, as well as nighttime situations and gradient roads can be reproduced, and the default routes can be completed by individual operators with customized backgrounds showing actual routes using CG technology. Another major distinction is the simulator's ability to reproduce accidents that cannot be recreated with training vehicles.

Focusing on the aging of drivers in the context of the development and spread of safety systems is urgently spurring work on systems that can ensure safety even in the event of a sudden driver physical impairment. More and more operators are having drivers undergo brain examinations to predict brain diseases that would lead to a major accident if they occurred while driving.

Devices that identify signs of sleepiness from the driver's veins have been commercialized, and systems that coordinate with the drive recorder and enable real time verification of driver condition by the operation manager when events that could lead to an accident, such as sudden braking or lane departure warnings, have become more common.

Since the Class 2 heavy vehicle license test is based on an MT vehicle, some operators who have completed the switch to AT vehicles have purchased used MT vehicles to train drivers. The bar for licenses for bus drivers, who are entrusted with human lives, should not be lowered without due consideration, but given the spread of heavy-duty AT vehicles, and in terms of expanding the scope of license holders, it may be worthwhile to consider also having a license test based on AT vehicles in the future.

1. 3. Circumstances outside Japan

The shortage of bus drivers is not a situation limited to Japan, but a problem shared by operators throughout the world. Dedicated bus driving simulators were developed and commercialized in the U.S. and Europe earlier than in Japan.

What is the underlying cause of the shortage of drivers?

While salary and work conditions are major prerequisites in selecting an occupation, the drop in status of occupations is also a concern. Bus driving used to rank high among driver occupations, with charter buses, which require extensive experience, perceived as the best position, and long-distance bus drivers in the U.S. and Europe were both proud and highly skilled. In Japan, drivers of charter sightseeing buses worked long hours in-season, but it was a well-paid and sought after occupation. It is also important to point out that at the time, there were few serious sightseeing bus accidents caused by insufficient driver skill or operator labor management such as those seen more recently.

Given the harsh business environment and a labor-intensive industry, securing staff requires bus operators to apply measures to minimize turnover and expand their pool of potential employees, but at the same time, users must make a fair appraisal of professional bus drivers, who supports the day-to-day life of society. The recent tendency to value the position of the consumer has led to international praise for Japanese *omotenashi*—hospitality—, but it is possible that, conversely, a situation that only increase the number of people seeking to receive *omotenashi* might influence the shortage of professional drivers. The spread of drive recorders has reduced the number of accidents inside vehicles, but there are few examples of the use of data to eliminate problems caused by passengers. Buses also represent an environment expected to contribute to a society that does not cultivate a greater number of so-called monster clients.

In Japan, the heavy vehicle license is the same for trucks and buses, but some countries separate the two and also have different manuals for each. There are also cases where the type of bus that can be driven, such as urban buses, long-distance sightseeing buses, articulated buses or double-decker buses, is specified on the license. Given the different knowledge and experience required to drive buses, to which lives are entrusted, and trucks, which carry diverse goods, that approach is rational. The Japanese mindset of professionals being trained and growing through actual work and initiatives adapted to the change in the hiring environment, should contribute to solving the issue of driver shortage.

1. 4. Expectations Placed on Automated Driving

As the shortage of bus drivers becomes increasingly serious, bus industry expectations surrounding automated driving are growing. Some bus operators are specifically envisioning its introduction in depopulated areas with low demand. Automated and autonomous driving are also discussed in another section. Since 2016, demonstration test of bus automated driving have been conducted throughout Japan. From the point of view of the bus industry, these tests primarily consist of collaborations between other sectors such as IT corporations and universities, with most results on a global level obtained from the light-duty buses of two French companies. These buses drove along a pre-planned route, and actions such as getting on or off along the route and avoiding objects have been verified. There has also been a test using a Japanese-made light-duty bus performing an automated driving making a round trip on a public road. Mobile communication is essential to realizing this tech-

Fig. 4 Demonstration Tests of Unmanned Driving Are Taking Place Worldwide

nology, and buses operating on a fixed schedule and route, like the mining heavy-duty dump trucks already using remote operation to perform driverless automated driving, can be considered entry-level automated driving. However, buses are characterized by allowing an unspecified large number of people to board in the same space. This has some similarity with elevators, but since the shared travel time is longer than the movement between the floors of a building, determining whether remote monitoring alone provides security will have to involve a consensus with users. This may lead to a reevaluation of the presence of a driver or crew member.

Improved GPS accuracy is a prerequisite for automated driving, and the ability to more accurately ascertain the location of a bus in motion has already started to expand the range of bus location systems and improve the convenience of operation information provided to terminals in real time, which in itself represents a major change.

1.5. Post-Diesel Developments

The image of buses mounting diesel engines is also changing. Although alternative fuels such as CNG and LPG have been test in Japan as well, high thermal efficiency, low cost, and ease of handling and given diesel engines an unshakable position. However, since the WHO listed the particulate matter (PM) included in diesel vehicle emissions as a carcinogenic agent in 2013, criticism of diesel vehicles has increased. Major cities in Europe, also concerned with vibration and noise, are taking steps to oust diesel vehicles. Cities such as Paris and London have decided to adopt electric urban buses. In China, where air pollution is a severe problem, tens of thousands of electric buses are in operation, while Europe is taking measures to adopt natural gas as an immediate alternative fuel for inter-city transportation.

Diverse forms of energy are considered optimal for automobiles depending on the resources available to a specific country, and it may be in the interest of Japan, which relies on imports for many resources, to avoid adopting of a single type of energy. Nevertheless, it is necessary to share knowledge of electric buses and other characteristics of individual technologies with other countries. The cruising range on a single charge of Japanese-made electric buses currently operating in Japan is limited, and bus operators in Japan would agree that it is not possible to use them in the same way as fuel-powered vehicles. However, some imported electric buses have a cruising range permitting actual operation as urban buses. This is accomplished by mounting a large battery representing a significant portion of the gross vehicle weight, an achievement that requires a lighter vehicle body than the ones on current Japanese-made buses. At the same time, electric buses are not suited to long-distance driving, and despite lower operating and equipment costs than diesel buses, the price of the vehicles causes expenses to mount. In contrast, arguing for the advantages of natural gas will require dispelling the existing negative image held by operators who have tried operating with CNG buses.

1.6. Efforts to Harmonize Vehicle Safety Regulations

The recent drop in the profitability of bus operators has created a situation where Japanese buses have become smaller and the number of deployed models has decreased, facilitating the standardization of specifications. As a result, another recent trend is the increase in cases of bus operators looking to imported vehicles for models not found in Japanese-made buses. The appearance of Chinese-made Midi-sized sightseeing buses after the manufacturing of rear-engine light-duty buses popular in the sightseeing industry was discontinued provides a perfect example. Imports of double-decker and articulated buses are also rising. The import of electric heavy-duty bus chassis is also a new development. Vehicle standards in the U.S. and Europe differ not only on the position of the steering wheel, but also on basic specifications such as vehicle body width and permitted axial weight. Although this poses a significant obstacle to the entry of foreign buses into the Japanese markets, efforts to overcome this obstacle are being multiplied. Buses launched in 2017 will be introduced in a later section.

This concludes the overview of the effects of technological breakthroughs in the automotive industry on the Japanese bus industry. They will provide the context for the 2017 trends derived from data on the number of passengers and number of vehicles produced presented in the following section.

2 The Japanese Bus Industry in Statistics

2. 1. Passenger numbers

Figure 5 shows bus passenger numbers. The number of bus passengers in 2016 was 4.577 billion, consisting of 4.283 billion passengers riding transit buses and 294 million riding charter buses. This represents an increase of 18.65 million passengers for transit buses and a decrease of 900,000 passengers for charter buses compared to 2015. The number of bus passengers shrunk continuously for many years, but started to show a slight increase in 2012. With the continued decrease in regional routes corresponding to the decline in the population living along those routes, these figures reflect increased demand in metropolitan areas. However, it is not possible to predict whether the shortage of drivers noted earlier will have an impact.

Figure 6 visualizes the passenger kilometer data for the distance actually traveled by the above-mentioned number of passengers, with transit buses exhibiting a slight increase while charter buses show a slight decrease. This has reversed the positions of transit and charter buses, and probably reflects the inclusion of long-distance inter-city buses in transit buses as well as the fact that stricter labor management for drivers of charter buses means that the amount of long-distance travel is not as high as it once was.

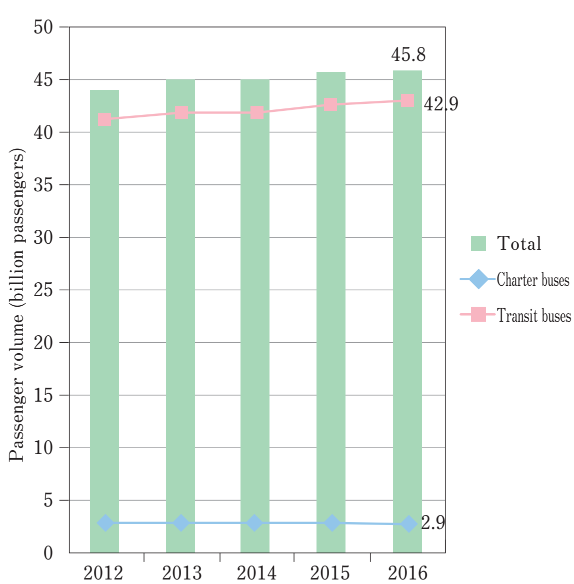


Fig. 5 Passenger volume (number of passengers)

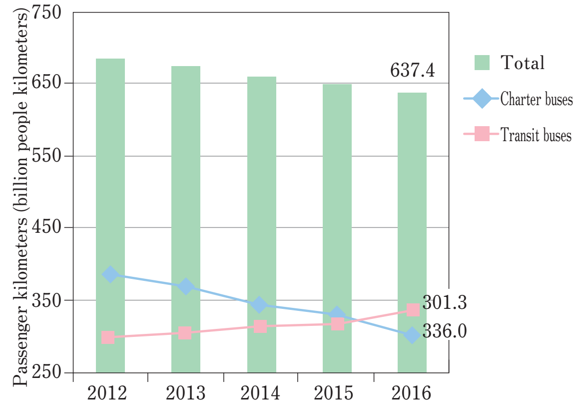
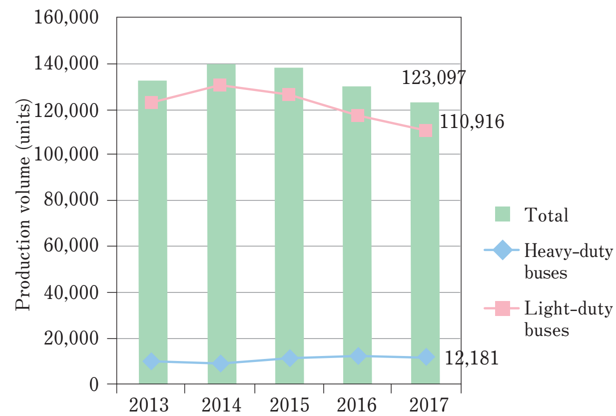


Fig. 6 Passenger volume (passenger kilometers)



*Quoted from Ministry of Economy, Trade and Industry dynamic statistical data since 2016.

Fig. 7 Bus production in Japan

2. 2. Market trends, Production and Registration

Figure 7 shows that bus production was 12,181 units for heavy-duty buses and 110,916 units for light-duty buses. The rise of inbound tourism led to a continuation of the previous year's strong demand for heavy-duty buses, but production of light-duty buses decreased by 6%. Industry interest is focused on whether orders for heavy-duty buses will increase again.

The number of bus registrations in Japan in Figure 8 quantitatively demonstrates that while there were no major changes for buses mainly found in substitute markets, successive orders of new vehicles prompted by rising demand from inbound tourism in 2016 resulted in a higher number of registrations. Although those figures were essentially the same in 2017, the maintained a high level compared to the last few years.

Figure 9 shows the trend in the number of exported buses. Exports in 2017 decreased by 10% compared to 2016, falling below the 120,000 mark. The Japan Automo-

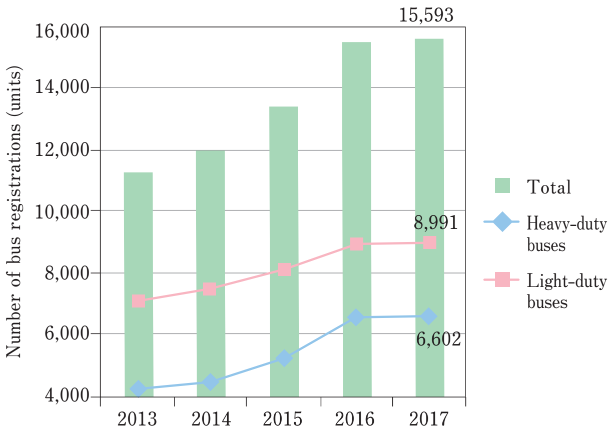


Fig. 8 Number of bus registrations in Japan

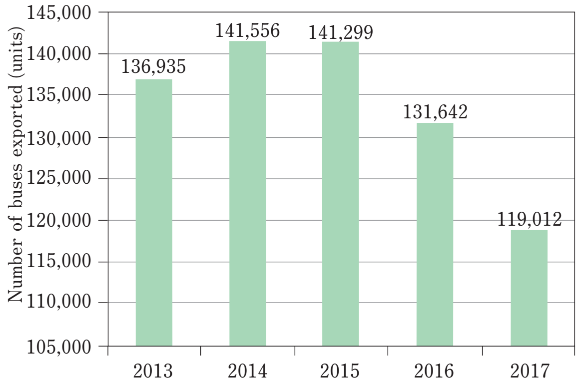


Fig. 9 Number of buses exported

bile Manufacturers Association (JAMA) database stopped distinguishing heavy- and light-duty buses in 2016, obscuring the details, but the drop for the Middle-East in the number of exports and main export destinations presented in Figure 10 stands out. Since that region represents an export destination for Japanese-made light-duty buses, the drop in exports probably centers on that category. While this presumably reflects economic conditions in oil-producing countries, the question is now whether exports will start to increase again. From a medium term perspective, the product appeal of buses from various competitor countries in those nations is increasing, with a notable rise in completed vehicle exports from China and Korea in Asian markets where Japanese-made buses had a strong presence, and the number of buses completed locally using European-made chassis is also growing. This creates doubts as to whether the trust in Japanese vehicles cultivated in those destinations in the past is matched by the product appeal of completed vehicles.

Figure 11 shows the number of imported buses, which

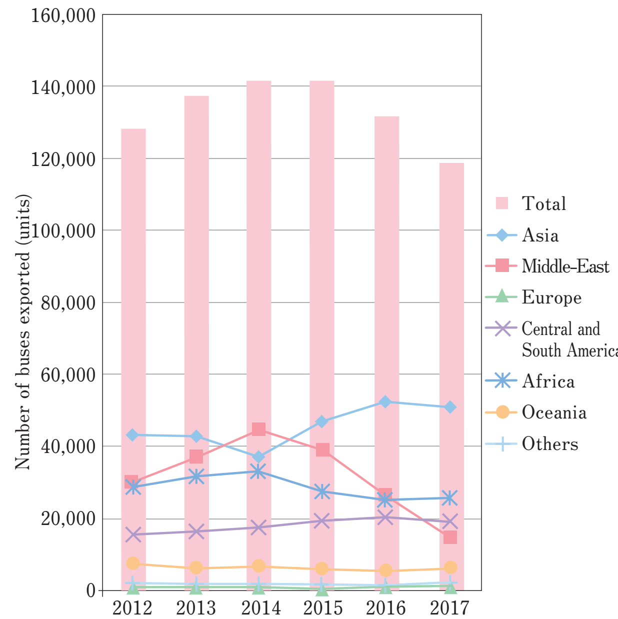


Fig. 10 Main export destinations

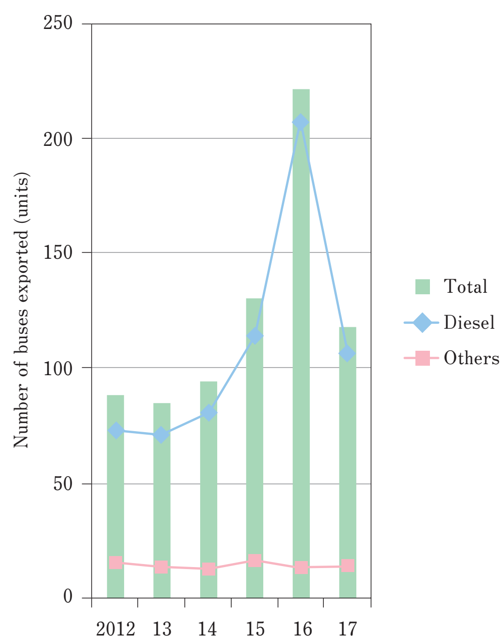


Fig. 11 Number of imported bus registrations

exhibits an annual transition of approximately 100 vehicles. The majority of imports consist of Korean-made heavy-duty vehicles, and the large increase in the number of vehicles observed in 2016 is attributed to the inability of Japanese-made vehicles to respond to the vigorous inbound tourism demand. Demand for double-decker buses is also on the rise, and they are predicted to make up a significant proportion of imported buses if vehicle replacements proceed smoothly.

3 New Bus Models

This section presents new bus models introduced in 2017 in chronological order by size. Many new heavy-duty bus models were introduced to comply with the 2016 regulations and achieve the 2015 fuel efficiency standard for heavy-duty vehicles. However, modifications centered on the engine and other components, or driving systems, with extremely few changes made to vehicle appearance.

3. 1. Heavy-Duty Buses

In May, the Mitsubishi Fuso Aero Queen and Aero Ace were upgraded, becoming the MS06 series (Fig. 12). The engine was significantly downsized from the previous 12.8-liter displacement to 7.7 liters, while securing a maximum output of 280 kW and maximum torque of 1,400 Nm. The weight of the engine was reduced by 540 kg, improving fuel efficiency by 10%.

The transmission was standardized to the first 8-speed AMT used on Japanese-made sightseeing buses, and the collision mitigation braking system is the second-stage regulations-compliant Active Brake Assist 3 (ABA3).

Vehicle stability control and automatic stopping systems have been complemented with systems such as Proximity Control Assist, which automatically starts following the preceding vehicles if it starts moving within two seconds after stopping, a lane departure warning system, and a speed limiter that can be assigned any speed limit between 15 and 100 km/h to offer a full array of other advanced safety systems. This is the Japanese-made bus closest to a transition to automated driving. However, models with an overall length of 9 m have been discontinued.

In June, Hino released new models of the S'elega heavy-duty sightseeing bus. The 12 m range has a 13-liter engine with a maximum output of 331 kW (6-speed MT) or a 265 kW 9-liter engine (7-speed MT).

In both cases, a fuel adding valve has been included immediately after the turbocharger to raise the automatic regeneration efficiency of the exhaust aftertreatment (DPR).

The 9 m range combines a 191 kW 5.1-liter engine with a 7-speed AMT (Fig. 13). The same revamp has been applied to the Isuzu Gala integrated model.

In July, the Isuzu Erga heavy-duty route bus was upgraded to comply with the 2016 emissions regulations. The engine retains the same displacement while reducing maximum output from 184 kW to 177 kW (the maxi-

Fig. 12 New Mitsubishi Fuso MS06 Aero Queen Model

Fig. 13 The New Hino S' elega 9 Uses a 7-Speed AMT

Fig. 14 LED Headlamps on the Isuzu Erga

mum torque of 735 Nm remains unchanged). The switch to LED headlamps distinguishes it from the previous model (Fig. 14). With the change to a new body model, the shuttle front door (two-step) floor inherited from the body of the previous model has been replaced with an integrated non-step floor between the front and middle doors, and the floor under the seats has been raised (Fig. 15). The same modifications have been applied to the Hino Blue Ribbon integrated model.

In August, Hino released a new Blue Ribbon Hybrid model compliant with the 2016 emissions regulations (Fig. 16). The engine has higher output, and optimized shifting achieved through cooperative control of the hybrid system and AMT has improved fuel efficiency. Other modifications include switching to LED headlamps.

In October, the Mitsubishi Fuso Aero Star heavy-duty route bus was made compliant with the 2016 emissions regulations. A side view camera and LCD monitor pro-

Fig. 15 Isuzu Front Door Erga Bus Changed to a Non-Step Base

Fig. 16 Hino Blue Ribbon Hybrid Compliant with the 2016 Emissions Regulations

viding improve left-side visibility for left turns and vehicles merging in from the left has been made standard equipment. The reported fuel economy varies depending on the installed air conditioner, and there are also two emissions designations. The floor is offered in non-step and one-step configurations, and the two-step vehicle for private use has been discontinued.

3. 2. Medium-Duty Buses

In July, the Hino Melpha medium-duty bus for private use or sightseeing was upgraded. The engine is the same 4-cylinder engine with a 5.1-liter displacement as in the above-mentioned 9 m S'elega and has a maximum output of 162 kW and maximum torque of 795 Nm. The transmission has been standardized to a 6-speed AMT, but the transmission in the Melpha uses a lever system similar to a torque converter AT rather than the rotary system found in the 9 m S'elega. The same revamp has been applied to the Isuzu Gala Mio integrated model.

In July, the Isuzu Elga Mio and Hino Rainbow integrated model medium-duty route buses were made compliant with the 2016 emissions regulations. The engine was converted, retaining the same maximum output and torque, but producing that maximum torque at a lower engine speed. A urea selective catalyst reduction system was adopted for exhaust aftertreatment.

3. 3. Light-Duty Buses

In December, Hino released a new Poncho light-duty bus model compliant with the 2016 emissions regulations. This upgrade was also used to install a 5-speed AT in all models.

In July, Nissan partially redesigned the NV350 Caravan one-box commercial vehicle, and simultaneously introduce a new micro bus with a 14-passenger capacity. The design of the front mask was changed, and an all-direction view monitor (with a moving object detection function) has been made available as an option. A 4WD model was also added in December.

Fig. 17 AMT Lever in the Hino Melpha

Fig. 18 New BYD K9 Electric Bus Introduced in Okinawa

3. 4. Imported Buses

In September, Hyundai released a 2016 emissions regulations-compliant model of its Universe heavy-duty sightseeing bus. Engine displacement has been reduced from 12.3 liters to 9.9 liters and combines an electronically controlled common rail and wastegate turbocharger to produce a maximum output of 316 kW and a maximum torque of 2,060 Nm. The transmission is a 6-speed MT, and the installation of a 6-speed AT has been announced for the spring of 2018.

An AT model has been added to the lineup of the Chinese-made Onoen Star, which made its Japan debut in 2016. It consists of an Allison 6-speed automatic transmission combined with a 4-cylinder Cummins engine.

A new model of the Chinese BYD K9 electric bus first unveiled in 2016 has been released (Fig. 18). The three battery locations in the first model (two at the front and one at the rear) were reallocated to two locations, one on the roof and one at the rear, an arrangement known as the two-battery package.

The 2016 rise in imports of the Mercedes-Benz Citaro

G and the Scania-Volgren articulated bus models continued, and the number of Scania-Volgren Astromega double-decker buses also increased.

One particular case involves the remodeling of a route bus operating in Malaysia into an electric bus carried out in Japan (Fig. 19). Based on a NEDO initiative aimed at deploying Japanese technology internationally, the project involved shipping 11 new buses built locally to Japan, where the engine and transmission were removed and replaced with motors and batteries to convert them to electric buses, and sending them back to Malaysia. The batteries installed have a capacity of 86 kWh and are sodium titanate ion batteries, which have a solid track record in mass-produced passenger vehicles. A pantograph has been set on the roof for rapid charging. The battery pack is compliant with international safety regulations (UNECE R100.02).

Fig. 19 Malaysian Urban Bus Remodeled as an Electric Bus in Japan

Design Trends

1 Japanese-Made Buses

1. 1. Buses Planned and Introduced by Operators

Buses exhibiting the originality operators impart to the standard specifications vehicles produced by bus manufacturers were seen throughout Japan again in 2017. This section introduces vehicles involving a comparatively significant secondary exterior or interior remodeling of the standard specifications model, and vehicles presented at various events.

1. 1. 1. Tobu Bus Tram Bus

Tobu Bus Nikko, which operates route buses in the Nikko area, has used medium-duty Isuzu Erga Mio as a base to reconfigure one vehicle with a body style and coloring reminiscent of the Tobu Nikko Tramway that was discontinued in 1968. The remodeling was performed by Iwado Kogyo (Fig. 20).

1. 1. 2. All Private Booths Overnight Bus

A private booth overnight expressway bus has started operating between Tokyo and Osaka. Partitions are used to define one-person spaces on the left and right sides of the center aisle, with doors along the aisle creating private booths. The operators using this bus are Ryobi Bus Kansai Company and Kanto Bus. The one-way fare of 20,000 yen, which makes it more expensive than the Shinkansen, has drawn attention. This heavy-duty super high decker does not have an emergency exit since its 11-passenger capacity means that even with the crew, it does not carry more than 13 people (Fig. 21).

1. 1. 3. Seats Exhibiting Greater Independence

With the strengthening of safety regulations concerning seats, individual strength tests are now required for new seat models, and many vehicles adopting seats with a greater degree of independence have been adopted for nighttime or other operations. Willer, which operates expressway route buses, has developed an 18-passenger capacity bus offering six rows of independent seats enclosed in a shell-like partition set in the longitudinal direction (Fig. 22). JR Bus Kanto and West JR Bus Company have launched a new bus limited to 18 passengers

Fig. 20 Tram Bus Used by Tobu Bus Nikko

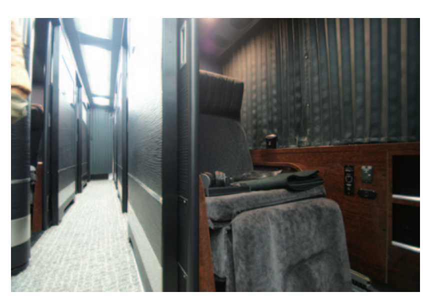


Fig. 21 Interior of Overnight Bus with Doors Providing Private Booths

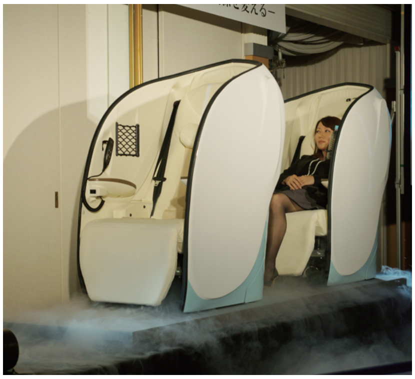


Fig. 22 Overnight Bus Using Shell-Like Partitions

Fig. 23 Interior of Luxury Sightseeing Bus Offering an Overwhelming Sense of Openness (JTB/KM Sightseeing Bus)

Fig. 24 Luxury Sightseeing Bus Keeping Tour Prices in Mind and Providing 24 Seats (Club Tourism/Kanachu Kanko)

Fig. 25 Toyota Sora Fuel Cell Bus Exhibited at the Tokyo Motor Show

with an interior divided in two classes consisting of 14 high grade seats and four highly independent seats.

1. 1. 4. Charter Bus Limiting Passenger Capacity of Expand Passenger Space

These vehicles are all luxury buses with a passenger capacity limited to 10 to 19 people and used exclusively for top-grade tours by travel agencies. All of them include the large lavatory (taking up the width of the vehicle body at the rear of the bus) that has been popular in the last few years and, with features such as taking advantage of the room provided by the seat pitch to provide a space for luggage while eliminating the overhead shelf and replacing standard curtains with roll curtains, offer a spacious atmosphere and an unobstructed view. Dark blue or dark green metallic colors providing a sense of luxury are chosen for the exterior, and the outer panels are expected to have excellent smoothness and a high level of paint quality (Figs. 23 and 24).

1. 1. 5. Buses Exhibited at the Tokyo Motor Show

The Tokyo Motor Show was held in October 2017. Since the format differs from that of U.S. or European business shows, bus exhibits were limited to four vehicles, most already available on the market, but also featuring the Sora fuel cell bus exhibit by Toyota Motor Corporation. Designed as the base models for 100 vehicles to be put in operation by the Bureau of Transportation of the Tokyo Metropolitan Government and other operators before the start of the 2020 Tokyo Olympic and Paralympic Games, it offers a vast array of advanced functions, including support for precise arrivals at bus stops through automatic steering using detection by camera, ITS Connect, which ensures safety through vehicle-to-vehicle and roadside-to-vehicle communications, and a bus peripheral monitoring function. Outward opening plug doors, which are becoming widespread in Europe, are used for the middle doors. The exterior and interior that differ from conventional Japanese-made buses caught the eyes of visitors. Nevertheless, the vehicle layout remains close to that of conventional models, using a low-entry structure with a difference in level on the rear side of the middle doors.

1. 1. 6. Buses Exhibited at Bus Tech in Shutoken

The Bus Tech Forum in Osaka in May and Bus Tech in Shutoken in autumn are annual events that allow people involved in the bus industry to promote their latest buses, equipment and accessories. Exhibitors have been outdoing themselves at each iteration of the events. Twenty-six new buses were exhibited at the Bus Tech Forum in May. Mitsubishi Fuso Truck and Bus Corporation held demonstration and test rides of bus safety systems, such as the latest collision mitigation braking sys-

Fig. 26 High Decker Prototype Bus Unveiled at the 2017 Bus Tech Forum

Fig. 27 Prototype Altis Electric Bus by Alstrom, a Manufacturer with Experience in Railway Cars

tem, unveiled for the first time. The November Bus Tech in Shutoken feature thirteen new bus exhibits, including vehicles presented in Japan for the first time. The Hino Motors, Ltd. wheelchair lift-equipped vehicle stows the lift itself in the trunk and offers super ingress/egress operability and an excellent interior layout. The Mitsubishi Fuso prototype high decker bus with an elevator (Fig. 26) was exhibited, with wheelchair users directly asked for their opinion. A demonstration of the automatic engine compartment fire extinguisher was also held, heightening appreciation of the opportunity to experience new bus technologies.

2 Buses outside Japan

European urban buses have accelerated their shift toward electrification, and Chinese-made buses, which have recently learned from European bus manufacturing, are deploying electric buses in no way inferior to European-made buses to articulated, double-decker, and sightseeing buses. Meanwhile, in the U.S., sales of both electric and fuel cell buses are increasing. Buses outside Japan are proceeding along a path quite different from that of Japanese-made buses.

In China, the 2010 Shanghai World Expo prompted the commercialization of electric buses, and the accumulated experience leveraging the large market scales has reportedly resulted in half of the over 70,000 electric buses in operation worldwide consisting of Chinese-made vehicles, which are also rapidly gaining market share in Europe, where a growing number of urban buses are electric buses. In response, the Europeans are making efforts to use the trust in the technology built up through railways and tramways as a stepping stone to gain electric bus market share. Although European transport operators put their faith in locally manufactured completed vehicles, bus manufacturers have been transferring their production bases to Eastern Europe or Turkey, where labor costs are lower, to compete with the low vehicle price of Chinese-made buses. In addition, bus manufacturers in NIS countries also have their eyes set on expanding into the European market. In that sense, the globalization of the bus market is advancing rapidly.

The development capability of component manufacturers skilled in drive trains has contributed to the spread of full flat non-step buses ensuring a non-step floor over the entire length of the vehicle in Europe. Similarly, components allowing the remodeling of diesel bus drivetrains into electric buses have been developed, and their adoption is encouraging the quick introduction of products. This is a concept currently lacking in Japanese-made buses.

In buses that emphasize the interior space occupied by the passengers, it may be tempting to think that electrification itself has little impact on design, but some unique prototype vehicles are occasionally introduced.

When a European bus manufacturer proposed an articulated bus design that also envisioned use as a tram a few years ago, another manufacturer skilled in making railway vehicles responded by developing an electric bus. The use of all-wheel steering at the four corners to maximize interior space was a surprising proposition only achievable in an electric bus in which the engine and drivetrain do not need to be considered.

Appealing designs are also found in light-duty buses targeting small-scale demand routes, including community buses and buses used in cities where the old city center has many narrow roads. Until now, the mainstream light-duty bus design was based on either a front-engine semi cabover van or the Japanese-made front-engine full cabover design, but more attractive choices are gradually found around the world, many of which are also electric buses (Figs. 28 and 29). Despite being described as light-duty, these electric buses boast practical performance by offering cruising ranges of 100 km or more on

Fig. 28 The Karsan Jest, an Example of an Appealing Electric Light-Duty Bus

Fig. 29 The Wolta, an Example of an Appealing Electric Light-Duty Bus

Fig. 30 Proterra Electric Bus Boasting Excellent Performance

a single charge.

Since 2000, a slanted front style has become standard in U.S. urban buses, which have also made clear technological advances, including the introduction of electric buses with a maximum cruising range of 560 km. Designs that make a non-step bus feasible despite storing the battery in the underbody and enhancing function without changing form to eliminate customer resistance exemplify the characteristic features of U.S. buses (Fig. 30.)

Every year, this article presents topic of interests concerning buses outside Japan, but it cannot cover everything. Instead, the background leading to such a diversity of topics will be presented.

There are numerous bus manufacturers outside Japan, with vehicle safety regulations boiling down to either the European or U.S. standards. Even with two types of standards, many countries comply with both, resulting in a substantial market size. At the same time, the development capability of component manufactures is leveraged to speed up the completion of products, and the increasing commonization of various technologies also plays an important role. Another factor is the high degree of interest invested in the technological upgrading of bus transportation by governments, which is one of the reasons underlying the differences with buses in Japan. Collaboration with the main public transportation operators must not be overlooked either. This probably stems from a shared recognition of the social role of public transportation and of the economic benefits of public transportation-related industries.

3 Summary

The technological advances faced by the automotive industry are affecting buses, which represent an everyday appliance for ordinary people, in various ways.

Looking only at the Japanese bus market might give the impression that the scope of international information, such as the spread of electric vehicles, automated driving technologies, and the participation of IT corporations, is limited, but some advanced technologies, including the bus location system with which users in Japan interact, and real-time operational management of long-distance buses have already been put into practice. Just as the number of imported buses rose after the number of Japanese-made bus variations dropped, operational or safety technologies from other countries may be introduced in Japanese buses. Similarly, despite the current small number of cases, it is possible that technology found in Japanese buses will be disseminated around the world. That, in a nutshell, is globalization.

Important decision-making elements range from discussions on what source of energy is appropriate to power Japanese buses and also includes a plethora of other topics, including the role of drivers based on user needs, and the perspective of those users must be the yardstick used in selecting those topics. The repeated discussions to ensure healthy and sustainable development for buses in the U.S. and Europe also arise from a recognition that buses represent an infrastructure worth using effectively to keep social costs down and believed to prove useful to improving the day-to-day life of people in other countries or regions. At the same time, it must be remembered that the relevant technologies are perceived as offering a great business opportunity.