Passenger Cars

Overall Trends

1 Introduction

In 2014, the recovery of the European and U.S. markets, the ongoing, if slower, growth of the Chinese market, and the expansion of the market in ASEAN nations (except Thailand), Central Europe and the Middle and Near East led to worldwide sales of 60.88 million vehicles in the 49 main countries, representing 103% of the previous year. While recovery and growth in individual countries were clearly affected by events such as the Ukrainian crisis and the drop in crude oil prices, the global market as a whole continued to grow.

In the 2014 Japanese market, last minute demand between January and March ahead of the raising of the consumption tax in April, as well as the remaining backlog of orders in April and later, boosted sales of passenger cars, bringing them over 4.6 million vehicles for the first time in eight years. Helped by the introduction of new mini-vehicle models by automakers, sales rose to 111% of the previous year, with mini-vehicles accounting for 39.1% for the entire year.

Although some manufacturers increased exports and despite the generally low yen in 2014, exports dropped to 94.3% of the previous year in part because of the ongoing shift toward local production.

2 State of Vehicle Production, Sales, and Exports

2. 1. State of production in leading manufacturing countries

Global production of passenger cars was 67.53 million vehicles, representing 102.9% of the previous year. China continued to lead global production, exhibiting a double-digit growth, reaching a rate of 110.2%. While still low, levels in European countries have started to recover, and the EU as a whole achieved a rate of 103.9%. The increase in sales in Japan brought a slight production increase, bringing the rate to 101.1%. The vigorous U.S. market sustained high production levels, but as the demand centered on SUVs, passenger car production dropped to 97.4% (Table 1).

The ranking for passenger car production by manufacturing country remains unchanged from last year, with the Hyundai Group in first place, followed by Toyota, the Volkswagen Group, BMW and Daimler, in second to fifth place. Honda, which increased production in Japan, rose to 6th place, while Mazda, which reduced domestic production, dropped to 7th place. Honda, Suzuki, Fuji Heavy Industries and Mitsubishi increased production in Japan, while Toyota, Mazda and Nissan reduced it, and

Table 1 Passenger car production in leading manufacturing countries

	2014	2013	2014 vs. 2013 (%)
Japan	8 277 070	8 189 323	101.1
U.S.	4 253 098	※ 4 368 835	97.4
Canada	913 533	965 191	94.6
Germany	5 604 026	5 439 904	103.0
UK	1 528 148	1 509 762	101.2
France	1 495 000	※ 1 458 000	102.5
Italy	401 317	388 465	103.3
Spain	1 898 342	※ 1 754 668	108.2
EU	15 229 978	※ 14 662 374	103.9
South Korea	4 124 116	4 122 604	100.0
China	19 919 795	※ 18 084 169	110.2
India	3 158 215	※ 3 155 694	100.1
Brazil	2 314 789	※ 2 722 979	85.0
World total	67 525 346	※ 65 638 451	102.9

※ Revised

Note 1) The values announced by the International Organization of Motor Vehicle Manufacturers (OICA) are preliminary figures. There are 27 countries in the EU.

Note 2) The number of vehicles for the U.S. and Canada excludes SUVs and other models that are considered as trucks in those countries.

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Table 2 Passenger car production according to manufacturer and country.

Ranking in 2014	Ranking in 2013	Manufacturer	Country	2014	2013	2014 vs. 2013 (%)
1	1	Hyundai group	South Korea	3 208 685	3 091 731	103.8
2	2	Toyota	Japan	2 915 185	3 021 519	96.5
3	3	VW group	Germany	2 252 470	2 185 979	103.0
4	4	BMW	Germany	1 117 778	1 112 727	100.5
5	5	Mercedes-Benz	Germany	1 019 028	1 006 340	101.3
6	10	Honda	Japan	922 533	805 499	114.5
7	6	Mazda	Japan	918 502	950 834	96.6
8	8	GM	U.S.	861 483	831 854	103.6
9	9	PSA	France	843 917	827 726	102.0
10	11	Suzuki	Japan	825 890	797 385	103.6
11	7	Nissan	Japan	764 230	854 057	89.5
12	14	Fuji Heavy Industries	Japan	695 790	639 756	108.8
13	13	Honda America	U.S.	684 196	733 998	93.2
14	15	Ford Germany	Germany	646 435	608 710	106.2
15	19	Mitsubishi	Japan	637 897	518 063	123.1
16	12	GM Daewoo	South Korea	623 034	757 719	82.2
17	16	Toyota	U.S.	615 019	607 623	101.2
18	17	Daihatsu	Japan	597 043	602 210	99.1
19	20	Nissan	UK	500 238	501 756	99.7
20	18	Ford	U.S.	485 349	553 446	87.7
21	21	Nissan	U.S.	461 777	470 232	98.2
22	23	Renault	France	340 667	336 537	101.2
23	24	GM Canada	Canada	247 298	297 853	83.0
—	22	Fiat Group	Italy	—	386 346	—

Source: Automobile manufacturers association in each country

Table 3 Passenger car production in Japan

	2014	2013	2014 vs. 2013 (%)
Ordinary trucks	4 657 765	4 618 014	100.9
Light-duty trucks	1 750 895	1 888 759	92.7
4-wheeled mini-vehicles	1 868 410	1 682 550	111.0
Total	8 277 070	8 189 323	101.1

Source: Japan Automobile Manufacturers Association

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

	2014	2013	2014 vs. 2013 (%)
North America	1 634 915	1 862 967	87.8
Europe	724 198	691 849	104.7
Oceania	330 765	361 004	91.6
Asia	400 066	355 563	112.5
Middle-East	448 493	432 263	103.8
Central America	109 030	122 328	89.1
South America	123 855	170 350	72.7
Africa	61 342	※ 67 394	91.0
Others	2 931	1 801	162.7
Total	3 835 595	4 065 519	94.3

※ Revised

Source: Japan Automobile Manufacturers Association

the rankings reflect those actions (Table 2).

2. 2. State of Japanese vehicle production, exports, and sales

2. 2. 1. Production

In 2014, the production of mini-vehicles rose while that of compact cars fell, and the overall production rate for passenger cars was 101.1%. Due to the ongoing shift toward local production, the low exchange rate providing impetus to compact car exports did not translate into higher production in Japan, which stopped at 92.7% of the previous year (Table 3).

2. 2. 2. Exports

The number of passenger vehicles exported in 2014 fell by 3.84 million vehicles, to 94.3% of the previous year. Although exports to Europe, Asia, and the Middle East rose, the ratio for North America fell to 87.8% (Table 4).

2. 2. 3. Sales

Sales of passenger cars in Japan rose to 4.7 million vehicles, or 103% of the previous year. Sales of ordinary cars reached 1.44 million vehicles, 102.7% of the previous year, while those of compact cars stalled at 1.42 million vehicles, or 96.6% of the previous year. By contrast, sales of mini-vehicles rose to 1.84 million vehicles, which is 108.8% of the previous year. Model changes and the introduction of new models by automakers spurred new demand on top of the last minute demand ahead of the consumption tax hike, resulting in mini-vehicles accounting for just about 40% of all vehicle sales (Table 5).

2. 2. 4. Used vehicle sales

Sales of used vehicles in 2014 dropped slightly to 5.65 million vehicles, or 99.8% of the previous year. Higher

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mini-vehicle sales compensated for the decrease in sales of ordinary and compact cars. Like the new vehicles market, the used vehicle market is exhibited continued growth in mini-vehicle sales (Table 6).

2. 2. 5. Imported vehicle sales

Sales of imported vehicles in 2014 fell to 320,000 vehicles, which represents 96.5% of the previous year. Among the higher ranking makers, Mercedes-Benz and Audi increased their sales, while VW and BMW sales remained essentially the same. Among the top 20 from the previous year, Nissan, Mitsubishi, and Toyota, who import vehicles produced outside Japan, each fell in rank as their sales dropped considerably (Table 7).

2. 3. Vehicle sales in markets outside Japan

Among the main countries, lower demand cause by Brazil's sluggish economy brought global passenger car sales down to 90.6 of the previous year.

Notwithstanding a decline in growth, China sales increased significantly to 109.9% of the previous year. Western European countries are also showing signs of recovery, with the sales ratio reaching 109.3% in the U.K., 104.2% in Italy, and 102.9% in Germany (Table 8).

Table 5 Passenger car sales in Japan

	2014	2013	2014 vs. 2013 (%)
Ordinary trucks	1 437 589	1 399 407	102.7
Light-duty trucks	1 422 883	1 472 704	96.6
4-wheeled mini-vehicles	1 839 119	1 690 171	108.8
Total	4 699 591	4 562 282	103.0

Source: Japan Automobile Manufacturers Association
Note 1) Categories for sales statistics are collated based on registration numbers

In Central and Eastern Europe, conflicts and crises have led to stagnant sales in Russia and Ukraine, but the market in the rest of that region is getting stronger. As in Brazil, the sluggish economy in other Central and South American countries is causing sales to stagnate.

3 Product Technology Trends

3. 1. New products (Tables 9 and 10)

Counting OEM vehicles, 13 registered vehicle models and 9 mini-vehicle models were introduced in Japan in 2014. Of those, 7 registered vehicle models and 5 mini-vehicle models are new.

New models have helped keep mini-vehicle sales strong even after the consumption tax hike, leading to an increase in both vehicle sales and the proportion of mini-vehicles in those sales.

3. 2. Fuel efficient and environmentally friendly technologies

Hybrid systems were installed on 5 of the 13 registered vehicle models, one of which is an exclusively hybrid model. In addition, December saw the launch of the world's first fuel cell vehicle for the public.

Despite limits on the extent of available motor assistance, some mini-vehicle models have also been equipped with a hybrid system for the first time.

Sales of passenger cars fitted with diesel engines have long been stagnant, but, following the introduction of vehicles with a 2.2 L class diesel engine some years ago, a model featuring a lower displacement 1.5 L diesel engine was launched.

Table 6 Used vehicle sales in Japan

	Ordinary trucks	Light-duty trucks	4-wheeled mini-vehicles	Total	Proportion of previous year (%)
1997	1 406 089	3 626 978	1 009 430	6 042 497	103.8%
1998	1 493 744	3 309 426	1 111 282	5 914 452	97.9%
1999	1 551 703	3 127 783	1 273 383	5 952 869	100.6%
2000	1 742 786	3 050 087	1 448 546	6 241 419	104.8%
2001	1 830 588	2 913 775	1 552 297	6 296 660	100.9%
2002	1 861 694	2 744 604	1 714 827	6 321 125	100.4%
2003	1 910 017	2 640 456	1 809 840	6 360 313	100.6%
2004	1 984 562	2 524 764	1 777 866	6 287 192	98.9%
2005	2 002 563	2 460 410	1 890 154	6 353 127	101.0%
2006	1 959 739	2 304 226	2 033 569	6 297 534	99.1%
2007	1 810 596	2 105 122	2 022 866	5 938 584	94.3%
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%

Source: Japan Automobile Dealers Association
Source: Japan Light Motor Vehicle and Motorcycle Association

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Automakers have been working on reducing vehicle body weight, improving combustion efficiency, reducing running resistance, and refining other technologies that increase fuel-efficiency, and gasoline vehicles without hybrid systems that achieve a fuel economy matching that of hybrid vehicles have been introduced in the market.

3. 3. Safety technologies

The adoption of advanced safety technologies has expanded. The number of vehicles equipped with safety systems that use devices such as laser radars, millimeter wave radars, or stereo cameras to mitigate damage from collisions or prevent them, systems that can check whether the vehicle surroundings are safe, systems that suppress unintended acceleration, or parking assistance functions has grown. Such systems and functions are not limited to registered vehicles, but are also being in-

Table 7 Imported vehicle sales in Japan

Ranking in 2014	Ranking in 2013	Manufacturer	2014	2013	2014 vs. 2013 (%)
1	1	VW	67 438	67 279	100.2
2	2	Mercedes-Benz	60 834	53 720	113.2
3	3	BMW	45 645	46 037	99.1
4	5	Audi	31 413	28 676	109.5
5	4	Nissan (vehicles produced outside Japan)	23 200	35 680	65.0
6	6	BMW Mini	17 596	16 982	103.6
7	7	Volvo	13 277	16 918	78.5
8	9	Fiat	7 289	7 007	104.0
9	11	Jeep	6 691	4 928	135.8
10	10	Peugeot	5 710	5 970	95.6
11	8	Mitsubishi (vehicles produced outside Japan)	5 598	12 429	45.0
12	12	Porsche	5 385	4 869	110.6
13	14	Renault	4 662	3 771	123.6
14	13	Ford	4 598	3 896	118.0
15	15	Land Rover	3 126	3 347	93.4
16	16	Alfa Romeo	2 661	3 148	84.5
17	18	Citroen	2 321	2 947	78.8
18	17	Toyota (vehicles produced outside Japan)	1 674	3 014	55.5
19	19	Chrysler	1 286	1 774	72.5
20	20	smart	1 114	1 298	85.8
—	—	Others	8 159	7 596	107.4
			319 677	331 286	96.5

※ Revised

Source: Japan Automobile Manufacturers Association

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

	2014	Japanese vehicles (within the total)	Share of Japanese vehicles (%)	2013	2014 vs. 2013 (%)
Japan	4 699 591	4 410 761	93.9%	4 562 282	103.0
U.S.	7 688 114	3 267 045	42.5%	※ 7 585 341	101.4
Canada	755 500	326 235	43.2%	※ 755 615	100.0
Brazil	2 504 161	326 535	13.0%	2 763 718	90.6
China	19 700 569	3 278 047	16.6%	17 928 858	109.9
India	2 601 766	1 516 225	58.3%	※ 2 583 033	100.7
UK	2 476 435	391 989	15.8%	2 264 737	109.3
Germany	3 036 773	268 584	8.8%	2 952 431	102.9
France	1 795 885	171 548	9.6%	1 790 456	100.3
Italy	1 359 616	143 180	10.5%	1 304 345	104.2
EU + EFTA total	12 995 527	1 650 786	12.7%	※ 12 328 655	105.4

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 that are considered as trucks in those countries (Source: Ward's).

Note 3) Calculated from the 27 countries in the EU and 3 countries in the European Free Trade Association (EFTA: Iceland, Norway, and Switzerland) (source: European Automobile Manufacturers' Association (ACEA)).

※ Revised

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Table 9 Product technology trends in compact cars produced in Japan in 2014

Release date	Vehicle type	Manufacturer	Manufacturers
January 20	Voxy Noah	Toyota	Full model change The adoption of a newly developed low flat floor provides a roomy cabin, facilitates ingress and egress for children and the elderly, and offers user-friendly luggage space. At the same time, the 7-seater grade provides a very long slide (810 mm) through a combination of the side-sliding mechanism in the second row of seats and one-touch storage in the third row. The hybrid system with a reduction gear achieves a fuel economy of 23.8 km/L. In the gasoline-powered grades, a fuel economy of 16.0 km/L is reached with the use of the new Super CVT-i and a stop-start system (in 2 WD vehicles fitted with a stop-start system). The Intelligent Parking Assist (with Easy Set), a color back guide monitor that expands the rear view monitor view angle up to approximately 180 degrees, and one-touch electric sliding doors (with dual easy-closing mechanisms) are also included. Wheelchair-enabled models offer a manual forward ramp and introduce a new dedicated Friendmatic model equipped with Welride that facilitates getting into the driver's seat and provides storage for the wheelchair itself.
February 5	Teana	Nissan	Full model change Response, stability and handling have been improved through the adoption of a newly developed multi-link rear suspension and Active Trace Control. Cooperative control between the refined QR engine and the CVT with a wider gear ratio provides a fuel economy of 14.4 km/L.
June 20	Levorg	Fuji Heavy Industries	New model The 1.6 L intelligent DIT combines a small displacement engine and direct injection turbo to achieve a fuel economy of 17.4 km/L. The 2.0 L high-performance DIT achieves a fuel economy of 13.2 km/L while offering a torque performance that achieves a high power of 221 kW (300 PS) and 400 N·m (40.8 kgf·m) at engine speeds of 2,000 rpm. This model is equipped with the EyeSight (ver. 3) advanced safety system, which has been greatly enhanced with a wider and longer acquisition range as well as color recognition. It also features state-of-the-art active safety technologies that upgrade the performance of the pre-collision braking system and cruise control with full speed following with the inclusion of new functions such as the Active Lane Keep steering support function, Pre-collision Throttle Management, and brake light recognition.
July 29	NX	Lexus	New model The newly developed 2.0 L turbo engine combines a twin-scroll turbocharger and Dual VVT-iW with expanded variable angles and uses D-4 ST to optimize combustion efficiency. A new 6-speed automatic transmission was developed in tandem with the turbo engine. The hybrid unit achieves a fuel economy of 21.0 km/L by combining a 2.5 L Atkinson cycle engine focused on thermal efficiency and a hybrid transmission with a built in high torque motor. When active, the radar cruise control with all-speed tracking function coordinates with the stop-start system when the vehicle is stopped to detect the lead vehicle start and automatically restart the engine. Safety features include a panoramic view monitor that compensates for blind spots on the sides of the vehicle, and LED cornering lamps that illuminate a wide area around corners at night.
August 25	WRX S4	Fuji Heavy Industries	Full model change The 2.0 L horizontally-opposed DIT engine achieves a fuel economy of 13.2 km/L while delivering a torque performance that achieves a high power of 221 kW (300 PS)/5,600 rpm and 400 N·m (40.8 kgf·m)/2,000 to 4,800 rpm. This model is equipped with the EyeSight (ver. 3) advanced safety system, which has been greatly enhanced with a wider and longer acquisition range as well as color recognition. It also upgrades the performance of the pre-collision braking system and cruise control with full speed following with the inclusion of new functions such as the Active Lane Keep steering support function, Pre-collision Throttle Management, and brake light recognition.
August 25	WRX STI	Fuji Heavy Industries	Full model change Careful tuning of the 2.0 L horizontally-opposed turbo engine delivers a high power of 227 kW (308 PS)/6,400 rpm and a high torque of 422 N·m (43.0 kgf·m)/4,400 rpm. Greater use of high tensile strength steel sheets and the reinforcement of joints in every structure achieves a high strength even as weight is reduced, and the vehicle offers superb safety in all directions against frontal, side or rear collisions.
September 26	Demio	Mazda	Full model change This vehicle features the newly developed SkyActiv-G 1.3 gasoline or SkyActiv-D diesel engine. The SkyActiv-G 1.3 remains as fuel-efficient as the preceding model while increasing torque in all ranges by 5 to 10 %. The SkyActiv-D 1.5 (automatic transmissions) achieves a 250 Nm maximum torque equivalent to that of 2.5 L gasoline engines. The SkyActiv-D 1.5 (manual transmission) achieves a fuel economy of 30 km/L, the highest for a vehicle with an internal combustion engine outside of the hybrid or mini-vehicles categories. For the transmission, a small displacement 6-speed automatic SkyActiv-Drive and a 5-speed SkyActiv-MT were developed.

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Table 9 Product technology trends in compact cars produced in Japan in 2014 (cont.)

Release date	Vehicle type	Manufacturer	Manufacturers
September 26	Demio	Mazda	Full model change This vehicle features the newly developed SkyActiv-G 1.3 gasoline or SkyActiv-D diesel engine. The SkyActiv-G 1.3 remains as fuel-efficient as the preceding model while increasing torque in all ranges by 5 to 10 %. The SkyActiv-D 1.5 (automatic transmissions) achieves a 250 Nm maximum torque equivalent to that of 2.5 L gasoline engines. The SkyActiv-D 1.5 (manual transmission) achieves a fuel economy of 30 km/L, the highest for a vehicle with an internal combustion engine outside of the hybrid or mini-vehicles categories. For the transmission, a small displacement 6 -speed automatic SkyActiv-Drive and a 5 -speed SkyActiv-MT were developed.
October 4	Legacy Outback/B4	Fuji Heavy Industries	Full model change Approximately 80 % of parts in the FB25 horizontally-opposed engine are new designs, with refinements centered around the intake and exhaust, system and the combustion system. In the Outback, the symmetric AWD is supplemented with X-Mode, a system that enhances rough road performance through optimal integrated control of systems such as the engine, the drive force in the four wheels, and the brakes when, for example, the road surface is slippery. In addition to the EyeSight (ver. 3) state-of-the-art safety system which features a wider and longer acquisition range as well as color recognition, the performance of the pre-collision braking system and cruise control with full speed following have been upgraded with the inclusion of new functions such as the Active Lane Keep steering support function, Pre-collision Throttle Management, and brake light recognition. The model also features the i-ActiveSense advanced safety technology package that includes Smart City Brake Support (SCBS) which helps mitigate damage in a rear end collision at low cruising speeds, Blind Spot Monitoring (BSM) which detects, and alerts the driver to, vehicles approaching from the side and rear, and the Rear Cross Traffic Alert (RCTA) where, while moving in reverse in a parking lot, for example, the car detects incoming vehicles and warns the driver.
October 23	Coupe RC	Lexus	New model TVD, a drive force control system that provides optimum electronic control of the drive force in the left and right rear wheels based on driving conditions to achieve ideal vehicle behavior during cornering was developed and is offered as an option. In the powertrain, the cylinder heads and connecting rods were revamped, and the D-4 S direct injection technology and VVT-iE on the intake side of the Dual VVT-i were adopted.
October 23	RC 350 RC 300h	Lexus	New models The 3.5 L engine in the RC 350 optimizes combustion efficiency through the use of advanced technologies such as D-4 S, which provides ideal control of direct injection and intake port injection in accordance with the state of the two injectors, and Dual VVT-i, which provides fine-grained control of the timing for the opening and closing of the intake and exhaust valves. The hybrid system in the RC 300 h combines a high output motor and electric continuously variable transmission, improving fuel efficiency and reducing CO_2 emissions to achieve a fuel economy of 23.2 km/L. These models also feature safety systems such as a pre-collision system that helps avoid collisions or mitigate collision damage, a lane departure alert system to warn the driver of lane drifts, VDIM, which provides integrated control of running, turning, and stopping, and a pop-up hood system that instantly lifts the hood to protect pedestrians.
October 29	Esquire	Toyota	New model The low flat floor package secures such basic minivan functions as a roomy cabin and excellent ingress and egress. In addition, the hybrid grade achieves a fuel economy of 23.8 km/L.
December 1	Grace	Honda	New model Using the Sport Hybrid i-DCD that combines the 1.5 L Atkinson cycle DOHC i-VTEC engine, 7 -speed DCT with internal high-output motor system with an IPU featuring an internal lithium-ion battery to achieve a fuel economy of 34.4 km/L. In addition to Vehicle Stability Assist (VSA) and the Hill-Start Assist function, the Emergency Stop Signal system, which warns the car behind of sudden braking, has been made standard equipment on all model types. This model includes the crash-compatibility body technology that both protects the vehicle itself through Honda's original G-Control technology and reduces aggressiveness toward the other vehicle, and the Pedestrian Injury Reduction Body that uses a structure designed to soften impacts at the front of the vehicle, which can easily injure pedestrians in the event of a collision. In addition, the Safety Package consisting of the City Brake active system that helps prevent collisions at speeds below 30 km/h, side curtain airbag system and front-seat i-Side airbag (variable capacity) system is offered as an option on individual model types.
December 15	Mirai	Toyota	New model The Toyota Fuel Cell System (TFCS), a fusion of hybrid technology and fuel cell technology built on an internally developed fuel cell stack developed in-house and a high-pressure hydrogen tank, achieves higher energy efficiency than internal combustion engines and offers excellent environmental performance through eliminating the emission of CO_2 or other harmful substances during driving. Motor driving at all vehicle speeds provides superb acceleration performance and quietness, while the lower center of gravity increases handling stability and controllability. What's more, the Mirai can serve as a high capacity power supply in emergencies such as power outages or natural disasters, and it also features a dedicated communications system.

All fuel economy values are JC08 test cycle fuel consumption rates (verified by the Ministry of Land, Infrastructure Transport and Tourism)

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Table 10 Product technology trends in mini-vehicles produced in Japan in 2014

Release date	Vehicle type	Manufacturer	Manufacturers
January 8	Hustler	Suzuki	New model The vehicle packaging offers both roominess matching that of wagon mini-vehicles and excellent performance on rough roads, and the 4WD CVT grade includes the Hill Descent Control and Grip Control systems. Installed advanced safety technologies include the Radar Brake Support collision mitigation braking system and an unintended start control system, and environmental technologies such as eNe-CHARGE achieve a fuel economy of 29.2 km/L.
February 13	eK Space	Mitsubishi Motors	New model Featuring a 1,400 mm cabin height and 2,235 mm cabin length, this model also offers amenities such as (independent) 260 mm rear seat slides, a rear circulator that cycles air throughout the cabin, and rolling sunshades for the rear seats. The Active Stability Control (ASC) system that offers stability and traction control functions to prevent skidding on slippery roads, anti-lock brakes to prevent the wheels from locking during sudden braking, and the Emergency Stop Signal system that automatically flashes the hazard lamps rapidly during sudden braking or when the ABS engage to warn the driver of the vehicle behind and help prevent rear-end collisions. Except for the Custom T, all grades are equipped with the Assist Battery, which makes use of regenerative energy during deceleration. Thanks to the adoption of the Auto Stop & Go (AS&G) system, which automatically cuts off the engine during deceleration (at around less than 9 km/h) to mitigate fuel consumption, fuel economy is 26.0 km/L in 2WD grades with standard engines (the E, G and Custom G), 24.6 km/L in 4WD grades (but 25.4 km/L for the E), 22.2 km/L for 2WD grades with a turbo engine (Custom T), and 20.8 for their 4WD counterparts.
February 13	Dayz Roox	Nissan	New model This model offers an expanded field of view through the Around View Monitor that assists with parking by providing a bird's eye view of the vehicle surroundings, and also achieves ease of handling with a minimum turning radius of 4.4 m (for grades with 14-inch tires). The inclusion of the new battery assist system contributes to improved fuel economy by reducing the frequency of electricity generation by the alternator, a process that consumes gasoline, through the use of that electricity to charge the nickel-hydrogen battery and power electronic components such as the audio or navigation systems. This allows grades with the naturally aspirated engine to surpass the 2015 fuel economy standards by 20 %, and the grades equipped with a turbo engine to meet those standards.
June 19	Copen	Daihatsu	Full model change The use of new D-Frame structure to ensure the high rigidity required by sports cars with the frame alone makes it possible to change the design even after purchase through the Dress-Formation interchangeable outer panels.
November 10	Wake	Daihatsu	New model A roomy cabin and excellent ingress and egress were ensured with a full height of 1,835 mm, an interior height of 1,455 mm, and a height of 1,700 mm from the ground to the top of the door opening. The use of e:S Technology systems, including Cooled i-EGR, CVT Thermo-Controller, and Eco Power Generation Control achieves a fuel economy of 25.4 km/L.
December 12	Move	Daihatsu	Full model change The frame and chassis were redesigned with a new lightweight high-rigidity body, and reverse control capabilities were added to the Smart Assist collision avoidance support system. The 2WD, NA grade achieves a fuel economy of 31.0 km/L.
December 12	Stella	Fuji Heavy Industries	Full model change This model improves rigidity through the use of a lightweight high-rigidity body and optimum reinforcement of the underbody. It also supplements the existing low-speed collision-avoidance support braking, pre-collision braking, and lead vehicle start alert Smart Assist functions with the addition of Pre-collision Throttle Management, offering greater safety both ahead of, and behind, the vehicle by preventing sudden starts due to pressing the wrong pedal. The Vehicle Dynamics Control (VDC) system that automatically controls engine power and the brakes to ensure vehicle stability when the handle is turned suddenly or during cornering on slippery road surfaces has been made standard equipment (in vehicles with Smart Assist). This is an OEM model supplied by Daihatsu.
December 22	Alto	Suzuki	Full model change The adoption of a new platform, extensive weight reduction initiatives that made the vehicle 60 kg lighter, and increased powertrain efficiency all work together to achieve a fuel efficiency of 37.0 km/L. Advanced safety technologies, such as the Radar Brake Support collision mitigation braking system are installed, raising both fuel economy and safety performances. This is the first mini-vehicle equipped with the new Auto Gear Shift (AGS) transmission that offers the advantages of both manual and automatic transmissions. Cooperative control between the transmission and engine provide a smooth shift feeling with minimal shift shock and achieves excellent fuel economy.

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Table 10 Product technology trends in mini-vehicles produced in Japan in 2014 (cont.)

Release date	Vehicle type	Manufacturer	Manufacturers
December 22	N-Box Slash	Honda	New model The box coupe exterior makes this box style model look like a coupe. Some grades are equipped with the Sound Mapping System that features a speaker layout designed to pursue high quality sound supplemented with soundproofing materials. As an option, individual model types offer the Safety Package that consists of the City Brake active system that helps prevent collisions at speeds below 30 km/h, a side curtain airbag system that softens impacts to the head and chest in a collision, and the front-seat i-Side airbag (variable capacity) system.

All fuel economy values are JC08 test cycle fuel consumption rates (verified by the Ministry of Land, Infrastructure Transport and Tourism)

stalled in more mini-vehicle models.

However, the safety-related quality problem of abnormal airbag deployment also arose. The scope of the problem was broadened by the increasing commonization of parts.

Design Trends

1 Pragmatism and Crossovers: the New Global Popularity Criteria

Sales in Europe center around compact and practical C-segment vehicles such as the VW Golf or the Ford Focus, as well as B-segment models such as the VW Polo and the Ford Fiesta, showing that in Europe, as in Japan, buyers are looking at pragmatic factors such as price and fuel economy. The Audi A3 was named World Car of the Year, while the Peugeot 308 received the European Car of the Year title. The relatively affordable Renault-Nissan Alliance Dacia model, in particular, is gaining market share in Europe, as are the Volkswagen Group's Skoda and SEAT lines. The growing recognition received by those brands is attributed to their reasonable prices and customer trust in the parent Renault-Nissan and Volkswagen brands.

In the U.S. market, many customers favor pickup trucks for practical use, and SUVs and sedans such as the Toyota Camry also enjoy high ratings.

In growing markets, customer tastes are leaning toward larger and more luxurious vehicles, as shown by the rising popularity of wide sedans, SUVs and crossovers in the Chinese market.

In Japan, despite market changes such as lower sales in the August following the consumption tax hike and mini-vehicles accounting for over 40% of new vehicle sales, the general trend of hybrids and mini-vehicles dominating sales rankings remains unchanged.

From a long-term perspective, it is common for buyers in all regions to base their choices on pragmatic factors such as practical use and cost efficiency, and a model most suited to a given region can be found. The same can be said for designs, which reflect the market: barring major changes in lifestyle or the economy, tendencies concerning the designs chosen by customers in that market rarely change.

Fig. 1 Renault Captur

Fig. 2 Peugeot 2008

Fig. 3 Renault Espace

This makes the growing shared popularity and recognition enjoyed crossovers in all parts of the world, regardless of differences in use environment or culture, particularly noteworthy.

In Europe, the introduction of vehicles such as the Renault Captur (Fig. 1) and Peugeot 2008 (Fig. 2) has established the compact crossover as its own category. Even the aforementioned Dacia lineup includes the Duster crossover, which plays an important role within the brand. The new Renault Espace unveiled at the 2014 Paris Motor Show (Fig. 3) behaves like a 5- or 7-seater

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minivan, but is built on crossover specifications.

2 Reliability and a Sense of Security Sought in Crossover Designs

Functional advantages anyone can appreciate, such as superb rough road capability, the outstanding line of sight provided by the high seating position, and extremely convenient ingress and egress suggest themselves as reasons for the strong global popularity of crossovers. Further possible reasons include the impression of safety and reliability stemming from a sturdy exterior, as well as the sense of freedom offered by the ability to drive both on and off road.

The common psychological factors bringing people in many different regions to favor crossovers at the same time are not known, but there must be some common phenomena influencing those people. One possible factor underlying that shared consciousness may be the similar anxiety triggered in all parts of the world by the global situation or natural disasters. In Japan and Western countries, the slowing of economic growth found in mature societies and changes in lifestyle arising from a declining birth rate and the aging of the population are other potential factors. Taking a second look at the characteristics of crossovers in that light, the ease of getting in and out of the vehicle and their safety is suited to an aging society, while their sense of freedom to go anywhere and impression of sturdiness gives them a personality that proves attractive in markets where consumers feel walled in and uneasy.

In the last year or two, many compact models have been introduced in the crossover category, which has now established itself as a primary segment. Many of the vehicles belonging to this category feature a solid appearance resulting from compound materials obtained through the use of large tires and plastic parts, as well as the application of decorative patterns or two tone coloring, and exude a sense of reliability while remaining compact.

3 State of the Art in Environmentally Friendly Technology: HVs in Japan, PHEVs in Europe: Universality, Environmental Friendliness and Achieving a Sustainable Society are the Common Design Points

When EVs and HVs were in their infancy, the necessity of advanced technologies had yet to permeate, and conveying the leading edge feel require adopting unconventional designs. However, now that such technologies are widely recognized as essential, a greater number of models eschew unconventional or special exteriors even if they are EVs, HVs or PHEVs (Fig. 4).

Fig. 4 Mitsubishi Outlander PHEV

Fig. 5 BMW i3

Fig. 6 Mass production fuel cell vehicle: the Toyota Mirai

Of course, that does not mean all models are designed to emphasize universality. Motivated by the keyword "sustainable", the BMW i3 EV (Fig. 5) achieves a lightweight body through the use of fiber. The side panels were split from the body by blacking out the center of the body to achieve the distinctive design with a sense of lightness that expresses the state-of-the-art lightweight structure and the no-compromise concept that uses many recycled and natural material in the interior. The design, and underlying concept of the car were well received, and it won the 2014 World Car Design and World Green Car of the Year award, as well as the COTY Innovation Award in Japan. Such concepts showcased through the design are based on the themes of the environment or a sustainable society rather than being meant to express unconventionality.

The Mirai mass production fuel cell vehicle launched by Toyota in Japan (Fig. 6) also features a design which, with the exception of elements designed to evoke leading edge technology and the future, also incorporates universal elements and is balanced to naturally blend in with current market tastes. Design concepts are moving away from innovation and change, and toward emphasizing a universality that engenders peace of mind and trust, as well as achieving a sustainable society.

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Fig. 7 Daihatsu Tanto

Fig. 8 Mazda Demio

4 The Japanese Market: Mini-Vehicles, Compact Cars, and HVs

As in Europe, sales in the Japanese market center on a pragmatic model where cost-efficiency is combined with convenience. The mini-vehicles category, which emphasizes practicality, made up 40% of new vehicles sales in the Japanese market.

Among those mini-vehicles, models where the limited floor area successfully provides a roomy cabin proved popular, and the highest sales came from the tall wagon type models typified by the Tanto from Daihatsu Motor Co., Ltd. (Fig. 7).

Performance improvements and the market shift to favoring pragmatism led to an expanded mini-vehicle share, and given that the acclaim received by brands such as Dacia in Europe is similarly based on higher quality and a growing preference for pragmatism, it can be said that there are common points in cars valued by both European and Japanese consumers.

The Mazda Demio (Fig. 8), a pragmatic model that is compact and features a 1.5 L light-duty clean diesel engine, received the COTY award for its attractive exterior and above-and-beyond sense of quality. Compact crossovers are gaining popularity in the Japanese market as well. The Honda Vezel (Fig. 9) presents a stylish exterior that expresses the fusion of a coupe and an SUV, and the cost-efficient, environmentally-hybrid grade accounts for 80% of sales for that model. Similarly, the Toyota Harrier offers an intelligent and pragmatic choice in response to market demand for crossovers.

Mini-vehicles exhibit the same tendencies, and the Suzuki Hustler, winner of the RJC Car of the Year award (Fig. 10), is a model that is both as practical as the WagonR and cost-efficient.

5 Safety is Global: Changes in Interior Design

In Japan, the active safety technology exemplified by

Fig. 9 Honda Vezel

Fig. 10 Suzuki Hustler

Fig. 11 Subaru XV fitted with the EyeSight system

Fig. 12 Honda N-WGN

Fig. 13 Demio with Mazda Connect

Subaru's EyeSight (Fig. 11), has become so prevalent as to become virtually standard. Mini-vehicles are no exception, and the Honda N-WGN mini-vehicle (Fig. 12) received a five star safety rating. The past correlation between prioritizing cost efficiency meaning choosing a mini-vehicle, but prioritizing safety meaning having to choose a more expensive, larger vehicle has weakened, and high levels of safety are now required even in cost-efficient mini-vehicles.

Moreover, technologies paving the way for automated driving, which flows from active safety technologies, are gradually taking on concrete form, and the relationship between automobiles and the information and communication technologies essential to realizing automated driving is becoming more tight knit. Vehicles with a permanent internet connection are called connected cars (Fig. 13), and are expected to improve fuel economy through planned, efficient travel achieved by continuously updating information in real time. EVs and PHEVs require real time monitoring of charging station conditions, making permanent connections essential.

As standard equipment evolves to include features such as systems that enable prompt rescue in the event of an accident, space to display information other than driving information will be required. Since the limited space on current instruments cannot display such vast

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Fig. 14 Audi TT multi-display

quantities of information, advances in multi-display systems that only bring up necessary information can be imagined, and the effects of such advances are expected to potentially lead to significant changes in interior design (Fig. 14).

6 Global Color and Material Trends

Looking at designs outside the automotive field, the 2014 Milan Furniture Fair and other interior design shows featured an emphasis on expressing a sense of quality through materials and intermediate colors, and many of the exhibits proposed themes revolving around universal and reliable concepts such as tradition or immutable nature. Designs characterized by the coordination of color, material, finish (CMF) were also seen at the Paris Motor Show. A second look at the characteristics of crossovers increasingly popular with consumers shows that hardness and softness are incorporated through the inclusion or exclusion of color, material, or sheen, and different materials are coordinated to achieve a rich and expressive design. This matches the above-mentioned trend of expressing design through the coordination of different materials seen in other industries (Fig. 15).

7 Impact of Inescapable Realities

Societies with a declining birth rate and an aging population are facing the problem of being unable to sustain their economic foundation unless the age of retirement is raised to secure a sufficient working population. This suggests the need for an infrastructure that makes commuting possible even for older workers, and is leading to proposals for mobility providing comfortable travel. To be ready for the further aging of the population, Japan and Europe have started to look into ultra-compact mobility (Figs. 16 and 17).

Unlike personal use means of transport which must satisfy the desire to own, personal transportation is designed from a macroscopic and pragmatic perspective. Nissan has announced that its NV200 taxi (Fig. 18), already in service as a taxi in New York, will also be sold in Japan in 2015. Toyota also announced a high-functionality taxi concept vehicle measuring over 1,700 mm in late 2013. Taxis are expected to offer pragmatic aspects such as reducing fatigue for passengers of all ages, and efficient transportation of both people and luggage, which makes minivans, which are extremely easy to get into and out of, an optimal choice.

Fig. 15 CMF-based coordination Citroën C4 Cactus

Fig. 16 Toyota i-Road

Fig. 17 Nissan New Mobility Concept

Fig. 18 Nissan NV200 Taxi

8 Summary: Global Phenomena and a World in Sync

Design is influenced by the environment surrounding people and the phenomena that manifested in the market show that in terms of global trends, this led to a high degree of popularity for crossovers, as well as to many elements tying in to reliability and peace of mind, such as advances in driving safety support technologies. At the same time, models exhibiting a pragmatic awareness of environmental issues are well-received all over the world, and design proposals targeting the realization of a sustainable society are common to mature societies.

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Although it is impossible to determine whether anxiety over natural disasters occurring around the world or the global situation directly affected the simultaneous manifestation of such phenomena, it is likely to have been influenced by the sharing of information resulting from the rapid spread of the Internet, which makes events in distant countries feel immediate, regardless of nationality or where people live.

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Body Structures

1 Trends in Body Structures

Over ten years have passed since global warming prompted a focus on reducing CO_2. The European CO_2 emissions regulatory value, which was 140 g/km or less in 2008, will become increasingly stricter, dropping to 120 g/km in 2015, 90 g/km in 2020, and 70 g/km in 2025 (1).

This has prompted striking progress in fuel-efficient technologies. Around 2008, the fuel economy of hybrid vehicles was 35.5 km/L for the Toyota Prius, and 24.0 km/L for the Honda Fit, a gasoline vehicle. Six years later, in 2014, the hybrid Toyota Aqua and the gasoline-powered Suzuki Alto have reached 37.0 km/L. Of course, such CO_2 reduction initiatives are not limited to fuel-efficient technologies for gasoline engines.

Diesel engines, which emit less CO_2 than gasoline engines (Fig. 1), have also been changing.

The Mazda Demio announced in 2014 is one of the few compact cars in Japan equipped with a diesel engine. The subsequently announced Mazda CX-3 (Fig. 2) is only available with a diesel engine. Diesel engines, which make up approximately half of the engines in Europe, may be poised to become more common in the Japanese market as well.

At the same time, hybrids are leading the way to increasing electrification. Hybrid vehicles monopolized the top five ranks for sales of registered vehicles in Japan in 2014, and are reported to have exceeded 1 million units (4).

Internal combustion engines are not the sole focus of activities. The end of 2014 saw the launch of the Toyota Mirai (Fig. 3), a fuel cell vehicle that uses hydrogen to generate electricity and produces zero emissions.

As powertrains featuring such next-generation power units and the aforementioned hybrid and diesel engines, which tend to be heavier than gasoline engines, become more common, it becomes necessary to further reduce vehicle body weight.

However, even more technology improvements are required to maintain body performance while achieving that weight reduction.

This article looks at trends in body structure technologies from the point of view of achieving both body performance and weight reduction.

2 Technological Trends Concerning Required Body Performance

2. 1. Stability and controllability

Stability and controllability goes beyond providing the driver with the joy of controlling the vehicle as desired and also encompasses the critical function of achieving

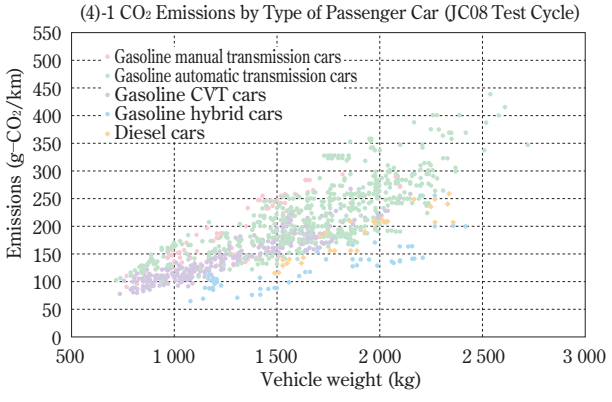

Fig. 1 Passenger car CO_2 emissions (2)

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Fig. 2 Mazda CX-3 [3]

Fig. 3 Toyota Mirai [5]

safe driving, and automakers have presented reports on various initiatives in that vein.

Nissan, Toyota and Subaru have issued reports on the development of technology to simulate behavior during cornering, apprehend how the vehicle body moves, and understand the necessary body rigidity (6). Mazda had already reported work on the development of technology focusing on hysteresis, i.e., the phase difference in vehicle body torsional deformation (7). As shown by the above examples, full vehicle development reaching beyond the body to encompass the suspension as well is becoming increasingly common.

2.2. Noise, vibration, and harshness (NVH) performance

With the rapid progress made in improving fuel economy as well as the lower normal speed and reduced weight of the engine, ensuring NVH performance, which operates in opposition to those factors, requires ever greater ingenuity. As with stability and controllability, work on NVH performance is moving from development based on components such as the body or engine to full vehicle development encompassing the engine and inputs from the suspension.

Honda, for example, has presented a report on overall vehicle development that proposes rigidity guidelines to reduce the force transmitted to the body based on the characteristics of suspension bushing springs and the rigidity of the body at their attachment point (8).

2.3. Safety performance

In terms of passive safety performance, examples where structures were revised to conform with assessments involving stricter requirements such as the IIHS small overlap have been reported (6).

At the same time, more creative approaches are required due to the increased weight resulting from the electrification of power units prominent in hybrid vehicles, and the shortening of the crushable zone and adaptations to protect the battery.

3 Technological Trends to Mitigate Weight Increase and Satisfy Performance

These advances in technologies that make the points for improved performance clear are prompting the creation of various adaptive measures. Obviously, approaches that avoid weight increases to maintain fuel efficiency, and efficiently satisfy performance requirements, are expected of these measures.

The following sections will highlight trends in body technologies from the standpoints of material ideas, process ideas, and structure ideas.

3.1. Material ideas

3.1.1. Steel sheets

The tensile strength of high tensile strength steel sheets, which allow for thin sheets while ensuring strength within the plastic deformation range, has gradually been increasing from approximately 590 MPa, and

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Fig. 4 Volvo XC90 [10]

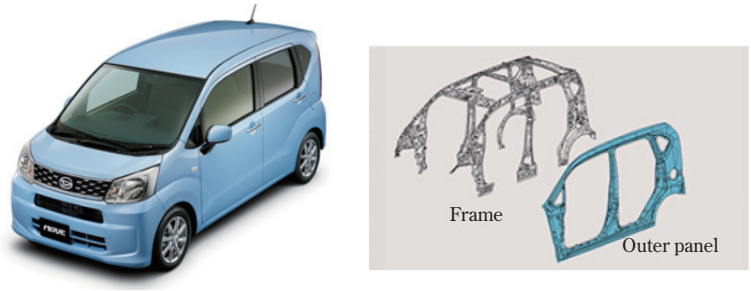

Fig. 5 Daihatsu Move [11]

Fig. 6 Mercedes-Benz C-Class [12]

there are now cases where cold rolled steel sheets with a tensile strength of 1,180 MPa are used. In the Nissan Skyline launched in 2014, 780 MPa class or higher ultra-high tensile strength material rose to 11% of overall use, 6% of which is of 1,180 MPa class or higher (9). Among European makers, the Volvo XC90 presents an example of 1,500 MPa class die quenched material being used in over 40% of the cabin frame (Fig. 4), but among Japanese makers, the use of such material has not risen appreciably and is remaining at its current level.

Efforts to reduce weight are not limited to ultra-high tensile strength sheets, and there are examples of initiatives involving the use of 440 MPa or 590 MPa class materials for the exterior panels. The Daihatsu Move uses high strength steel sheets for the outer side body and aims for both overall weight reduction and better strength and rigidity through the use of thicker sheets (Fig. 5).

3. 2. 2. Aluminum

Due to its lower specific gravity than steel, aluminum has long been focused upon as a lightweight material, and its use in vehicle body structures is common, but until now, it was often limited to expensive luxury cars. However, the Mercedes-Benz C-Class launched in Japan in 2014, which is sold in the 4 million yen price range, marks the use of aluminum in a lower priced vehicle than in the past.

Aluminum is used in exterior parts such as the roof and doors. Die casting is used for portions where local rigidity needs to be raised, such as the suspension attachments and frame nodes, and the sleek shaping unachievable with stamped parts ensures rigidity while reducing the number of parts and reducing weight. As much as 50% of the vehicle body consists of aluminum, an important factor in making the vehicle is 70 kg lighter than the previous model (Fig. 6).

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3. 2. 3. Plastic

A shift toward plastics can also be seen. Plastics are characterized by their lightness, greater shaping flexibility than stamped steel sheets, and not being subject to rusting. The Daihatsu Copen, which uses steel sheets in the frame to ensure strength and plastic for outer panel parts, uses interchangeable structures to incorporate the idea of easily modified styling (11).

3. 2. 4. CFRPs

The one area where plastic is lacking is strength. Plastic materials that compensate for that lack include plastics containing glass fibers, and CFRPs, where carbon fibers are impregnated with plastic. The use of CFRPs has increased dramatically in recent years, as evidenced by examples such as their full-scale use in aircraft. In the automotive field, their use had been limited to high-end sports cars, but they are starting to find their way in less expensive vehicles. In Japan, BMW is selling the i3, which uses a body-on-frame structure where CFRPs are placed on top of aluminum, in the 5 million yen price range (13). These materials are expected to see expanded application as technological advances overcome productivity issues.

3. 2. Process ideas

3. 2. 1. Welding

Vehicle bodies consisting of steel sheets typically use spot welding to join the sheets. Although the holding force in spot welding can be increased by setting the spots closer together, at intervals of less than 25 to 30 mm, electricity generally flows in adjacent sections to weld and prevents welding. Various solutions to the issue have been reported.

As noted in the August 2014 Year Book edition of the Journal of Society of Automotive Engineers of Japan, Toyota has used laser screw welding (LSW) to refine technology that can apply extra welds between existing weld spots. The technology was applied in the Lexus IS (6), and then in the NX (14), and its adoption is expanding. For its part, Honda has adopted welding technology using a narrower pitch. Both technologies have been described as contributing to improved rigidity (15).

Moreover, spot welding also includes reported examples of the adoption of single-sided welding (6).

In standard spot welding, spot gun electrodes are applied from both sides of the steel sheets to be welded, which are then energized by applying pressure. This means that joining two closed cross-sections requires drilling a hole for the electrode to weld the sheets, or using bolts to tighten them. However, adding holes results in decreased rigidity, and from the standpoint of production efficiency, tightening with bolts, unlike spot welding, makes it difficult to ensure proper rigidity simply by adding joining points. If sheets can be welded by pressing the electrode on a single side, frame cross-sections can be made continuous with no loss of rigidity. Joining technologies that yield higher rigidity are expected to become adopted more widely.

3. 2. 2. Adhesion

Bonding based on continuous joining or adhesives aimed at achieving tighter joining has been around for a long time. Various automakers, including Toyota (6), Mazda (16)(17), and Nissan (6) make use of adhesives, particularly in parts such as door openings and rear wheel housings, and there is a growing number of cases where rigidity is further increased. Adhesives play an important role not only in joining steel sheets, but also materials that differ, such as joining plastics like the aforementioned CFRPs with steel sheets or aluminum. These technologies will advance in tandem with the diversification of materials used.

3. 3. Structure ideas

3. 3. 1. Optimum placement of stiffening members

Many instances of adding stiffening members to increase rigidity and ensure or improve maneuverability have been reported. In cars such as the Nissan Skyline (6) and Subaru Levorg (18), a simulation of body behavior during cornering is used to identify portions that affect maneuverability and add reinforcing parts at the most appropriate locations. There are various accounts of proposals to improve maneuverability by increasing torsional rigidity and local rigidity at the suspension attachments.

3. 3. 2. Revision of the cross-sections

In addition to stiffening parts on the outside of the vehicle body, internal cross-sections are also being rethought. The Mazda Demio launched in 2014 sets foamable plastic in the center pillar and uses technology based on the idea of using the heat from the painting process to cause the plastic to foam and fill the cross-section to simultaneously improve performance and reduce weight (16). Parallel advances will be made in the use of different materials for strengthening as part of technologies to use metal to the fullest.

3. 3. 3. Radical revision of the frame structure

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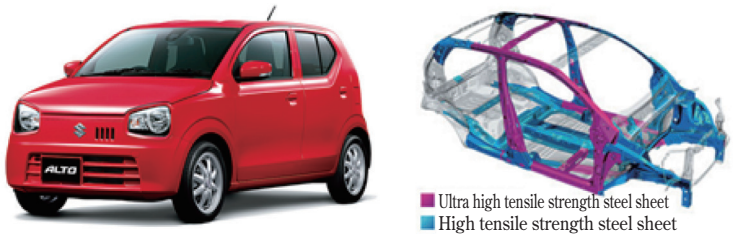

Fig. 7 Suzuki Alto [19]

There are more and more cases where the platform is being revamped and the layout reconsidered, and its shape and structure are fundamentally revised to reduce weight and ensure performance.

At Mazda, the SkyActiv technologies adopted in the CX-5 launched in 2012 led to revising the structure and shape, and the use of a linear design resulted in both improved performance and a lighter weight.

Mazda applied the same principles in the 2014 Demio, achieving a 22% improvement in static torsional rigidity and reducing weight by approximately 7% compared to the previous model (16).

The Suzuki Alto launched at the end of 2014 also uses a revamped platform that ensures performance while reducing weight. At its lightest specification of 610 kg (19), it matches the vehicle curb weight of mini-vehicles from 20 years ago while meeting modern performance requirements (Fig. 7).

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