PASSENGER CARS

Overall Trends

1 Introduction

With successive announcements of bans on sales of new gasoline and diesel vehicles starting in 2040 made by France and the UK, the 2017 global automotive market accelerated its shift toward electrification. At the same time, cross-industry partnerships were formed in fields such as electric vehicles (EVs), connectivity, and automated driving.

The North American market saw a significant decline in sales of passenger vehicles, but sales of light-duty trucks remained strong. Total sales including the light-duty trucks locally counted in the truck category therefore only decreased slightly. Thanks to stable employment and low gasoline prices, there are currently no signs of a major slowdown in consumer willingness to buy, but with rising interest rates and increases in sales subsidies, the prevalent view is that demand in the North American market is reaching its peak.

In the European market, the switch away from diesel intensified, and the various automakers announced electric vehicles or other plans for greater electrification.

The growth rate of the Chinese market dropped compared to last year. With the tax rebate for light-duty vehicles, a contributor to increased sales, ending in 2017, a strong growth rate is unlikely over the next few years. The announcement of new fuel economy and new energy vehicle (NEV) regulations in September also marked an intensification of the government-led shift toward electrification.

In Japan, mini-vehicles and light-duty vehicles led the way in a renewed rise in sales. Contributing factors include the leveling off of the impact of the mini-vehicles tax increase in April 2015 and a succession of completely redesigns of the main mini-vehicle models by automakers.

2 Production, Sales, and Exports

2. 1. State of Production in Leading Manufacturing Countries

Table 1 shows passenger car production in leading manufacturing countries. Overall production was 73.45 million vehicles, or 101% of the previous year. By country, strong production of light-duty- and mini-vehicles in Japan resulted in 8.34 million vehicles, representing 106% of the previous year. In the U.S. production continued to decrease and was limited to 3.03 million vehicles, which is 77% of the previous year. Production in India, which had surged considerably in 2016, continued to grow in 2017 despite a slower pace of 106% of the previous year. Brazil, where production had slumped in the previous year, enjoyed a significant increase of 127% of said previous year, reaching 2.26 million vehicles.

Table 2 shows passenger car production according to manufacturer and country. The Hyundai Group, where

Table 1 Passenger car production in leading manufacturing countries.

		2017	2016	Compared to previous year (%)
Japan		8,347,836	7,873,886	106.0
U.S.		3,033,216	※ 3,916,584	77.4
Canada		749,458	※ 803,230	93.3
EU		16,973,088	※ 16,887,225	100.5
	Germany	5,645,581	5,746,808	98.2
	UK	1,671,166	※ 1,722,698	97.0
	France	1,748,000	※ 1,636,000	106.8
	Italy	742,642	※ 712,971	104.2
	Spain	2,291,492	2,354,117	97.3
South Korea		3,735,399	3,859,991	96.8
China		24,806,687	24,420,744	101.6
India		3,952,550	※ 3,707,348	106.6
Brazil		2,269,468	1,778,464	127.6
World total		73,456,531	72,388,433	101.5

Note 1 : Preliminary figures announced by the International Organization of Motor Vehicle Manufacturers (OICA)
Note 2 : * denotes revised values
Note 3 : The 27 EU countries.
Note 4 : The number of vehicles for the U.S. and Canada excludes SUVs and other models considered trucks in those countries.

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Table 2 Passenger car production according to manufacturer and country

Ranking (Previous year)	Manufacturers	Country	2017 (Units)	2016 (Units)	Compared to previous year [%]
1 (2)	Toyota	Japan	2,869,600	2,847,367	100.8
2 (1)	Hyundai group	South Korea	2,814,150	2,891,032	97.3
3 (3)	VW group	Germany	2,190,499	2,325,447	94.2
4 (4)	BMW	Germany	1,195,557	1,190,935	100.4
5 (5)	Daimler	Germany	1,131,316	1,066,249	106.1
6 (6)	Mazda	Japan	961,039	967,510	99.3
7 (8)	Nissan	Japan	921,505	835,058	110.4
8 (10)	Honda	Japan	817,500	820,226	99.7
9 (17)	Suzuki	Japan	770,994	580,389	132.8
10 (19)	Daihatsu	Japan	749,828	562,323	133.3
11 (12)	Subaru	Japan	709,643	727,741	97.5
12 (11)	VW Spain	Spain	699,709	745,863	93.8
13 (15)	Ford Germany	Germany	631,104	670,376	94.1
14 (14)	Toyota	U.S.	584,421	676,970	86.3
15 (20)	Mitsubishi	Japan	579,642	555,018	104.4
16 (13)	Honda America	U.S.	526,818	686,378	76.8
17 (18)	GM Daewoo	South Korea	511,867	569,394	89.9
18 (7)	GM	U.S.	490,629	864,779	56.7
— (9)	Groupe PSA	France	—	829,419	—
— (16)	FCA	Italy	—	657,995	—

Source: Automobile manufacturers association in each country and automaker public relations material
No 2017 data available for France or Italy

Table 3 Passenger car production in Japan.

	2017	2016	Compared to previous year (%)
Ordinary trucks	5,147,256	4,999,566	103.0
Light-duty trucks	1,715,970	1,610,486	106.5
4-wheeled mini-vehicles	1,484,610	1,263,834	117.5
Total	8,347,836	7,873,886	106.0

Source: Japan Automobile Manufacturers Association (JAMA)

the reduction in production from 2016 continued, slid from first to second place in Korean production, while a small increase in production brought Toyota back to first place in Japanese production. In Japanese production, both Suzuki and Daihatsu rose to considerably higher ranks with increases of 30%, while Nissan reached 0.92 million units with a 10% increase in production.

2. 2. State of Japanese Vehicle Production, Exports, and Sales

2. 2. 1. Production

Table 3 shows passenger car production in Japan. Stagnant demand for mini-vehicles due to tax increase on those vehicles in April 2015 showed signs of recovery in 2017 with a significant boost in production of 117% of the previous year, reaching 1.48 million vehicles. Production of both ordinary passenger cars and light-duty vehicles rose only slightly, and registrations as well as overall production of mini-vehicles reached 8.34 million vehicles.

Table 4 Number of passenger cars exported from Japan according to destination.

	2017	2016	Compared to previous year (%)
North America	1,892,647	1,868,638	101.3
Europe	842,045	803,978	104.7
Oceania	382,243	346,978	110.2
Asia	444,254	434,897	102.2
Middle-East	350,838	382,001	91.8
Central America	148,500	135,832	109.3
South America	106,338	86,317	123.2
Africa	49,561	57,424	86.3
Others	2,003	2,367	84.6
Total	4,218,429	4,118,432	102.4

Source: Japan Automobile Manufacturers Association (JAMA)

Table 5 Passenger car sales in Japan.

	2017	2016	Compared to previous year (%)
Ordinary trucks	1,548,214	1,490,216	103.9 %
Light-duty trucks	1,394,796	1,311,275	106.4 %
4 -wheeled mini-vehicles	1,443,368	1,344,967	107.3 %
Total	4,386,378	4,146,458	105.8 %

Source: Japan Automobile Manufacturers Association (JAMA)
Note 1 : The classification criteria of the sales statistics are based on the license plate number.

2. 2. 2. Exports

Table 4 shows the number of passenger cars exported from Japan according to destination. The top three destinations of North America, Europe and Asia all exhibited a minor increase over the previous years, with no major changes in either rank or number of vehicles. The Middle-East, which ranked fourth in the previous year, slipped to fifth place at 0.35 million vehicles, a decrease of over 8% compared to the previous year. Conversely, the previous year's fifth place Oceania exhibited an increase of over 10% of the previous year, or 0.38 million vehicles, bringing it to fourth place. The regions exhibiting significant changes were South America, with an increase of over 23% compared to the previous year and, in contrast, Africa, which saw a drop of 13% from the previous year.

2. 2. 3. Sales

Table 5 shows passenger car sales in Japan. Sales of mini-vehicles, benefiting from the impact of the tax increase wearing off, rose 107% over the previous year to reach 1.44 million vehicles. At the same time, sales of both ordinary passenger cars and light-duty vehicles rose slightly, and registrations as well as overall sales of mini-vehicles reached 4.38 million vehicles.

2. 2. 4. Used Vehicle Sales

Table 6 shows used vehicle sales in Japan. These fig-

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Table 6 Used vehicle sales in Japan.

	Ordinary trucks	Light-duty trucks	4-wheeled mini-vehicles	Total	Compared to previous year (%)
2008	1,728,090	1,944,766	1,995,333	5,668,189	95.4%
2009	1,619,370	1,855,071	1,864,874	5,339,315	94.2%
2010	1,592,110	1,816,696	1,873,466	5,282,272	98.9%
2011	1,542,614	1,733,519	1,906,523	5,182,656	98.1%
2012	1,688,606	1,826,335	2,133,725	5,648,666	109.0%
2013	1,666,732	1,740,725	2,255,560	5,663,017	100.3%
2014	1,630,421	1,653,214	2,367,235	5,650,870	99.8%
2015	1,668,429	1,602,719	2,354,077	5,625,225	99.5%
2016	1,729,194	1,564,982	2,322,533	5,616,709	99.8%
2017	1,802,956	1,588,747	2,414,874	5,806,577	103.4%

Sources: Japan Automobile Dealers Association (JADA) and the Japan Light Motor Vehicle and Motorcycle Association

Table 7 Imported vehicle sales in Japan.

Ranking (Previous year)	Manufacturers	2017 (Units)	2016 (Units)	Compared to previous year [%]
1 (1)	Mercedes-Benz	68,215	67,378	101.2
2 (2)	BMW	52,527	50,571	103.9
3 (3)	VW	49,036	47,233	103.8
4 (4)	Audi	28,336	28,502	99.4
5 (5)	BMW Mini	25,427	24,548	103.6
6 (7)	Volvo	15,764	14,553	108.3
7 (6)	Nissan (vehicles produced outside Japan)	14,899	17,824	83.6
8 (8)	Jeep	10,101	9,388	107.6
9 (10)	Peugeot	8,242	7,403	111.3
10 (13)	Renault	7,119	5,303	134.2
11 (11)	Porsche	6,923	6,887	100.5
12 (12)	Fiat	6,522	6,717	97.1
13 (9)	Suzuki (vehicles produced outside Japan)	5,768	9,026	63.9
14 (15)	Smart	4,638	4,508	102.9
15 (14)	Mitsubishi (vehicles produced outside Japan)	3,909	4,637	84.3
16 (16)	Land Rover	3,597	3,165	113.6
17 (19)	Citroën	3,152	2,009	156.9
18 (—)	Honda (vehicles produced outside Japan)	2,987	793	376.7
19 (17)	Jaguar	2,614	2,883	90.7
20 (20)	Abarth	2,286	1,857	123.1
	Total (including ranks 20 and below)	333,451	327,607	101.8

Source: Japan Automobile Manufacturers Association (JAMA)

ures, stable and exhibiting little variation, since 2013, had a slight rise of 103%, or 5.80 million vehicles, in 2017. By category, sales of ordinary passenger cars and mini-vehicles were strong at 104% of the previous year.

2. 2. 5. Imported Vehicle Sales

Table 7 shows imported vehicle sales in Japan. The overall figure of 0.33 million vehicles remained at essentially the same level as the previous year. There was no change in the top 5 manufacturers or their rankings, and the number of vehicles sold was also virtually identical to that of the previous year. Amid a major decline in sales of vehicles produced overseas by Japanese manufacturers, Honda, which was not in the top 20 in 2016, rose to 18th place with an impressive increase of 376% over the previous year.

2. 3. Vehicle Sales in Markets outside Japan

Table 8 shows passenger car sales in leading manufacturing countries along with the share of Japanese vehicles. In Brazil, where the economy recovery had lagged, exhibited a rise of 111% over the previous year. In the U.S. and Canadian North American markets, the decline observed in 2016 continued. The U.S. market, in particular, showed a large decrease of 88% of the previous year. In contrast, Japan, where the impact of the mini-vehicles tax increase wore off, sales started rise again to 106% of the previous year, while India enjoyed a continuation of the strong sales seen in 2016.

3 Product Technology Trends

This section presents the main technologies introduced in the Japanese market in 2017 with new models, com-

Table 8 Passenger car sales in leading manufacturing countries and share of Japanese vehicles.

	Total passenger	Japanese vehicles within the total	(share of Japanese vehicles)	Total passenger car sales 2016	Total passenger car sales Compared to previous year
Japan	4,386,378	4,081,335	(93.0%)	※ 4,146,458	106%
U.S.	6,079,584	2,863,790	(47.1%)	※ 6,872,729	88%
Canada	635,347	285,280	(44.9%)	※ 659,475	96%
Brazil	1,856,097	379,754	(20.5%)	※ 1,676,722	111%
China	24,718,321	4,401,173	(17.8%)	24,376,902	101%
India	3,229,109	1,976,991	(61.2%)	※ 2,966,603	109%
EU + EFTA total	15,606,865	2,068,030	(13.3%)	※ 15,118,305	103%
UK	2,540,617	421,433	(16.6%)	2,692,786	94%
Germany	3,441,262	329,956	(9.6%)	3,351,607	103%
France	2,110,748	215,940	(10.2%)	2,015,177	105%
Italy	1,970,497	210,177	(10.7%)	※ 1,825,892	108%

Source: Automobile manufacturers association in each country

Note 1 : Japanese vehicles refer to all Japanese brand vehicles and include those produced outside Japan.

Note 2 : The number of vehicles for the U.S. and Canada excludes SUVs and other models considered trucks in those countries (Source: Ward's).

Note 3 : Calculated from the 26 countries in the EU and 3 countries in the European Free Trade Association (EFTA: Iceland, Norway, and Switzerland) (source: European Automobile Manufacturers' Association (ACEA)).

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plete redesigns, and facelifts (including partial improvements, additional powertrains, and special specifications models). Table 9 shows the new product technologies for Japanese-produced ordinary and light-duty vehicles, while Table 10 presents those for mini-vehicles. For facelifts, only particularly noteworthy technologies were listed, and OEM models were excluded.

3. 1. Environmental Performance

Ordinary and light-duty passenger vehicles in 2017 continued to reflect automaker environmental awareness with the introduction of technologies such as downsized turbocharged engines, the addition of hybrid settings, and improvements in the performance of hybrid systems and electric vehicles. Efforts at environmental friendliness were not limited to advances in powertrains, but also included weight reduction and improvements in aerodynamic performance. Mild hybrid systems became more common in mini-vehicles which, combined with new lighter, high rigidity, led to a greater number of models achieving a fuel efficiency of 30.0 km/L or more. At the same time, efforts to significantly reduce weight also led to the launch of a model achieving a fuel efficiency of 35.2 km/L without a hybrid system.

3. 2. Safety Performance

In ordinary and light-duty passenger vehicles, advanced safety technologies previously installed primarily in models in a certain price range became more widespread, finding their way into a greater number of models. Similarly, an expansion of the objects detected, range of detection, and activation area brought a larger number of safer and more secure vehicles to the market. The Ministry of Land, Infrastructure, Transport and Tourism and Ministry of Economy, Trade and Industry-led measure to reduce traffic accidents involving elderly drivers through activities to raise awareness and encourage the spread of safe driving support vehicles (nicknamed safety support cars), which are equipped with driver assistance functions, has prompted automakers to introduce a succession of models touting such features. Mini-vehicles are ahead of light-duty passenger vehicles in terms of the inclusion of advanced safety technologies such as collision mitigation support systems, and the first mini-vehicle model featuring a collision mitigation braking system that applies to backing up was introduced. Other systems contributing to safety, such as heads-up displays or systems displaying an overhead panoramic view on the navigation system screen, previously found only on some models, have become more widespread.

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Table 9 Main product technology trends in ordinary and light-duty automobiles produced in Japan in 2017

Release date	Vehicle model	Brand	Main technologies
February 9	Outlander Outlander PHEV (Partially refined)	Mitsubishi	With respect to passive safety, added pedestrian detection to the collision mitigation braking system, improved the accuracy of the lane departure warning system alert and optimized its timing, introduced new side and rear vehicle warning (with lane change assist function) and a vehicle backup warning system, and established a false start suppression (forward and reverse) function and parking sensors (front and rear) as a manufacturer option set. For nighttime driving, an automatic high beam headlight system that automatically switches between high and low beams based on surrounding conditions and the presence of a preceding or oncoming vehicle has been included. In addition to the above, the supply of electric power to the drive battery in the PHEV has been made more durable, and delaying the engine start to generate electricity allows EV driving to be maintained longer than before. A new EV priority mode that suppresses engine start as long as possible to prioritize EV driving has been made available.
February 15	Prius PHV (Complete redesign)	Toyota	Mounts a large capacity lithium-ion battery and made the plug-in hybrid system more efficient to extend the EV cruising range to 68.2 km and raise the maximum EV cruising speed to 135 km/h. Adopts the Dual Motor Drive System which allows the electricity-producing motor (generator) to provide drive in combination with the drive motor. Adopts a dedicated drive battery heater, the world's first heat pump automatic air conditioner with gas injection, and the world's first solar charging system in a mass-produced vehicle. Equipped with a 1.8-liter high efficiency engine that achieves a fuel economy of 37.2 km/L in HV driving mode. The inclusion of the first Toyota 11.6-inch T-Connect SD navigation system and a DCM provides access to connected services. Offers e-Care Driving Guidance, which allows operators or dealership staff to provide appropriate advice based on information transmitted by the vehicle when a warning lamp comes on, as well as functions such as the ability to check and operate battery charging, operate the air conditioner, and searching for service stations even when the driver is away from the vehicle.
March 16	Lexus LC (Complete redesign)	Lexus	Adopts the newly developed GA-L platform. Newly developed suspensions mounted at both the front (high-mount multi-link) and rear (multi-link). Adopts advanced technologies such as understeer/oversteer control with enhanced dynamic rear steering control, VGRS, and an active rear spoiler. Adopts the world's first multi-stage hybrid system, which combines the Lexus hybrid system with gear stages. Newly developed Direct Shift-10 AT mounted. Significant weight reduction and part downsizing achieved through the use of aluminum for component parts. Adopts a new control that deduces driver intent from the accelerator, brake, and vehicle G (gravitational acceleration) and optimizes gear selection.
April 20	Demio (Partially refined)	Mazda	Smart City Brake Support [Forward] automatic braking system that provides support for avoiding collisions with the preceding vehicle when driving at low speeds and mitigates damage, Acceleration Control for AT [Forward], which prevents sudden starts if an object is detected ahead when the vehicle is moving slowly or stopped, Blind Spot Monitoring, a recognition support technology alerting the driver to the presence of a vehicle diagonally behind them when changing lanes, and Rear Cross Traffic Alert, which detects vehicles approaching from the side in situations such as backing out of a parking spot and warns of the danger of a collision, have been made standard equipment. Qualifies for the Safety Support Car S basic category.
May 24	XV (Complete redesign)	Subaru	All versions include a pedestrian airbag and the EyeSight (version 3) advanced driving support system as standard equipment. the next-generation Subaru Global Platform. the X-Mode AWD control system, and the 200 mm minimum ground clearance achieves rough road performance matching that of SUVs. A new 1.6-liter engine has been adopted to complement the 2.0-liter naturally aspirated engine that uses direct injection.
June 8	X-Trail (Redesigned)	Nissan	Adopts the ProPilot single-lane automated driving technology that automatically controls all accelerator, brake, and steering functions on the highway. Improves convenience with the adoption of a new remote controlled automatic back door with a hands-free function and improvements to the Intelligent Parking Assist system. The hybrid model features various aerodynamic improvements, as well as improved control functions that increase the amount of electric power regeneration when the accelerator is not depressed, achieving a fuel economy of 20.8 km/L with 2WD.
June 30	Fit (Special specifications vehicle)	Honda	Adopts the Honda Sensing advanced driving safety support system. The hybrid model achieves a fuel economy of 37.2 km/L. Improved engine combustion technology and friction reduction combine with attention to the smallest shape details for aerodynamic purposes, such as the optimization of the shape of the front pillar and front bumper spoiler, to improve fuel economy.
July 10	Camry (Complete redesign)	Toyota	Combining the new TNGA 2.5-liter Dynamic Force Engine that features a maximum thermal efficiency of 41% and high power with the hybrid system (THS II) achieves both a top fuel economy of 33.4 km/L for its displacement class and superb dynamic performance. Hydraulic engine mounts are used at all four points (a Toyota first) and placing them optimally mitigates the vibrations and reduces the noise due to the higher torque to provide a high quality ride. Expanded use of hot stamped high strength steel sheets contributes to both reducing weight and ensuring excellent passive safety.
July 12	Swift (Hybrid model added)	Suzuki	Mounts the unique Suzuki hybrid system that combines the drive motor with Auto Gear Shift to achieve a fuel economy of 32.0 km/L. Combining a drive motor (MGU) that is compact, yet capable of momentary high output with the lightweight and compact Auto Gear Shift (AGS) system offering excellent transmission efficiency and supplying the power accumulated during driving to the MGU provides not only motor assist when driving, but also allows automatic engine shutdown for EV driving during creep driving or constant speed cruising.

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Table 9 Main product technology trends in ordinary and light-duty automobiles produced in Japan in 2017 (cont.)

Release date	Vehicle model	Brand	Main technologies
July 26	Escudo (Powertrain added)	Suzuki	Mounts a 1.4 -liter turbocharged engine. This 1.4 -liter turbocharged Boosterjet engine offering high power and high torque comparable to those of a 2.0 -liter naturally aspirated engine is combined with a 6 -speed AT to achieve sporty, powerful driving.
July 27	CX-3 (Powertrain added)	Mazda	This new variant with the next-generation SKYACTIV-G 2.0 gasoline engine offers high responsiveness and enjoyable driving while simultaneously exhibiting environmental friendliness with a 75 % reduction relative to the 2018 emissions standards. The i-ACTIVSENSE advanced safety technology has been made standard equipment on all models. Qualifies for the Safety Support Car S wide category.
August 3	CX-5 Atenza (Partially refined)	Mazda	The i-ACTIVSENSE advanced safety technology is standard equipment. Equipped with Advanced Smart City Brake Support, Acceleration Control for AT [Forward] (only in AT models), either High Beam Control System or Adaptive LED Headlights advanced lighting, a lane departure warning system, Blind Spot Monitoring, Rear Cross Traffic Alert, Smart City Brake Support [Rearward] (only in AT models), Rear Parking Sensors (center/corner), Driver Attention Alert (Atenza only). Qualifies for the Safety Support Car S wide category.
September 12	Hilux (New model)	Toyota	Mounts a 2.4 -liter 2 GD-FTV diesel engine and achieves a cruising fuel economy of 11.8 km/L. Features the Pre-collision Safety System with Pedestrian Detection and Lane Departure Alert. Includes Hill Start Assist Control, Active Traction Control and Downhill Assist Control to offer high driving performance worthy of a full-fledged 4 WD vehicle both on- and off-road. The adoption of a high-strength frame and a suspension that boosts vibration damping ensures excellent driving stability and ride comfort both on- and off-road. Equipped with a part-time 4 WD system allowing drive system selection through a dial.
September 20	Swift Sport (Complete redesign)	Suzuki	The adoption of the K14 C 1.4 -liter direct injection turbocharged Boosterjet engine with a maximum torque of 230 N•m and the new lightweight, high-rigidity HEARTECT platform reduces weight by 70 kg, and the newly developed suspension provides strong dynamic and handling performance. With the first-time adoption of a lane departure prevention by Suzuki, as well as the inclusion of Dual Sensor Brake Support, which uses a monocular camera and laser radar to detect pedestrians or vehicles in front of the vehicle and mitigate damage in the event of a collision as manufacturer options, this model qualifies for the Safety Support Car S wide category.
September 21	Axela (Partially refined)	Mazda	All variants offer Advanced Smart City Brake Support, Acceleration Control for AT, a lane departure warning system and advanced lighting as standard equipment. Blind Spot Monitoring and Rear Cross Traffic Alert have been made standard equipment. First Mazda model to offer the 360° View Monitor.
September 29	Civic (Complete redesign)	Honda	Using the newly developed platform as a core, this model adopts a low and wide advanced form that merges beauty and functionality, as well as a direct injection VTEC turbocharged engine that provides smooth and powerful acceleration as well as high environmental performance.
	Stepwgn (Redesigned)	Honda	Adds a variant of the Spada equipped with the two-motor Sport Hybrid i-MMD system, which achieves a top-level fuel economy of 25.0 km/L in its class. All variants offer the Honda Sensing advanced driving safety support system as standard equipment.
October 2	Leaf (Complete redesign)	Nissan	Achieves a cruising range of 400 km. Adopts the new e-powertrain that generates a maximum output of 110 kW and a maximum torque of 320 Nm Equipped with ProPilot Parking, which automatically controls all steering, accelerator, brake, gear change, and parking brake functions during parking, in addition to the ProPilot highway single-lane automated driving technology. Adopts the e-Pedal, which enables starting, accelerating, decelerating, and even stopping to be controlled using only the accelerator pedal.
October 11	Corolla Fielder Corolla Axio (Redesigned)	Toyota	Newly includes the Intelligent Clearance Sonar (parking assist brakes) that helps mitigate collision damage when the accelerator is pressed by mistake. All variants come with the Toyota Safety Sense C active safety package as standard equipment. Models with Intelligent Clearance Sonar and Toyota Safety Sense C correspond to the Safety Support Car S basic+ category.
October 19	Lexus LS (Complete redesign)	Lexus	Equipped with a newly developed V6 3.5 -liter twin turbo engine and a V6 3.5 -liter multi-stage hybrid system. The Lexus CoDrive advanced driving support technology supplements the basic radar cruise control and lane tracing assist functions with lane change assist, coordinating the three functions to provide steering assist in harmony with driver intent on highways and motorways, as well as driving support for lane changes. Pre-collision safety is addressed by complementing the existing brake control with active steering avoidance support that automatically controls steering, as well as with the inclusion of Driver Emergency Stop Assist, the Two-stage Adaptive High-beam system, Front Cross Traffic Alert, Road Sign Assist, parking support brakes (the first in the world to support detecting pedestrians in the rear), Panoramic View Monitor, the Digital Rear-View Mirror and other advanced safety systems. Corresponds to the Safety Support Car S wide category. Notifications on support status provided by the first large color heads-up display and the multi-information display make understanding that support intuitive and straightforward. The navigation system uses a 12.3 inch wide display and hybrid navigation that merges cloud-based and on-board unit route searches. Voice recognition that automatically switches between the on-board unit and the cloud based on the contents of the utterance and the situation, providing hybrid voice recognition functionality that enables operations through natural speech, as well as the next-generation Remote Touch offer high-level operability.

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Table 9 Main product technology trends in ordinary and light-duty automobiles produced in Japan in 2017 (cont.)

Release date	Vehicle model	Brand	Main technologies
December 7	Solio Ignis (Special specifications vehicle)	Suzuki	Equipped with Dual Camera Brake Support, a false start prevention, lane departure warning, weaving alert, and preceding vehicle start notification functions, with a camera package for the all-direction monitor available as a manufacturer option.
	Demio (Partially refined)	Mazda	Advanced Smart City Brake Support has been supplemented with a lane departure warning system and the High Beam Control System as standard equipment on all variants which, in conjunction with the already standard Acceleration Control for AT [Forward], qualifies for the Safety Support Car S wide category. The 360° View Monitor and front parking sensors have been made available as a manufacturer option.
December 19	X-Trail (Special specifications vehicle)	Nissan	Driving support systems such as ProPilot, Intelligent LI (lane departure prevention system), a vehicle backup warning system, High Beam Assist, Intelligent Around View Monitor, and Intelligent Rearview Mirror have been made standard. Qualifies for the Safety Support Car S wide category.
December 25	Xbee (New model)	Suzuki	First light-duty Suzuki vehicle equipped with the Back-up Brake Support system to mitigate collisions when reversing in addition to the Dual Sensor Brake Support collision mitigation braking system. Adopts 3 D View, providing a 360° view of the surroundings. Adopts the new lightweight, high-rigidity HEARTECT platform, and all variants use a 6-speed AT with the 1.0-liter direct injection turbocharged engine and mild hybrid system, a Suzuki first. The 4WD variants offer two new modes, the Sports Mode providing powerful driving performance and the Snow Mode that alleviates tire spinning at starts or during acceleration on snowy or icy roads, made standard equipment in conjunction with grip control and hill descent control.

All fuel economy values are for the JC08 test cycle and verified by the Ministry of Land, Infrastructure Transport and Tourism.

Table 10 Main product technology trends in mini-vehicles produced in Japan in 2017

Release date	Vehicle model	Brand	Main technologies
February 1	Wagon R Wagon R Stingray (Complete redesign)	Suzuki	Equipped with a mild hybrid system allowing driving using only the motor at start off. The adoption of the new lightweight, high-rigidity HEARTECT platform achieves a fuel economy of 33.4 km/L, the best in wagon mini-vehicles. Equipped with the Dual Sensor Brake Support system, which uses a monocular camera and infrared laser radar to detect pedestrians or vehicles in front of the vehicle and mitigate damage in the event of a collision, and the High Beam Assist function. First mini-vehicle to offer a heads-up display.
May 9	Mira e:S (Complete redesign)	Daihatsu	First model featuring the new DNGA platform. The adoption of a new body structure both reduces weight and provides high rigidity, improving stability and controllability, ride comfort, and quietness. The expanded use of high strength steel sheets and the replacement of steel with plastic for the rear gate, front fender and fuel tank result in a maximum weight reduction of 80 kg and a fuel economy of 35.2 km/L. Adopts the Smart Assist III collision avoidance assist system which significantly improves object recognition with the use of a stereo camera and also activates to avoid collisions with pedestrians. First mini-vehicle equipped with two front and two rear corner sensors and a function to notify the driver of the approach of pedestrians or objects during reversing.
August 1	Move (Redesigned)	Daihatsu	Equipped with the Smart Assist II collision avoidance assist system that also applies emergency braking for pedestrians. Adopts the Panorama Monitor that displays a virtual bird's eye view of the vehicle on the navigation system screen.
September 1	N-Box (Complete redesign)	Honda	Newly developed platform and powertrain. Weight has been reduced by approximately 80 kg, providing excellent driving performance, fuel economy and ride comfort. Adopts the Honda Sensing advanced driving safety support system for the first time on a Honda passenger mini-vehicle.
September 11 October 4 November 30	Move Canbus Cast Wake (Partially refined)	Daihatsu	Equipped with the Smart Assist II collision avoidance assist system that also applies emergency braking for pedestrians. Adopts the Panorama Monitor that displays a virtual bird's eye view of the vehicle on the navigation system screen.
December 4	Hustler (Special specifications vehicle)	Suzuki	Advanced safety systems such as Dual Camera Brake Support, a false start prevention, lane departure warning, weaving alert, and preceding vehicle start notification functions, and a camera package for the all-direction monitor are available as options. (Some systems are standard equipment in certain grades.)
December 7	Alto Lapin (Special specifications vehicle)	Suzuki	Equipped with radar brake support and a false start prevention function, with a camera package for the all-direction monitor available as an option
December 14	Spacia Spacia Custom (Complete redesign)	Suzuki	The new lightweight, high-rigidity HEARTECT platform has been equipped with a mild hybrid system allowing driving using only the motor at start off on all variants, achieving a fuel economy of 30.0 km/L. First mini-vehicle to adopt the Back-up Brake Support system to mitigate collisions when reversing in addition to the Dual Sensor Brake Support collision mitigation braking system, which are standard equipment on all variants. In addition to a heads up display, adopts 3 D View, providing a 360° view of the surroundings, for the first time in a mini-vehicle. Qualifies for the Safety Support Car S wide category.
December 22	N-One (Redesigned)	Honda	Adopts a front windshield glass with sound insulation properties for the first time in a mini-vehicle, and improves quietness through the optimal placement of sound insulation or sound-absorbing materials.

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Design Trends

1 Introduction

Advances in automobile electrification and practical applications of automated driving made 2017 a year involving significant change in not only how society and relevant IT technologies relate to automobiles, but in what the automobile itself represents. Under these circumstances, small changes can be seen in the course sought by automakers for their respective future visions and designs. This section defines the automobile design trends observed in the concept cars and mass-production models presented at various exhibitions and motor shows in and outside Japan, in which these changes are prominent.

2 SUVs and Crossovers

The momentum of SUV crossovers immediately draws attention when new models announced in 2017 are surveyed. In Japan, the Toyota C-HR (Fig. 1), highly acclaimed in the market for its compact cabin design giving a sense of speed and its diamond-inspired sculpture-like face, has revolutionized the general perception of compact SUVs. Similarly, the Mazda CX-5 (Fig. 2) and CX-8 (Fig. 3), which combine distinctive long-nosed proportions with a panel design imparting a sense of dynamism directly express the innate sense of balance and performance of automobiles and offer a unique personality. Models offering a modern expression and emphasizing the rough road performance of SUVs include the Subaru Forester (Fig. 4) and XV (Fig. 5), and the Mitsubishi Eclipse Cross (Fig. 6). Unique models such as the Suzuki Xbee, representing a new, compact category, have also come on stage, highlighting the diversity of designs expressed in the SUV crossover segment.

The same trends are observed globally, with one automaker after another following the purported easy approach unveiling appealing vehicles represented mainly by compact premium cars or SUV models. Another recent trend, highlighted by the Maserati Levante (Fig. 8), Alpha Romeo Stelvio (Fig. 9), and Aston Martin DBX (Fig. 10), is the entry into other classes of premium brands originally focused on sports cars and sports sedans. The announcement of the ultra-high performance Urus SUV by Lamborghini (Fig. 11) clearly shows the momentum gained by this category. Similarly, among ultra-premium brands, Bentley had already announced its first SUV, the Bentayga (Fig. 12), and even Rolls Royce has added this category to its lineup.

The majority of SUV designs basically balance the large diameter wheels with a body imbued with dynamism, and the premium brands are building upon this to

Fig. 1 Toyota C-HR

Fig. 2 Mazda CX-5

Fig. 3 Mazda CX-8

Fig. 4 Subaru Forester

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Fig. 5 Subaru XV

Fig. 6 Mitsubishi Eclipse Cross

Fig. 7 Suzuki Xbee

Fig. 8 Maserati Levante

break ground into new forms of expressions that nevertheless retain their unique image. This is a truly fascinating category offers an active and diverse array of ideas.

3 Five-Door Fastbacks

A separate trend primarily propagated from Europe, is the stylish 4-door coupé. Major brands such as Mer-

Fig. 9 Alpha Rome Stelvio

Fig. 10 Aston Martin DBX

Fig. 11 Lamborghini Urus

Fig. 12 Bentley Bentayga

cedes-Benz, BMW, and Audi are offering a lineup based on the two pillars of 4-door coupés and sedans, and 5-door fastbacks have been presented as an evolution of the 4-door coupé. Volkswagen has unveiled the high-end model Arteon (Fig. 13), which is strongly characterized by offering strong practicability even as it achieves elegant styling through cabin smoothly extending even further near the rear end than in a 4-door coupé. The Mercedes-Benz AMG GT Concept (Fig. 14) is similar, featuring an overall sporty impression that does justice to the image of the brand. This category offers appealing designs with ample sized vehicles emphasizing freedom

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Fig. 13 Volkswagen Arteon

Fig. 14 Mercedes-Benz AMG GT Concept

from constraints, and it will be interesting to see whether this trend finds favor in markets outside Europe and further expands into other classes.

4 EV Design

In light of the introduction of the world's most stringent CO_2 reduction targets in Europe in 2021, the various countries have started moving toward banning sales of internal combustion engine vehicles. India also has plans for all vehicles sold to be EVs, and the U.S. Tesla has released a mass-produced EV called the Model 3 (Fig. 15). In Japan, the second-generation model of the Nissan Leaf dedicated EV (Fig. 16) has improved its cruising range to 400 km, and Toyota, Mazda, and Honda are all actively moving to review and mass produce EVs.

But how does a shift to EVs change automobile design? While the mounting of a very large battery obviously imposes strict constraints on layout in terms of hardware requirements, the primary issues affecting the design itself for makers are improving aerodynamic performance to achieve any possible extension of cruising range, and the promotion of EV distinctiveness to consumers with little knowledge of EVs or, alternatively, determining whether differentiation is needed in the first place. Compared to its first-generation predecessor, the above-mentioned second-generation Nissan Leaf features a design that would not raise eyebrows as an internal combustion engine vehicle. This is the basis for the hypothesis that EVs have already gained recognition in society and do not need a special design. The Tesla Model

Fig. 15 Tesla Model 3

Fig. 16 Nissan Leaf

3, in contrast, has the overall shape of an ordinary sedan, but inherits the front mask with almost no cooling outlets found in previous high-end EV models. Design approaches will certainly vary based on the lineup and aims of the various makers, as well as on different EV categories. There are expectations for the introduction of new design interpretations, including offerings originating outside the current automakers.

5 Major Transformation Brought about by Fully Automated Driving

Driving automation holds the opportunity to fundamentally change automobile design. Automated driving in a single lane is already commercially available in Japan, and testing on ordinary public roads has begun. Nevertheless, the "automated" in current automated driving applies to limited driving locations and remains subject to various restrictions and, from a design perspective, offers no difference from ordinary vehicles, even for the interior. The evolution of automated driving to-

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Fig. 17 Audi Elaine

Fig. 18 Audi Aicon

ward the highly advanced level 4 automation requires adaptations not just to the scope of driving, which goes without saying, but also to safety-related monitoring. Moreover, reaching level 5 full automation means that the presence of the driver will no longer be required. Simply put, the system will perform all driving operations and safety-related monitoring of the surroundings. Automakers are obviously all working on the development of commercialized automated driving that achieves level 5, and the government is targeting its realization around 2025.

Once level 5 is achieved and driving operations no longer require a human driver, both the design and the interior of the automobile while change drastically. In the interior, the steering wheel, pedals, shift lever and other instruments for driving, as well as meter or navigation system display devices will effectively become unnecessary. For the exterior, the concept of visibility will change as windows no longer become a means of enabling driving, and substantial changes in seating posture will have a strong impact on packaging and vehicle proportions. Once that happens, the major questions will

Fig. 19 Mercedes-Benz automated driving study model

center around determining the ideal design for automobiles, and on identifying the points that will prove appealing to consumers.

Many concept car exhibits were designed with the age of levels 4 and 5 automation in mind, each proposing its own ideas and strategy. Neither the Audi Elaine SUV (Fig. 17) aimed at level 4 and the Aicon large sedan aimed at level 5 (Fig. 18) include any instruments for driving. The Mercedes-Benz study model for automated driving (Fig. 19) also targets level 5, proposing a design oriented toward car sharing and how the inside the vehicle during travel is spent. Japanese manufacturers, including manufacturers that are not automakers, such as electrical parts suppliers, have also presented proposals, and the direction of approaches to design, at least, has yet to become clear. Solving these issues will clearly require finding and proposing new visions based on each manufacturer's brand strategy rather than simply trying to expand upon conventional automobile design.

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Body Structures

1 Current Circumstances

Regulations on CO_2 emissions are being strengthened by various countries year after year. In the EU, a tightening of CO_2 emissions regulations that would cut the 2021 target of 95 g/km by 15% in 2025 and 30% in 2030 has been proposed, while in North America, the 95 g/km value will have to be met in 2025. Bans on sales of gaso-

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line and diesel vehicles are planned by 2030 in India, and 2040 in France and the U.K. At the same time, the new energy vehicle (NEV, which includes EVs, FCVs, and PHEVs) regulations require electric-powered vehicles to represent 10% of vehicles sold in 2019[1]. This situation is creating ever more stringent demand for vehicle body weight reduction, which must be urgently applied to the various electric-powered vehicles. At the same time, there is also intensifying demand regarding performance in areas such as stability and controllability, NVH, and crashworthiness, which has been leading not only to replacing materials, but to structural rationalization that encompasses multi-material structures.

2 Weight Reduction

The demand for lightweight vehicles bodies to reduce CO_2 emissions has been intensifying, and is growing even stronger due to the fact that the need to mount batteries on electric-powered vehicles increases the overall vehicle weight. With respect to vehicle bodies, this makes it necessary to complement the replacement of material with multi-materials and structural rationalization with a reduction in the weight of the system as a whole.

2. 1. Structural Rationalization

In conjunction with stronger body frames, the rationalization of the frame layout has achieved a reduction in weight. One recent rationalization technique integrates stronger outer panels with the reinforcing members. The Honda N-Box[2], for instance, uses 440 MPa sheets and 1.2 GPa high strength steel sheets (high strength steel) for the outer body side, providing an example of integration with the reinforcing members. Another frequent example of rationalization is the use of aluminum castings in the struts, which contributes to both decreasing the number of parts and to improving rigidity.

2. 2. Steel Sheets

Historically, the reduction of vehicle body weight has paralleled the creation of stronger steel sheets, in which the extra strength contributed to weight reduction by decreasing the thickness of the sheets. Even stronger steel sheets continue to be developed, and are often applied in light-duty vehicles. Until now, the disadvantage of increasing the strength of steel sheets was the drop in their ductility. However, the Nissan QX50 currently on sale uses high strength steel sheets with high ductility (Fig. 1). There are also examples of dual-phase 1,180 MPa high strength steel use in the easily formed locations of mini-vehicles. In hot stamping technology, which is one approach to increasing strength, the application of a partial tempering technique involving partial quenching to rear side members, presented more fully below in Section 4.3, Passive Safety, is an example of technology that achieves mode control and efficient energy absorption in an impact. Another approach, seen in the Audi A8, among others, is the use of tailor rolled blanks, which make it possible to optimize the thickness distribution within a single part, thereby contributing to weight reduction.

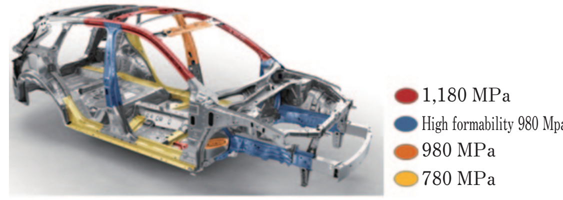

Fig. 1 Nissan QX50

Fig. 2 Lexus LS[13]

2. 3. Aluminum

The use of aluminum in outer panels and frames to reduce weight has also been increasing. Examples of the use of aluminum in outer panels can be seen in the L and LL classes. The Audi A8[3] uses lightweight aluminum alloys for all fender, door, hood, roof, and trunk outer panels, while the Lexus LS[4] uses aluminum alloys for the fender, doors, hood, and trunk (Fig. 2). Aluminum castings can be used to achieve rationalization through parts integration and are used in the strut assembly part of vehicles such as the A8 and the LS. Similarly, high strength 7000 series aluminum alloy extrusions are used for some bumper beams and door beams. In addition, efforts are being made to expand their use in vehicle body frame members such as the reinforcing members of front side members or seals.

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Fig. 3 Toyota Prius PHV back door[5]

2. 4. CFRPs and Plastics

The use of carbon fiber reinforced plastics (CFRPs) has gradually expanded since they were first developed, but their high cost remains an issue. Consequently, processes to cut the part production takt time for both thermoset material and thermoplastics have been developed. They are used in the outer panels of parts such as roofs and hoods, and there are also cases of partial use for inner parts only, as well as of use in the vehicle body frame. Other cases involve the ingenious use of CFRP fiber orientation. In PHVs and luxury vehicles, CFRPs have also been used for the inner part of the back door (Toyota Prius PHV[5], Fig. 3) or the seat back panel and upper shell (Audi A8[3]). The adoption of plastic for the back door spoiler or the replacement of glass with plastic, continue to represent examples of the use of plastics for weight reduction.

3 Joining

The expanded use of aluminum alloys has led to the use of various joining methods other than spot welding or rivets. The concurrent use of adhesives to suppress electrolytic corrosion at the joints between the dissimilar materials of steel and aluminum, and the application of adhesives aimed at improving the torsional rigidity of the vehicle body, have become more common (Toyota Camry[6], Lexus LS, Honda N-Box, Civic, and Accord[7], and Audi A8). Laser brazing is sometimes used to enhance the appearance of the roof (Lexus LS, Honda N-Box and Accord, Nissan Micra). Other examples include the use of remote laser welding for aluminum parts (Lexus LS doors) and the application of join rationalization to the B-pillar through seam welding, in which a roller electrode is used to perform continuous joining (Honda N-Box). In addition to applying hemming to the aluminum alloy and steel sheet joint, partially setting recesses and adjusting their position has been used to mitigate heat deformation caused by the differences in the coefficient of linear thermal expansion (Audi A8).

4 Technological Trends Concerning Performance Requirements

4. 1. Stability and Controllability

Initiatives to improve overall torsional rigidity as well as the rigidity of the shock absorber attachment point remain a common trend concerning vehicle body performance trends in the area of stability and controllability. Many of these aim to achieve a balance with the weight reduction resulting from the adoption of aluminum. In the Audi A8, for instance, the use of cyclic structures in the front end and in the frame around the back door, including the upper body, improves overall torsional rigidity by over 20%. Initiatives to improve the local rigidity of the vehicle body are also being undertaken in conjunction with the use of aluminum castings in the struts. Vehicles such as the Lexus LS and Volvo XC60, for example, use them in the front strut, while the Audi A8 also uses them in the rear strut.

4. 2. NVH

With the general elimination of vibrations from the engine resulting from electrification, background noises that had gone unnoticed until now and are now reaching occupants' ears through the vehicle body are becoming an issue. Reducing road and wind noises during driving has become increasingly necessary. The Nissan Serena addresses the issue of noise from inverters and the battery by both strategically placing acoustic and sound absorbing material around the dash and giving the windshield sound masking properties. At the same time, the worsening of NVH performance due to the thinner vehicle body panels used to reduce weight in gasoline vehicles is being addressed in various ways by automakers. The Toyota Camry and Mazda CX-8[8] add material to suppress the opening of the tunnel in an effort to reduce booming noise. Many vehicles, including the Lexus LS, use a compound glass with a sound masking film on the door glass closest to the driver's ears to reduce wind noise and other sounds heard outside the vehicle and provide a quiet space. Efforts to revise the types and position of sound absorbing materials based on identifying the transmission path of the sounds have also been made. In the Mazda CX-5[9], for example, sound absorbing

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material is placed along the path of sound intruding from the rear wheelhouse.

4. 3. Passive Safety

The adoption of active safety electronic devices aimed at avoiding collisions has been increasing. At the same time, passive safety, which involves measures against the collisions that do occur, has become even more crucial in improving the safety of the vehicle body following changes in the regulations and requirements of publicly released test information in various countries that have led to stricter evaluation methods. The U.S. Insurance Institute for Highway Safety (IIHS) has introduced a small overlap test[10] while Europe is planning to introduce a test for car-to-car collisions, for example. Vehicle body structures approaches that seek to address this in terms of the transmission or absorption of impact energy include the adoption of multiple load paths and mode control. The Honda Civic and Accord employ two innovations to against frontal collisions. The first is the use of a front subframe to raise reaction force. The second is the proactive use of breakage control partway through the subframe deformation, resulting in a structure that efficiently absorbs impact energy. Similarly, partial quenching is applied to a portion of the hot stamped rear side member to achieve break mode control. These innovative measures against collisions are developed for each model individually in consideration of the overall vehicle balance, which presents the difficulty that these structures and innovations cannot be immediately transferred from one model to another.

4. 4. Improving Visibility

There are ongoing initiatives aimed at improving visibility around the A-pillar and enhancing the assurance and confidence of customers when they drive. The Honda Accord raises visibility by reducing the A-pillar section. In the Daihatsu Tanto[12] and the Nissan Serena, the A-pillar is divided into front and rear areas whose respective sections are made smaller, an approach combined with creative A-pillar placement to provide broader visibility to the driver.

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