BUSES

Overall Trends

1 Introduction: Social Trends and Needs Affecting Buses

Among vehicles, buses have a small market scale but unlike trucks, which are also production goods, they are distinguished by the fact that they only transport people and that the needs of bus operators are essentially fixed. Consequently, the needs of the operators are directly reflected in the vehicles. The prerequisite of reliability results in a strong tendency to prefer vehicles with a conservative approach over those presenting major changes. With respect to bus vehicle technology, a system where the Nihon Bus Association takes the lead in compiling an "improvement wish list by brand (model)" from the main nationwide operators and calls upon manufacturers to address it has been firmly established for over 50 years, and these wish lists have been applied to improving ease of maintenance and durability. Improvements that are not urgently required are typically applied when performing one of the product updates known as a complete or major redesign, and as with trucks, it has become customary for such upgrades to be triggered by new environmental regulations.

Buses are no exception to the rapid advances in automotive technology and various innovation spurred by changes in the environment. Beyond conformity to regulations and the maintenance-based wishes of operators, social trends affecting buses are fostering changes in the bus industry, and the fact that buses are highly social vehicles means that many of those changes turn into needs that influence the evolution of technology. This perspective will inform the discussion that follows on the how the environment around buses in 2016 influences their technology.

1.1. Influence of the Karuizawa Ski Tour Bus Accident.

Shortly after 1 AM on January 15, 2016, a bus on its way to a ski resort in Karuizawa, Nagano, veered off the road and collided into trees, sustaining heavy damage. This serious accident cost the lives of 15 people, mainly university students. This was the highest number of bus fatalities since the 1985 accident involving a bus falling into the Sai River in Nagano, and the accident shocked society.

Immediately after the accident, the media presented images of the wreckage of the over 3.5 m tall super high decker tangled in trees with its cabin, which should have been about 2 m high, collapsed to about 1 m near the middle of the vehicle. It then came to light that the accident involved factors such as the bus veering off the road at a speed well over the limit, the driver being elderly and having minimal experience driving heavy-duty vehicles, and the bus traveling on a different route than scheduled. Later, it was also learned that the contract between the bus company and the travel agency, as well as the operation management framework, were full of infractions. These infractions were due to sloppy management practices, and measures following the accident focused primarily on improving the quality of bus operators and strengthening their management frameworks, and did not lead to the feared major damage in reputation for the entire sightseeing bus industry.

In contrast, although the investigation on potential technical causes is not finished, no fault has been found in the brake system. The significant deformation of the bus body also received attention, as had the severely damaged, torn wreckage of the still remembered severe expressway tour bus accident on the Kan-Etsu Expressway (April 2012), where the bus veered off the road shoulder and crashed into the soundproofing wall.

The bus in the Karuizawa accident was a 2002 model that was compliant with international standards for bus body rigidity (R66). These standards stipulate that passenger survival space must be ensured if there is deformation when a stopped bus is made to roll over from 800 mm above the ground. The survival space is defined as a

maximum deformation of 150 mm inward where the side direction has height of 500 mm above the floor, and 400 mm inward where that same height is 1,250 mm. Consequently, 1,250 mm of vertical space must be secured above the floor, but the pictures of the accident show that the roof crashed into trees almost exactly at its midpoint, subjecting it to concentrated loads that explain its significant deformation. Even current international regulations do not account for this kind of concentrated stress. It is safe to say that the extent of the speed and impact at the time of the accident were far beyond the what the designers had anticipated, making it more feasible to consider ways of prevent buses from veering off the road. This need to ensure safety is common to all automotive technologies, but it goes without saying that it becomes even more crucial in buses, where a single driver holds many lives in his hands. More objective evaluation criteria, and a work management system supporting them, have become prerequisites to continue guaranteeing the heretofore taken for granted skill level and experience of drivers—their quality, in other words, in the future.

It was not raised as a problem in this case, despite the vehicle in the accident having been in operation only slightly longer than the 11 year national average for charter buses, deterioration such as corrosion of its chassis stood out, and, upon selling it, the previous owner reportedly warned the operator that continued use was dangerous. Attention must be drawn the fact that the new operator actually kept the bus in operation after being warned of the danger of continuing to use it. While following up on the maintenance status of new vehicles is possible to some extent, doing so for vehicles that have changed hands several times is difficult. Use environment and the actual maintenance performed means that not all vehicles are in the same condition. It is imperative to immediately correct situations were vehicles identified as dangerous remain in operation.

Measures to expand the inspection and maintenance of aged vehicles are also urgently needed. Although some major operators have increased the number of maintenance inspection items for aged vehicles and pay particular attention to when parts or lubricants must be changed, doing so is not mandated by law. There is probably a need for extensive inspections of aged vehicles targeting operators without a proper maintenance framework.

The number of years buses remain in service continues to rise. Although this can be described as a result of parts and manufacturing quality, the degradation of bus operator business environment cannot be overlooked. It has become commonplace for operators unable to afford new vehicles to rely on used vehicles as replacements.

This may partially stem from the fact that the exterior styling of Japanese-made heavy-duty sightseeing buses does not change. In effect, there are only two styles of current Japanese models. The last complete exterior redesigns date to 2005 and 2007, which corresponds to the average vehicle age of charter buses in Japan. It aged vehicles cannot be distinguished from new ones, it is possible that the number of years they remain in service will rise even more. Although the fact that aged vehicles do not become obsolete is not a bad thing in and of itself, there is something to be said for modifying the external styling of buses in terms of revitalizing the market.

Given the premise that bus operations must ensure profitability through fare revenue, the rise in vehicle prices that accompanies compliance with environmental regulations cannot simply be ignored. In that respect, manufactures could effectively provide users with data showing how the superior environmental performance and improved fuel efficiency of new vehicles makes them more advantageous than superannuated models in terms of total cost, including maintenance. There is a need for persuasive activities aimed at educating operators who follow the principle of necessity knows no law.

1. 2. Overview of Technology Supporting Safe Bus Operation

The measures taken after the Karuizawa accident described in the previous section mainly focused on arrangements concerning intangible elements. The most important requirement for a bus operating business is instilling a corporate culture that makes safety the top priority not just for the obvious candidates represented by the drivers, mechanics and operation managers involve in operating the buses, but for the executives as well. The government is moving quickly to investigate operators with low safety awareness, reinforce the mechanisms to impose withdrawals as necessary, and recover consumer trust. At the same time, the spread technologies that support safe driving is setting higher expectations.

The latest heavy-duty sightseeing vehicles are being equipped with collision mitigation braking systems, fol-

lowing distance warning systems, lane departure warning systems and vehicle stability control. Further, more and more vehicles include driver monitoring systems that monitor the driver's gaze and to prevent distraction or drowsiness. In addition to those systems, accessories that detect signs of drowsiness from veins in the driver's ear have become available and are gradually being adopted by bus operators.

Some bus operators have also introduced systems that combine the alerts detected by those accessories or devices with drive recorder images to perform constant monitoring from the office and apply the information to the management of operations. It has now become possible to check operations and ascertain the driver's constantly from the time the bus leaves the depot to the time it returns, and some operators have started doing so.

In the truck industry, vehicle operation management systems that can check the temperature inside the refrigeration compartment or the fuel efficiency of a refrigerator truck in operation are being sold. Manufacturers are endeavoring to apply the knowledge gathered from actual operation data to their development projects, but in the bus industry, it is rather the needs of operators that has led to advanced operations management systems. When a sudden braking or unstable driving alert is emitted, actions such as the operation manager at the office checking the drive recorder image and communicating the need for caution to the driver have become possible (Figure 1).

However, when systems such as these also include information on the vehicle, there are restrictions imposed by differences between models. Among Japanese-made buses currently in operation, there are also cases where, for the same model, urban route buses and sightseeing buses made by different developers are reciprocally supplied as OEM models. Systems that differ by model are expected to eventually speak a "common language".

At the IAA Commercial Vehicles motor show held in autumn 2016, leaders from European truck manufactures gathered to discuss the significance of building a common electronic control system platform. This also comes across as a statement that automakers, rather than communication equipment makers, have taken the initiative in the field of connectivity, which is essential to achieving automated and autonomous driving.

Fig. 1 System enabling monitoring of on-board device alerts from the office

1. 3. How to Interpret New Needs

It goes without saying that achieving safety is the predominant concern of bus operators, and with several severe accidents highlighting the principle of getting what you pay for, there is growing consumer awareness that safety involves costs. Two years have passed since the lessons learned from the severe accidents of the past have led to revising the system for charter bus fares and pricing. The bus fares imposed on consumers have been rising, and more and more bus operators are reinvesting that money in improving safety systems and enhancing comfort. This trend became even more pronounced in 2016, with the launch of luxurious charter buses and overnight expressway buses equipped with every comfort throughout Japan. Although specific examples will be presented in a later section, many of these cases go beyond the bus manufacturing lines. Given the exceptional added value offered by these high-specification buses that reflect user desires, it is crucial to bolster the capability to meet orders for such buses.

The current situation regarding aged buses in operation has also put vehicle fires in the spotlight. A bus burning down on a city street during daytime does not just draw public attention, it also significantly damages the image of buses. Analyses of recent bus fires reveals that while almost half started in various locations such as the electrical system or the wheels and are attributed to poor servicing, over half of the fires broke out in the engine compartment. In Europe, the tightening of emissions regulations was followed by frequent bus fires. These were caused by the rise of the engine combustion temperature. Automatic fire extinguishers (Fig. 2) for the engine compartment were developed when its higher temperature conditions were confirmed. Upon detecting a fire in the engine compartment, the extinguisher sprays

Fig. 2 Engine compartment automatic fire extinguisher

a fire retardant (antifreeze) compressed to 100 bars and converts it to water mist to automatically extinguish the fire. This system is highly rated for not requiring electrical power. Its use has been made mandatory in Europe and North America for some applications, such as school buses, and it is also commonly found on urban route buses.

This fire extinguishing system is also available in Japan, and while some operators have finished installing it on all their buses, consisting mainly of expressway route buses, there is a large gap between them and executives who, for example, are not even aware that such devices exist. Although mandatory installation is desirable from the standpoint of users, top priority should be given to installing these systems in school buses, luxury charter buses, and overnight expressway buses designed to let passengers sleep soundly. Installing the system reportedly costs 500,000 yen per vehicle, including labor. Some Japanese bus manufacturers have expressed concerns over the impact on the price of the vehicles or the negative image projected by adopting measures against fires breaking out in the engine, but there is no point in refraining from taking steps that can keep unexpected accidents at bay or prevent damage from escalating. Further reductions in cost can be expected if the possibility optional settings are provided.

In a different vein, the Karuizawa accident once again underscored the necessity of wearing seat belts. The bus industry is united in calling for seat belt use with one voice, and various products, such as systems allowing seat belt use monitoring from the driver's seat, or seats featuring a warning lamp that lights up when the seat belt is not worn, are being developed. In passenger vehicles, it is easy to set up warning lamps or sounds to encourage seat belt use, but special consideration is required in buses. In addition, based on situations where the seat belt could not be removed and hindered escape from the vehicle, there are now also cases where a tool to easily cut the seat belt is included.

1.4. Changing Circumstances Affecting Charter Buses

After the record of 19,737,400 visitors to Japan set in 2015, the number of tourists has continued rise steadily, and exceeded 24,039,000 in 2016, which represents a 21.8% growth rate.

While the increase in foreign tourists stands out in large cities such as Tokyo and Osaka, the small absolute size of the local population in regional cities featuring tourist attractions gives the strong impression of a relative rapid rise in the number of foreign tourists. Even as they scramble to respond to the immediate demand, bus operators offering routes popular with tourists from abroad are increasingly addressing the need to offer information in multiple languages by offering services such as interpretation through tablets or other devices.

At the same time, with many travelers using the Internet to find information operators are rushing to implement means to guide those travelers to their own routes and build reservation systems targeting individual travelers, and the development of such systems has been building up momentum as a business opportunity.

In contrast, the shortage of bus operators, particularly regional operators, is turning into a serious problem. Some operators have suspended the operation of long distance expressway routes to ensure that transit bus routes necessary to everyday life remain in operation. There are also operators adopting the approach of hiring high school graduates as mechanics or salespeople and retraining them into drivers. The limited number of people holding a Category 2 large vehicle license also means that some drivers remain active almost up to the age of 70. Vehicle technology has already progressed in terms of labor saving and automation, and is now required to become friendlier to inexperienced beginners and elderly drivers. For buses, which have traditionally been operated by drivers with relatively high levels of skill and experience, one major concern, which overlaps with automated driving and other future technologies, involves thinking about parts of driving that can be performed through on-board technologies.

Although labor shortages in operational departments are not limited to the bus industry and are said to also be a serious problem in other industries such as delivery services, reduced overtime pay resulting from thorough

labor management has led some drivers to switch from the bus to the truck industry. Automated driving is a topic of the times in automotive technology, but whether unmanned operation will be accepted in the bus business where transporting mutual strangers and accepting fares are major factors, as well as the role of bus drivers and ensuring sufficient staffing, remain issues that society as a whole must address.

1. 5. Effect of the Tokyo Olympic and Paralympic Games

As the hosting of the 2020 Tokyo Olympic and Paralympic Games approaches, the development of Japanese-made non-step articulated buses and the operation of mass-produced fuel cell buses have been defined as innovations in bus transportation. The delay in the relocation of the Tsukiji Market makes some bus operating routes unclear, and other than the announcement that the articulated buses in development would be hybrid vehicles rather than pure diesel buses, no noteworthy activities took place in 2016.

Toyota has been running fuel cell buses in some cities, with plans for approximately 100 buses to operate in the Tokyo Metropolitan Area in 2020. The first two business vehicles for the Bureau of Transportation of the Tokyo Metropolitan Government, who is the vanguard of those operations, were delivered at the end of the 2016 fiscal year (March 2017). Already proven driver support technologies will reportedly be included in upcoming mass production vehicles.

2 The Bus Industry in Statistics

2. 1. Passenger numbers

The number of bus passengers in 2016 was 4.57 billion, 4.27 billion of whom rode transit buses and 0.3 billion rode charter buses.

On a macro scale, the numbers remain virtually unchanged (Fig. 3), but the number of transit buses has risen for three consecutive years. Since the number of charter bus passengers decreased by 30,000,000 compared to the previous year, this represents an increase of 0.1 billion for transit buses. The growth rate for the number of passengers is 2%, but compared to the steady population growth seen in large cities (the three metropolitan areas of Greater Tokyo, Tokai, and the Kyoto-Osaka-Kobe area), the number in other regions continue to decline, and the disparity is growing.

As of the end of March 2015, the number of passengers riding expressway route buses, which fall in the transit bus statistical category, was 108,615,000. Over the last several years, buses have been seen as an option for inter-city travel and accounted for 2 to 2.5% of the number of passengers on transit buses. In Tokyo, the development of a large-scale terminal and use by foreign tourists will continue to spur steady demand. However, further increasing the number of passengers will require increasing the number of long distance trips to respond to the surge in demand, and high expectations are being placed on securing a stable pool of drivers.

Fig. 3 Passenger volume (number of passengers)

Since the supply-demand adjustment regulation was abolished, the number of charter bus operators has grown rapidly, with approximately 4,500 companies doing business throughout Japan. Over 70% of those companies are small-scale operators that own fewer than 10 buses, which represents a significant difference with transit buses. Therefore, they tend to play a subordinate role to the travel agencies placing orders, which has led to harmful effects, leading to the previously mentioned revision of the system for charter bus fares and pricing. At the same time, an upper limit on the distance driven per day was set for the purpose of achieving safe operations. Due in part to that measure, the number of vehicle kilometers per day, which stood at 187.3 km in 2012, has been decreasing and dropped to 163.9 km in 2014. The same trend is observed in regions where long-distance transportation was typical, such as Hokkaido, and travel agencies have been switching to travel plans emphasizing flexibility through approaches such as reducing the

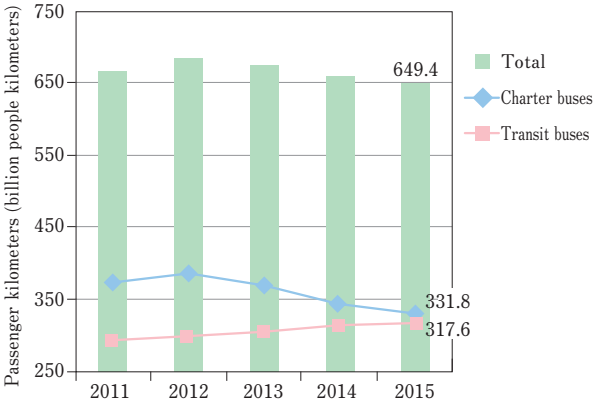
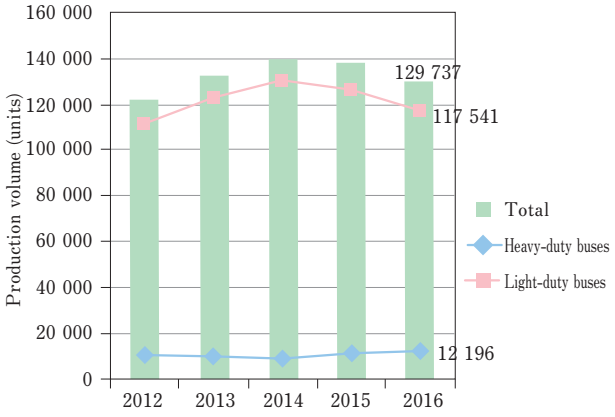


Fig. 4 Passenger volume (passenger kilometers)



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

Fig. 5 Bus production in Japan

distance traveled in one day and increasing the number of overnight stays. This, of course, increases the price of the trips. In addition, changes such as previously thriving foreign tourist group tours being replaced by travel in small groups or individual repeat travelers are also affecting the number of charter bus passengers.

The passenger volume, in which the distance traveled is factored in the number of passengers (passenger kilometers, Fig. 4) exhibits an increase in transit buses, reflecting the effect of expressway route buses that travel long distances, but for the reasons stated above, charter buses are clearly driving shorter distances.

2. 2. Market trends, Production and Registration

The number of buses produced in Japan has declined for three consecutive years, which reflects the drop in the number light-duty buses produced as the number of heavy-duty buses has increased over those same three years (Fig. 5).

Figures for the number of buses produced by vehicle category have not been released in the latest statistic

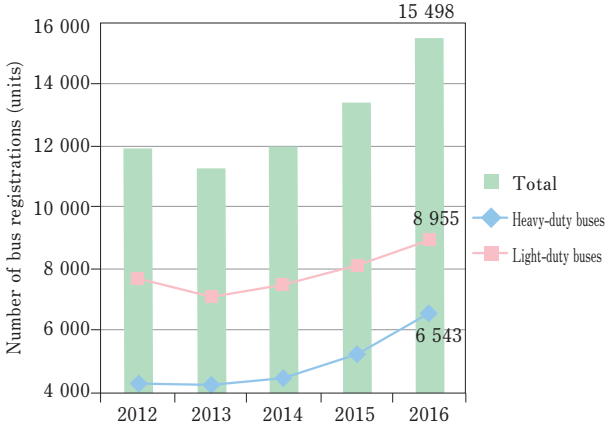


Fig. 6 Number of bus registrations in Japan

documents, but for heavy-duty buses, it seems reasonable to assume the increase is in the number of sightseeing buses since there is little fluctuation in the size of the market for urban route buses. There is no doubt that the rise in the number of foreign tourists and the above-mentioned system for charter bus fares and pricing have contributed to this strong production. Depending on the country, the political situation and exchange rate cause ebbs and flows in the number of foreign tourists, and the number of travelers from Asian countries other than Taiwan or China, as well as from Western nations, is rising. The growth of the Japanese bus industry hinges on getting people abroad to perceive Japan as an attractive destination.

Backed by a vigorous market, bus manufacturers are boosting their capacity to increase production through measures such as improving manufacturing efficiency and two-shift schedules in an effort to shorten delivery times. Moreover, as stated earlier, work involving secondary modifications to respond to diversifying customer needs is booming, and playing an increasingly important role in supporting orders. The number of registrations is also maintaining an upward trend (Fig. 6).

The production of super high decker buses, which was below 100 units in 2011, has started to rise as more operators have invested in vehicles, and 376 units were registered in 2016.

2. 3. Imports and Exports

There is considerable variation in bus exports due to the economic conditions and exchange rates in the destination countries, and exports declined in 2016, to 93% of the previous year (Fig. 7). Exports to Asia, the main destination for Japanese-made buses, remain strong, but those to the Middle-East and Africa have decreased (Fig. 8).

Fig. 7 Number of buses exported

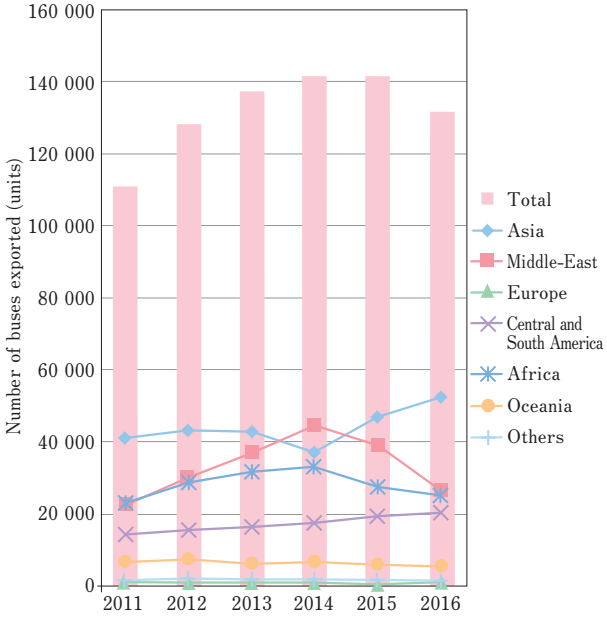


Fig. 8 Main export destinations

From the 1950s to 1970, many Japanese-made buses, including heavy-duty buses, were exported as completed vehicles and contributed to the acquisition of foreign exchange. This was the template underlying the development of buses targeting the Japanese market, but recent completed vehicle exports have been limited to light-duty buses, and heavy-duty buses are now only exported as CKD engine or chassis component packages. Higher development costs per vehicle cannot be avoid for completed vehicles aimed only at the Japanese market.

For many years, front-engine, cabover light-duty buses highly regarded for their durability, reliability, and quality, were the exclusive province of Japanese manufacturing, but the market has been expanding with the introduction of reasonably priced Chinese- and South Korean-made competing vehicles.

Inter-city and sightseeing buses in emerging countries,

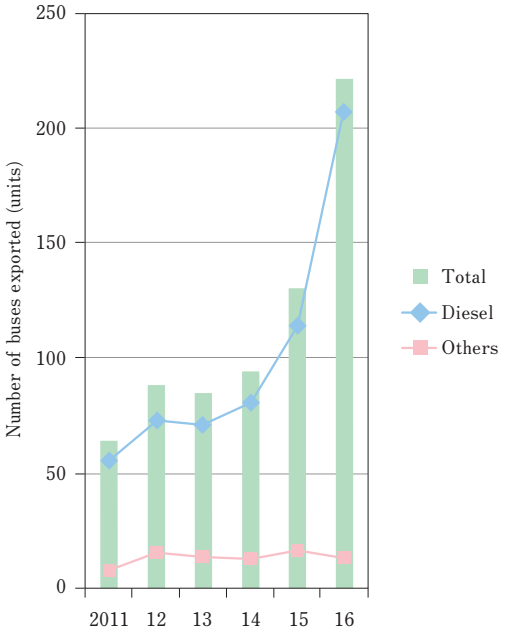


Fig. 9 Number of imported bus registrations

where durability is required, are the main export outlets for heavy-duty buses, and manufacturers have fallen behind in responding to the growing demand for low-floor urban buses in various regions. The direction of future trends can only be described as depending on the capability to provide the advanced buses demanded in various regions.

One example of a new trend is the export of completed vehicles developed and deployed in the Japanese market to Australia which, like Japan, is a right-hand drive country. Interest is focused on how the situation will evolve in terms of whether exporting heavy-duty bus and rear-engine light-duty bus completed vehicles for urban areas will lead to wide-ranging exports, as well as how they will be received locally.

Figure 9 shows the number of imported bus registrations. Sales of the Universe bus, which is made by the South Korean Hyundai Motor Company and was introduced in Japan in 2009, have been rising as it has attracted not only new operators, but also repeat customers, and this model has accounted for the majority of buses imported over the last several years.

The number of articulated buses, which are not available as Japanese-made buses, has also been growing, and operators adopting them are benefiting from a larger selection. In addition, sales of double-decker buses in Japan stopped approximately seven years ago, but increased demand for replacements has led to the import of com-

pleted vehicles from Europe.

Chinese-made sightseeing bus completed vehicles have also been imported to meet the demand for small group charter buses, and the import of completed vehicles from Taiwan, home to a large number of visitors to Japan, has been announced. These trends were triggered by the decline in options caused by the standardization of Japanese-made buses and reflect the new needs of operators.

3 Regulatory Trends

All buses currently sold in Japan are compliant with the latest environmental regulations, the next-generation 2016 emissions regulations are just around the corner. Existing diesel vehicles with a gross vehicle weight exceeding 3.5 tons will be required to comply with the standards as of September 1, 2017. They involve cutting nitrogen oxides by approximately 40% and a change in test cycles, and both Japanese and imported buses are gradually being adapted to comply with these standards.

4 New Buses

This section presents the new bus models launched in 2016 in chronological order by size category. There were few new heavy-duty bus models partly because of the upcoming next-generation emissions regulations.

4. 1. Light-Duty Buses

In June, the Toyota Motor Corporation light-duty HiAce Commuter bus received a full complement of safety systems including vehicle stability control (VSC), traction control (TRC), and a hill start assist function. At the same time, the emergency brake signal function, which makes the hazard life flash when the brakes are applied suddenly to warn following vehicles, was made standard equipment.

Last December (2016), the Toyota Coaster was completely redesigned (Fig. 10). The Coaster is a light-duty bus exported to over 110 countries and regions around the world with recent vigorous sales exceeding 20,000 units per year (including units produced in China). This was its first redesign in 24 years, and it was prompted by the application of the ECE-R 66 regulation concerning body rigidity (rollover performance) to light-duty buses and the anticipation that more export destinations will adopt it. The new model achieves greater rigidity through the use of a cyclic frame that integrates the roof, side, and floor frames (Fig. 11) and high strength steel sheets, and is compliant with the regulation. At the same time, the design of the body was revamped to give the entire vehicle a high roof, resulting in an overall boxy silhouette. This has expanded the cabin dimensions and improved comfort.

Fig. 10 Toyota Coaster

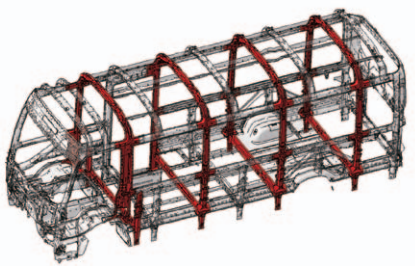


Fig. 11 Toyota Coaster cyclic frame

Representing components used in advance in some 2016 models, this bus is equipped with a 6-speed AT or 5-speed MT attached to an inline 4-cylinder engine with a 4 L displacement, as well as a double-wishbone independent front suspension and a rear leaf suspension. Also, since components such as driver and passenger seat airbags were made common with those of passenger vehicles, the electric equipment runs on 12 V. The Hino Liesse II, an OEM Coaster model, was also launched in the same manner.

4. 2. Medium-Duty Buses

In April, Isuzu Motors Limited completely redesigned its Erga Mio medium-duty route bus (Fig. 12). Adopting the modular design of the August 2015 complete heavy-duty bus (Erga) redesign, this updated design features a layout that integrates the plastic fuel tank into the wheel house, and all vehicles in the lineup also inherit the non-step front and middle doors from the Erga. The engine compartment has been downsized, lengthening the effective cabin length by 135 mm without changing the total vehicle length. The recesses for the sliding middle doors were made thinner, expanding the interior cabin dimensions. It is equipped with the same inline 4-cylinder engine with a displacement of 5.2 L as the Erga, which re-

Fig. 12 Isuzu Erga Mio

Fig. 13 New double-decker bus for the Japanese market imported by Hato Bus

duces power and improves fuel efficiency compared to the previous model, and also does not require the AdBlue aqueous urea solution. As 6-speed AMT has been made the standard transmission combined with the engine.

The Erga Mio integrated model, the Hino Rainbow, was launched in May. Without ornamentation, both models look identical.

4. 3. Heavy-Duty Buses

In May, Mitsubishi Fuso Truck and Bus Corporation refined the Active Mitigation Brakes (AMB) system on its Aero Queen, Aero Ace, and Aero Ace Short Type models. This refined system, dubbed AMB 2.0, establishes merges the existing AMBs for buses and heavy-duty trucks into a common system and boosts braking force. There are no changes in appearance from the previous generation.

4. 4. Imported Buses

4. 4. 1. Scania/Van Hool TDX24 Astromega

In March, Hato Bus, which operates regular sightseeing buses in Tokyo, acquired new double-decker bus models. This model, built on a Scania chassis by Belgian manufacturer Van Hool, who has delivered double-decker buses to Hato Bus in the past, addresses the needs of Hato Bus, which had been looking for replacement vehicles since Japanese double-decker buses when out of production. It is equipped with a Euro VI compliant inline 6-cylinder engine with a displacement of 12.7 L, and its transmission is a 12-speed AMT. The model features dedicated specifications for Japan, including a vehicle height of 3.8 m and length of 2.5 m to comply with Japanese regulations, and unique weight reduction efforts for the purpose of calibrating axle weight (Fig. 13).

4. 4. 2. Mercedes-Benz Citaro G

The 31 Euro IV compliant Mercedes-Benz articulated buses operating in Japan made their debut in the country in October (2017). Switching to a vertical engine layout to achieve the non-step floor reaching all the way to the rear for the European market increased the total length of the bus by 0.2 m, but there have been no major changes in the right hand drive model for the Japanese market. It is equipped with a 10.7 L engine and a 4-speed automatic transmission (Fig. 14).

Fig. 14 New Mercedes-Benz articulated bus

4. 4. 3. Scania–Volgren articulated bus

This articulated bus, which features a width of 2.5 m and an allowable axle weight of 10 tons for compliance with Japanese safety regulations and was first brought into use in the city of Niigata in 2015, has also been adopted by the city of Fukuoka. While riding capacity is limited to 116 passengers in Niigata due to restrictions applying to bridges on the route, the vehicles in Fukuoka, which has no such restrictions, have a capacity of 134 passengers, offering the full transport capacity inherent in articulated buses. However, since the axle weight standard is exceeded, it is a vehicle with special approval involving restrictions along the driving route (Fig. 15).

4. 4. 4. Yaxing Sightseeing Bus

November saw the start of sales of imported medium-duty sightseeing buses by manufactured Yaxing Coach of China. The bus has been designated Onoen Star by the import distributor. Its length of 8.14 m and total height of 3.36 m give it a unique size among medium-duty buses in Japan. It features a Euro VI Cummins 4-cylinder engine with a displacement of 4.45 L and an output

Fig. 15 Scania-Volgren articulated bus

Fig. 16 Chinese sightseeing bus imported as a completed vehicle

of 210 hp. The transmission is a 6-speed MT, but there are also plans to make an AT available (Fig. 16).

4. 5. New Technologies in Accessories and Devices Unique to Buses

An increasing number of sightseeing bus pursuing comfort and seeking to offer the pinnacle of luxury, as well as expressway route buses aiming to differentiate themselves, are increasingly including a large lavatory. These lavatories provide a dressing table and room for changing, and the toilets on these buses are also the first to offer a warm water cleaning function.

An increasing number of buses have been integrating an automatic ticket vending machine into the cooler box by the front door out of consideration for the narrow boarding space imposed by the fare box near the front door and the fact that many passengers are carrying luggage.

Design Trends

1 Buses in Japan

1. 1. Buses Planned and Introduced by Operators

Although bus operators who find value in differentiating buses such as charter or expressway buses have various needs, Japanese-made buses, as stated in the preceding section, have been reducing available options as they standardize their specifications, leading bus operators to turn their attention outside Japan. This section presents those Japanese-made buses launched in 2016 that stood out.

1. 1. 1. Willer Group Double-Decker Restaurant Bus

This is a Japanese-made double-decker bus, which has been refitted with a retractable roof and features a 25-seat restaurant on the upper deck and a kitchen on the lower deck, is a concept bus centered on enjoying a meal while traveling. Although inspired by the Paris restaurant bus, it has attracted attention for its innovative approach to regional revitalization though collaboration with farms and breweries, and it only operates in specific regions for limited periods. The roof is made of transparent polycarbonate and can be slid open or shut. It includes curtain to block the sun's glare, and can be fully opened in good weather (Fig. 17).

1. 1. 2. Shinki Bus Yui Prima

This is a premium sightseeing bus built upon a Japanese-made super high decker, with the interior and exterior design entrusted to a designer. The seats are arranged in six rows of 2 + 1, keeping riding capacity down to 18 people. On the left-hand side of the rear of the vehicle, facing the direction of travel, is the first toilet in a Japanese bus with a warm water cleaning function. The remaining rear space is taken up by a galley providing a drink service. The bus will be used exclusively for organized tours featuring carefully selected meals and accommodations, with service provided by specially trained staff. A two-day trip for one person starts in the 100,000 yen range. The exterior is a dark navy blue that almost looks black (Fig. 18).

Premium buses such as this one first appeared in 2008, but while their extremely high prices drew attention, they did not become popular. The bus operators who restored charter bus profitability did so by targeting financially comfortable elderly people, and seem poised to increase the number of vehicles in large urban regions to some extent.

1. 1. 3. Seats Designed for Comfort

Safety regulations for bus seats and seat belts have been reinforced in the context of harmonization with the

Fig. 17 Willer Group double-decker restaurant bus

Fig. 18 Interior of luxury charter bus introduced by Shinki Bus

Fig. 19 Demonstration model equipped with seats designed with comfort in mind

Fig. 20 Example of original design proposal for a light-duty bus

EC. Since then, seat options had been effectively nonexistent for bus operators, but there have been more and more cases of operators unsatisfied with the standard specifications bearing the costs of dynamic tests and adopting new types of seats. Figure 19 shows an example of a bus seat exhibited at the Tokyo Motor Show in 2015 mounted in an actual bus, which was unveiled at the Bus Tech Forum 2016 exhibition, where visitors had the opportunity to experience bus and other related technologies.

1. 2. Proposals by Japanese Manufacturers

J-Bus, which manufactures Hino Motors rear engine light-duty buses, has remodeled its mass-produced bus to propose the Routon Jr. as a model for operators seeking differentiation offering two types of original designs. Some remodeled buses like these, which promote their superiority in terms of delivery times, quality, and cost, have been adopted in tour buses or community buses that focus on urban sightseeing as a selling point.

2 Designs Observed in Buses outside Japan

2. 1. Mercedes-Benz Future Bus

In July 2016, Daimler used part of Western Europe's longest dedicated bus lane in the suburbs of Amsterdam, Netherlands, to demonstrate the vehicle performing automated driving, automated steering, as well as automated halting at bus stops and letting passengers on and off. While the company describes it as the semi-autonomous second stage of the five automated driving stages, the driver simply switched the semi-autonomous mode on at the first stop in the dedicated lane, then did nothing more than lightly hold the steering wheel when going past an oncoming vehicle, never touching the pedals as the bus repeated the cycle of starting, accelerating, and stopping at both traffic signals and bus stops.

The vehicle used in that demonstration is an original design called the Future Bus. Based on the Mercedes-Benz 12 m Citaro (with a vertically mounted rear engine), it makes no major modifications to the chassis, but the vision of designers is fully expressed in both its exterior design, which includes bold window graphics and a layout with only a middle door, and in its interior design. It uses LEDs for lighting, and substitutes side mirrors with camera-based recognition (Fig. 21). Of particular interest is the fact that the aim of exclusively driving European urban route buses increases the independence of the driver's seat and deliberately moves toward a layout that does not call for the type of customer interaction seen in Japan and yet, perhaps because less energy is expended on driving, the driver's seat has an open design that facilitates communication with passengers.

Fig. 21 Semi-automated Daimler Future Bus

Fig. 22 Neoplan Tourliner

2. 2. Neoplan Tourliner

Neoplan, which is responsible for the sightseeing series under the MAN umbrella, first unveiled a complete redesign of the Tourliner, a long-distance travel entry model superior to the Jetliner multi-purpose sightseeing bus used on inter-city routes, at the 2016 International Motor Show Germany. Recognizable as a Neoplan design at a glance with its style that does not break with the family identity, it offers improved aerodynamic characteristics and a purported CD of 0.36. The use of multiple LEDs in the interior is in line with the recent trend among European manufacturers (Fig. 22).

2. 3. Volvo Bus 7900 Electric Bus

Volvo Bus disclosed this bus at the 2016 International Motor Show Germany, actively promoting its lack of emissions and exceptional quietness. Unlike the models in the market with a straight line at the base of the side windows, this model has been given window graphics that exude dynamism. The bus uses an overhead charger rather than a rapid charging pantograph on the side of the vehicle, an approach that proves advantageous in terms of weight and motive power (Fig. 23).

2. 4. New Solaris Urbino Electric Bus

This Polish urban route bus made its debut in 2014. Despite the surprise caused by its radical design, it not only enjoys a predictable overwhelming market share in its native Poland, but has also been expanding its sales in other European cities. The manufacturer is actively producing hybrid and electric buses, and the picture (Fig. 24) shows a vehicle operating in Hannover, Germany. Batteries and control instruments are mounted in the roof, and the rear of the bus is equipped with a rapid charging pantograph.

Fig. 23 Volvo Bus 7900 electric bus

Fig. 24 New Solaris Urbino electric bus

2. 5. Iveco Urbanway Hybrid

This urban bus was completely redesigned and launched in 2014. It sports a distinctive design in areas such as around the headlights, and the reason the side panels of the vehicle in the picture look black is that the baseboard has been made transparent. The concept involves showing the frame of the vehicle from both inside and outside in pursuit of natural illumination and a fresh perspective. As a series hybrid bus, its roof contains a lot of equipment, but the ingenious application of different paints makes the thickness of the roof unnoticeable (Fig. 25). As shown by examples such as the large cover at the front of MAN buses, designers are taxing their brains over the bulky equipment on the roofs of hybrid buses.

2. 6. BYD Electric Bus for London

London has adopted the K9 electric bus, manufactured by the Chinese BYD Auto, which probably produces the highest number of heavy-duty electric buses in the world. Double-decker buses are already in operation, and

Fig. 25 Iveco Bus Urbanway Hybrid

Fig. 26 BYD electric bus that has started running in London (Picture: Mr. Chan)

the city will purchase 51 new standard single-decker buses. As with the double-decker buses, a U.K.-made Alexander Dennis body has been chosen, making the bus blend in naturally for local operators and users.

2.7. Electric Minibus

Trials of this French-made driverless light-duty electric bus are also being conducted in Japan. It can carry 11 passengers. The vehicle was developed as a shuttle between, for example, venues at events (Fig. 27).

3 Conclusion

This article has surveyed the topics in the 2016 Japanese bus industry, with a focus on technology. As stated in the introduction, the size of the bus market has remained essentially unchanged for many years, and the relationship between operators emphasizing reliability and manufacturers meeting operator needs has formed a closed circle. The main impetus behind recent bus technology has been compliance with environmental regulations, with unfortunate accidents and the attendant legislative response, as well as changes at the operational level, have also had a direct or indirect impact on that technology. In addition, needs other than those already mentioned are coming to the fore. Globally, the role played by buses in public transportation is stimulating technological change.

Fig. 27 Electric Minibus

Over the last 20 years, Japanese urban route buses have coupled diesel engines with manual transmissions and favored a structure where the low floor only extends from the front to the middle door. In new models, AT or AMT two-pedal systems have become more common, but operators throughout Japan are not necessarily all purchasing new vehicles and updating their urban route bus fleet with new models, and the use of older models is expected to continue for some time.

However, over those same 20 years, urban route buses in Europe and North America have changed considerably. The layout of the vehicle has changed, of course, and the engine and components are also being revised. Considerable public interest in automated and autonomous driving is also accompanied by growing interest in attendant business opportunities.

There is also a large gap in the perception of electric buses and other forms of next-generation energy. Given the current situation where the number of electric buses currently operating in Japan is extremely low and almost all buses are remodeled diesel buses, it is not surprising that appraisals of electric buses are limited. However, major European cities are making concrete plans to fully deploy them in the near future, and mass production vehicles designed exclusively as electric buses are already in service. Similarly, fuel cell buses have started to be commercialized in European and North American cities, and the rise in the number of vehicles has been bringing their price down. Although the day-to-day operations of the Japanese bus industry may be unrelated to global tendencies, but with users also interacting on several levels, more than a few bus operators are showing interest in buses from outside Japan. Sharing information of global bus technology is becoming increasingly meaningful.

References

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