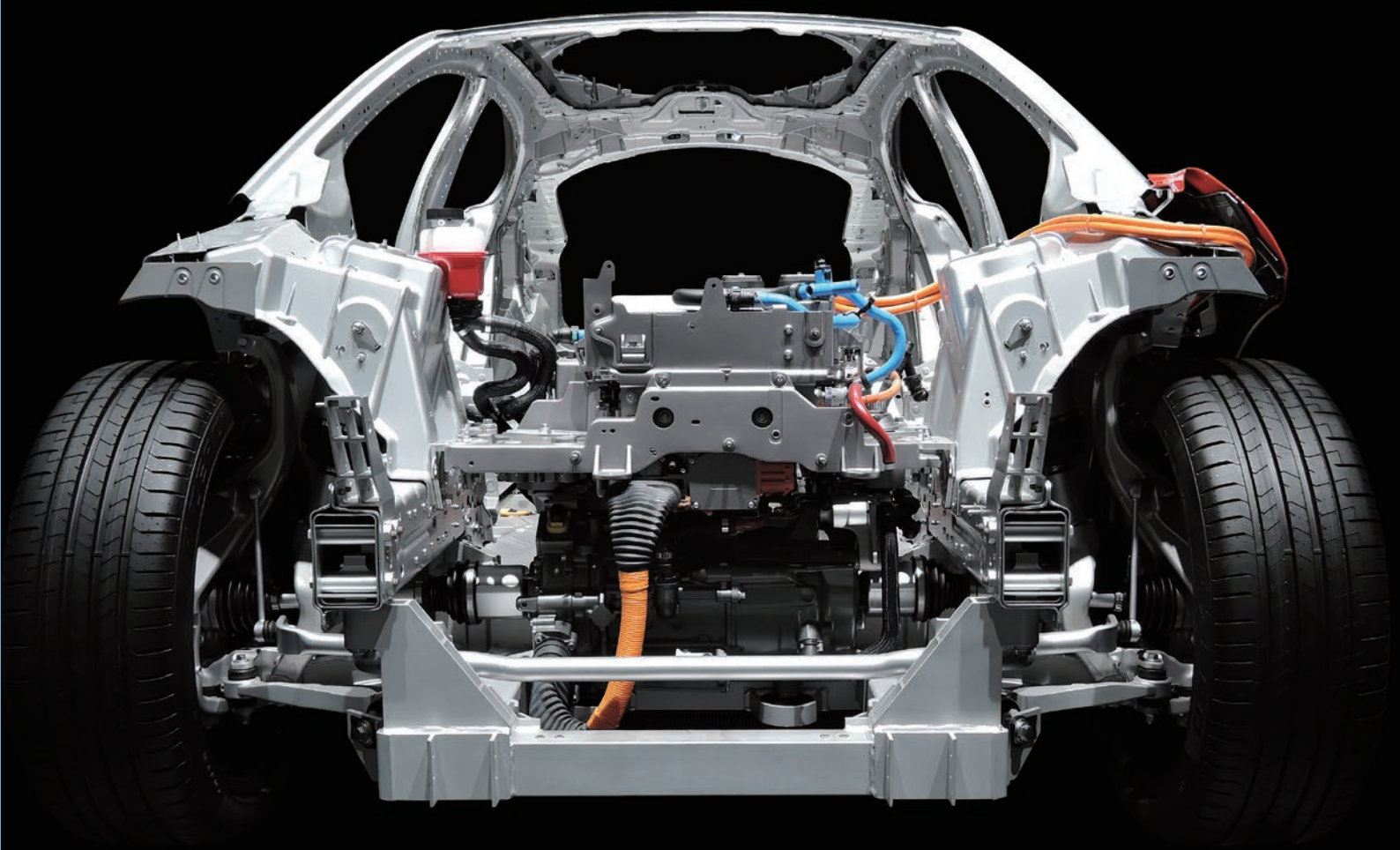
English Version

ATZ Extra Issue

Motor Fan illustrated

Special Edition

The more technologies are revealed, the more interesting cars become.



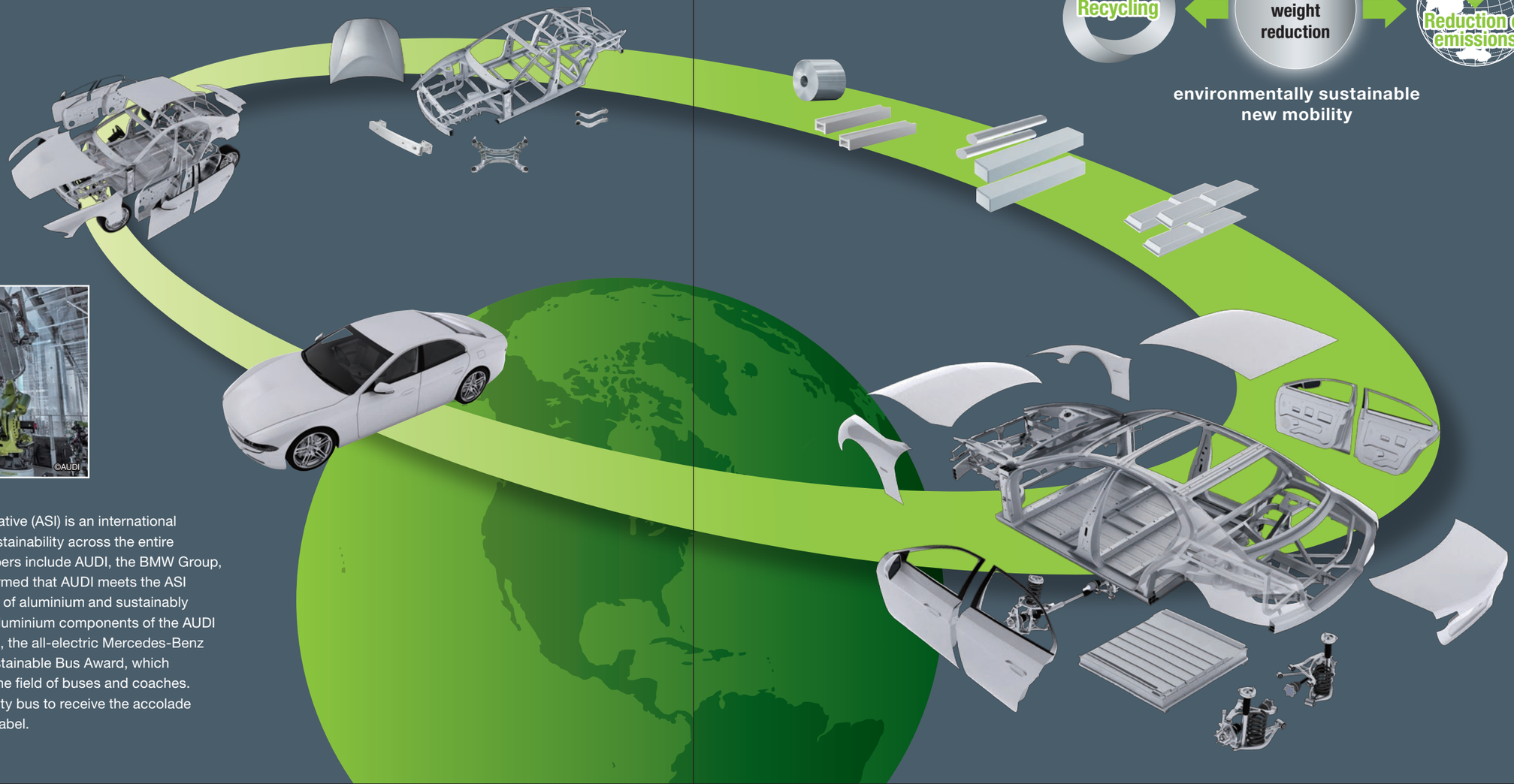
Special Feature **Aluminium Technology 6**

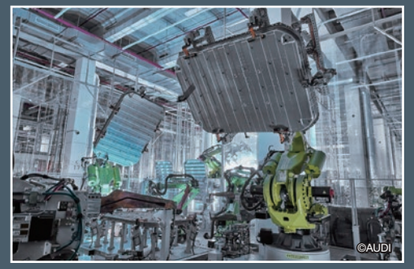
ALUMINIUM

Smart Developments

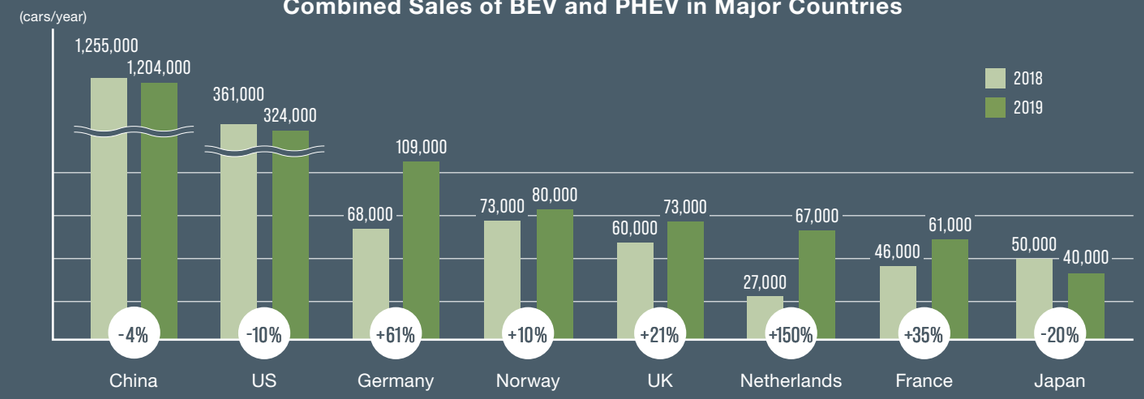
Lightweight and Sustainable Materials for Future eMobility

Mobility has reached a major turning point now we have entered the era of the Internet of things (IoT) and new mobility services (Maas), which can realize safe, comfortable and sustainable lifestyles. The implementation of sharing services and automated driving is bringing dramatic changes to ‘last mile delivery’ for urban logistics systems, mobility services such as the movement of people and things between cities, and urban development. Aluminium, the eco-friendly metal, is performing an important role in the electrification of mobility that is at the core of these new services. If the whole body weight is reduced using aluminium, components such as powertrains and brakes can be made smaller and their weight reduced, again lightening the body. The beneficial circulation created in this way is known as an ‘angel spiral’. Moreover, aluminium’s energy absorption capability enhances crash safety and contributes to battery thermal management systems. And thanks to its excellent recyclability, it reduces the environmental burden by requiring less energy for regeneration. aluminium is the most reliable structural material for the current trend of multi-materialization.





The Aluminium Stewardship Initiative (ASI) is an international industry-led initiative to drive sustainability across the entire aluminium value chain. Its members include AUDI, the BMW Group, Daimler and Magna. It has confirmed that AUDI meets the ASI requirements for industrial users of aluminium and sustainably designs and manufactures the aluminium components of the AUDI e-tron’s battery housing. In 2020, the all-electric Mercedes-Benz eCitaro has been awarded a Sustainable Bus Award, which acknowledges sustainability in the field of buses and coaches. eCitaro is also the world’s first city bus to receive the accolade of a ‘Blue Angel’ environmental label.

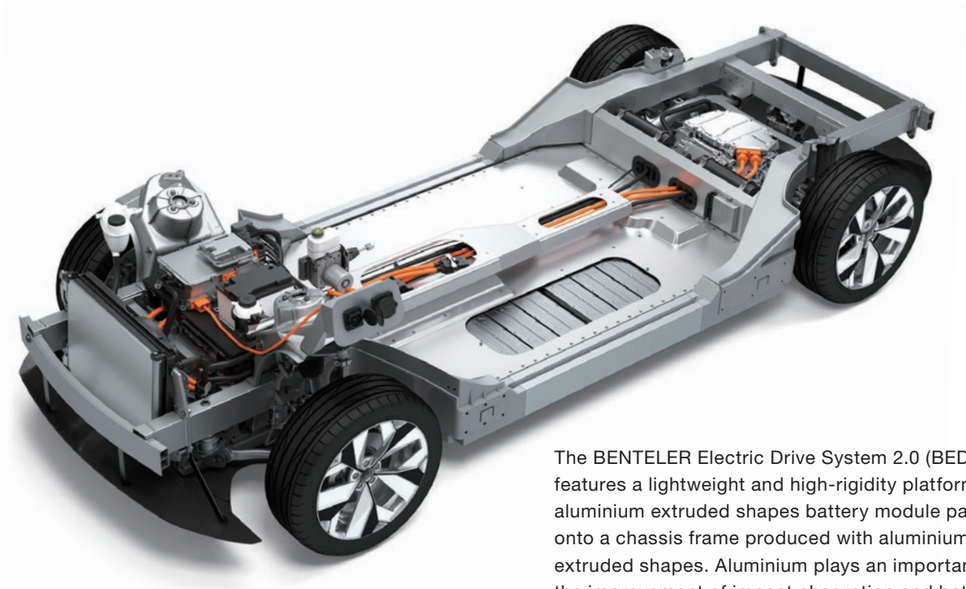


Source: Center of Automobile Management “Electromobility Report 2020” *Japan: Estimate on Statistics by the Japan Automobile Dealers Association

environmentally sustainable new mobility

Next-generation eMobility platforms

Sony Corporation introduced the VISION-S, its original EV concept car, at CES in January 2020. One of the world's largest electronics technology trade shows, CES serves as a stage for introducing visions and technologies for next-generation mobility against the backdrop of leading-edge technology, such as automated driving, AI and IoT. The VISION-S uses a Benteler rolling chassis. A rolling chassis is the basic chassis structure of a motor vehicle assembled with a set of vehicular devices, including powertrain, transmission, steering gear, suspension and wheels, that is able to move under its own power.
Today, in preparation for the full-scale diffusion of CASE (Connected, Autonomous, Shared & Services, and Electric), automobile companies are continuing their efforts to develop a common EV platform and component modularization. The sweeping trend for utilizing electric vehicles to address the issue of global warming can even affect supply chain management.



The BENTELER Electric Drive System 2.0 (BEDS) features a lightweight and high-rigidity platform with an aluminium extruded shapes battery module pack loaded onto a chassis frame produced with aluminium alloy extruded shapes. Aluminium plays an important role in the improvement of impact absorption and battery thermal management. BEDS is able to deal with B to E vehicle segments and offers flexible widths and lengths for different body types. The e-motor can support 2-wheel drive and 4-wheel drive.

[BENTELER Electric Drive System]

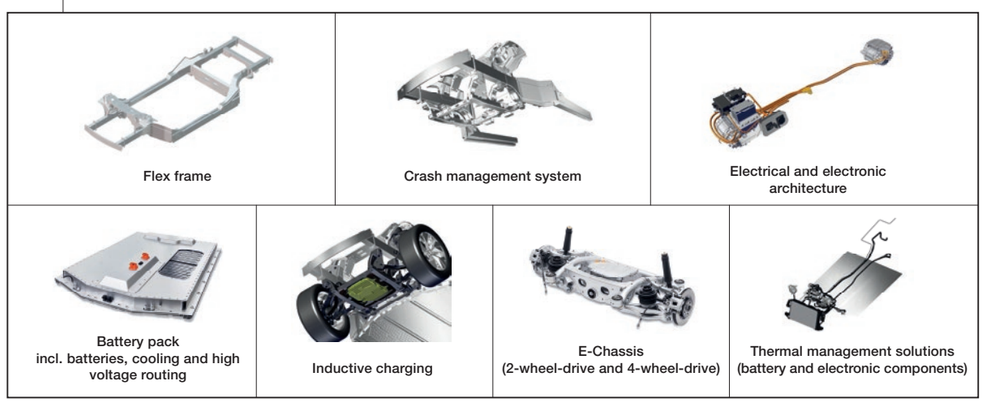


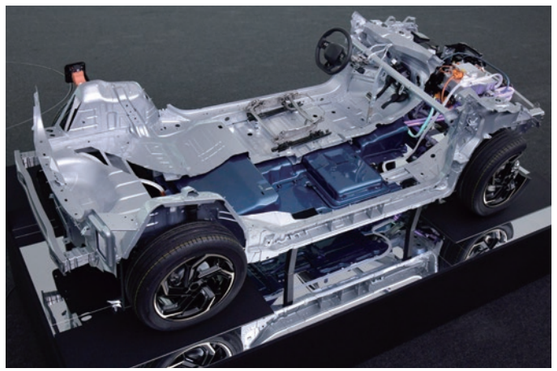
PHOTO: ©BENTLER

Volkswagen **MEB**

The Modular Electric Drive Matrix (MEB) developed by Volkswagen is a BEV exclusive platform that ensures versatility and a wide interior space. As it enables floor space battery storage and permits a flexible design of the wheelbase and total width, it's being adopted by all I.D. models. It can support all FWD, RWD and AWD drive systems. It's also being used in the new E-SUV developed by Ford and the ENYAQ iV, an SUV produced by Skoda Auto in the Czech Republic.

Mercedes-Benz **EQC**

Modular Electric Architecture (MEA) is an aluminium alloy flat-floor structural platform that is the base for the Mercedes-Benz EQ brands. The EQC battery electric vehicle features a maximum power output of 300 kW and a range of around 400 kilometers thanks to the 80 kWh battery and AWD, with two electric motors on the front and rear wheels. Based on the MEA electric vehicle platform, the EQV minivan (MPV), EQS S-Class full-size luxury sedan flagship, and E-class EQE sedan are all scheduled for release.



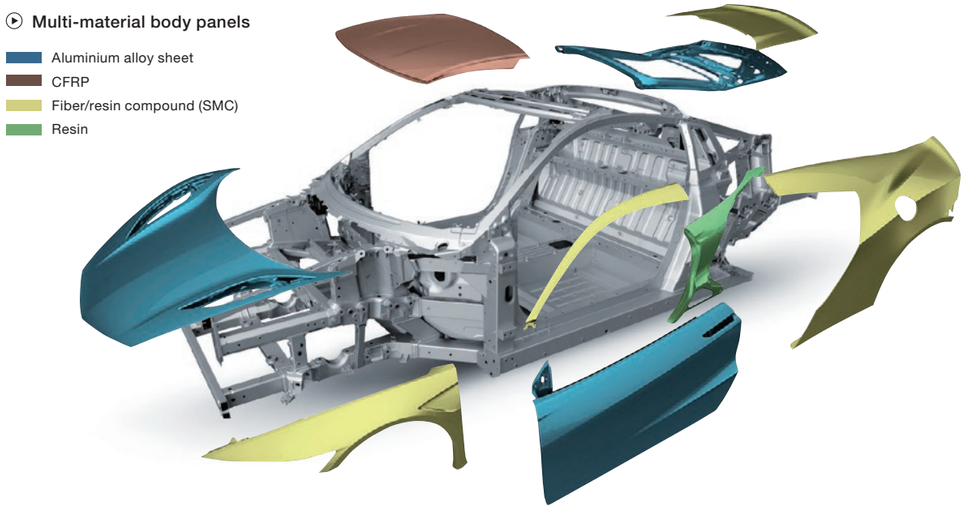
Groupe PSA **eVMP**

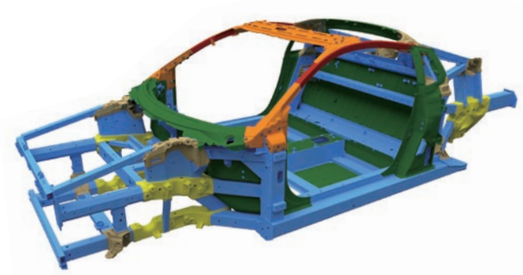
The Electric Vehicle Modular Platform (eVMP) from Groupe PSA is a new global modular platform that serves as the base for BEV. The eVMP features a maximum power output of 250 kW and a range of around 400 to 650 kilometers thanks to the 60 to 100kWh battery. It can support all FWD and 4WD drive systems. Until now, PSA has produced its EVs on the basis of the Common Modular Platform (CMP) used for smaller vehicles and the Efficient Modular Platform 2 (EMP2) used for combustion engine platforms. (Photo: CMP)

PHOTO: ©VW / DAIMLER / PSA / TESLA

HONDA NSX Aluminium automobile structure

The second-generation NSX is not an all-aluminium body structure, but a multi-material space frame structure using aluminium, high tensile strength steel, resin and other materials. Mainly high-strength extruded aluminium shapes are used. Aluminium alloy accounts for about 79% of the whole structure, steel for 13.5% and resin for 7.4%. The subframes made of aluminium extruded shapes at the front and rear of the body are joined with frames made of cast aluminium alloy. Structural joining techniques such as self-piercing riveting (SPR) and flow drill screwing (FDS) are frequently used.



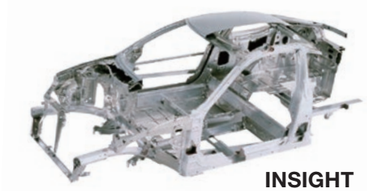


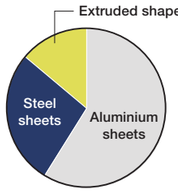
Space frame using multi-materials

- Aluminium alloy sheet
- Aluminium extruded shapes
- 3DQ ultra-high tensile strength steel tube
- Ablation cast Aluminium
- Gravity die cast Aluminium
- Steel

History of HONDA's ultralight bodies

The first-generation NSX maintained a monocoque structure, but the materials were changed from steel to aluminium alloys. Aluminium extruded shapes were used only partially; aluminium alloy sheet was used for most structures. After that, the range of aluminium extruded shapes increased in INSIGHT models, and they account for more than 50% of the materials used in the second-generation NSX.





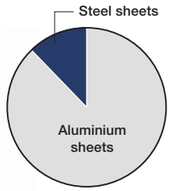
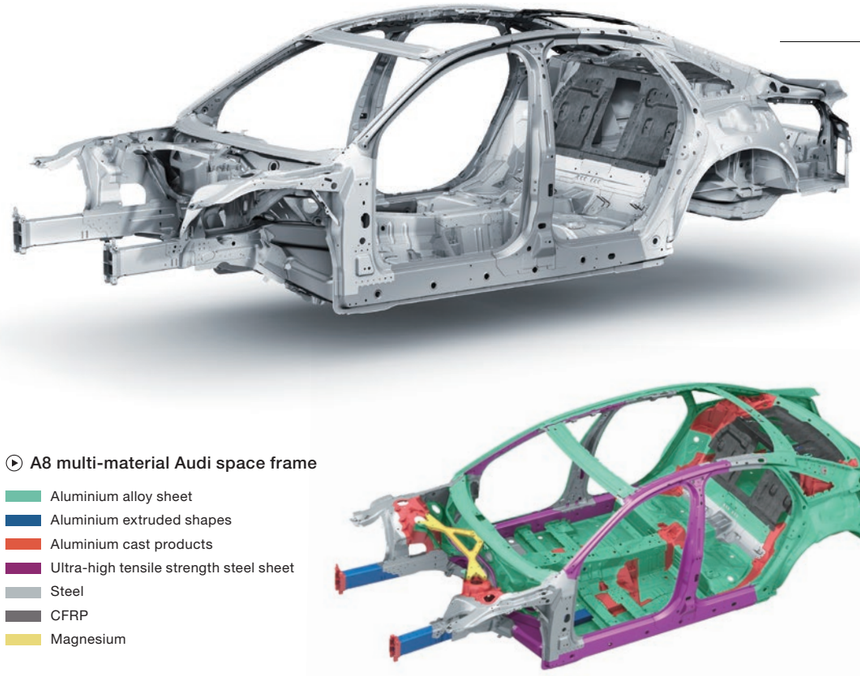


PHOTO: ©HONDA Source: MFi Vol. 162

AUDI A8 Aluminium automobile structure

Audi developed its all-aluminium body, the Audi Space Frame (ASF), in the early 1990s. With the latest A8, however, the composition of the ASF has changed to multi-material, consisting of aluminium alloy sheet, shapes and cast products, ultra-high tensile strength steel sheet, mild steel, CFRP and magnesium. With a lightweight, high-rigidity space frame, employing aluminium alloys enhances reliability. The body panels are all made of aluminium alloy sheet, and, for the doors in particular, 6000-series aluminium alloys are used for both the inner and outer panels.



AUDI e-tron55 quattro

The battery housing of the Audi e-tron is a module equipped with a cooling system which features sophisticated crash structures comprising 47% aluminium extruded shapes, 36% aluminium sheet, and 17% die-cast aluminium parts. In the 2.28-meter-long, 1.63-meter-wide and 34-centimeter-high housing, 36 battery modules are stably stored in the chamber divided with extruded aluminium shapes. The total weight of the battery system is around 700 kilograms.

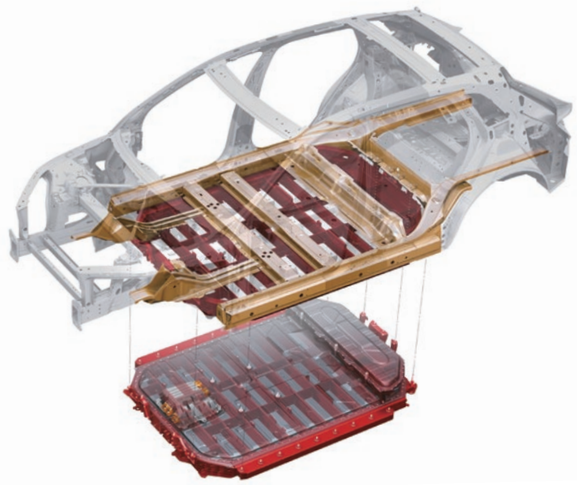
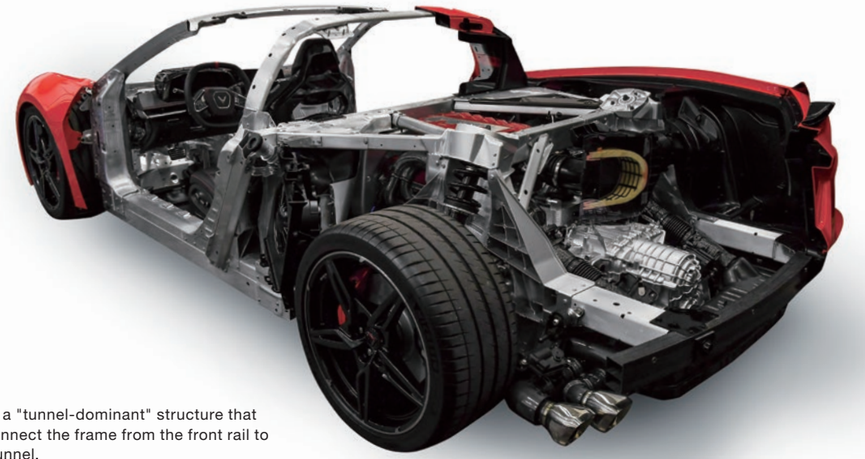


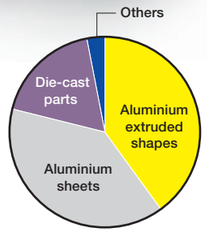
PHOTO: ©AUDI

CHEVROLET Corvette C8 Aluminium frames

Chevrolet introduced the eighth-generation Corvette C8 with an all-aluminium space frame in July 2019. Aluminium extruded shapes are used everywhere to improve performance by enhancing rigidity. The center tunnel is the backbone of the C8 “tunnel-dominant” architecture. Enlarging it to emphasize the importance of frame strength improved torsional stiffness by 18% compared to the C7. The C8 consists of 40% aluminium extruded shapes, 39% aluminium sheets, 18% die-cast aluminium parts, and 3% other materials.
Aluminium extruded shapes are used for approx. 25 separate parts, including the tunnel upper, side sills, crash boxes, windshield and crossmembers, and others. More than 1,200 mechanical fasteners are employed for the frame.

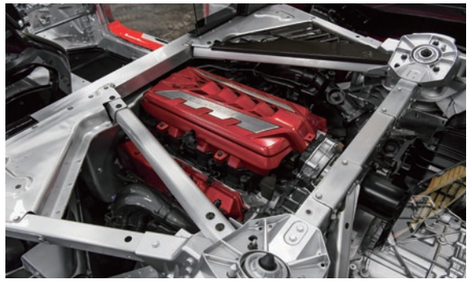


↓ The C8 is a "tunnel-dominant" structure that serves to connect the frame from the front rail to the center tunnel.



▲ All-aluminium alloy space frame

The aluminium stamping parts are joined to the aluminium extruded center pillar using flow-drilling screws.

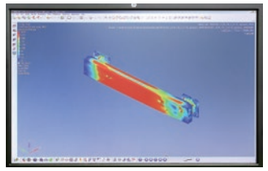


The die-cast aluminium rear shock towers are supported by extruded aluminium reinforcements.

PHOTO: ©GENERAL MOTORS

Mazda MX-5 Aluminium for safety-related parts

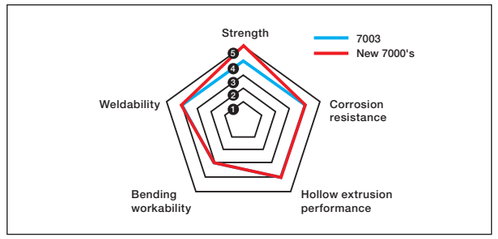
Among the aluminium components used for the Mazda MX-5, the bumper reinforcement is of special interest. In order to meet the increasingly strict crash test standards, the performance required for the front bumper is becoming very high. Regarding the MX-5, further weight reduction was achieved while at the same time securing a safety performance of the highest level. Reducing the weight of the components furthest from the vehicle’s center of gravity is effective not only for reducing vehicle emissions but also for increasing driving stability. However, to produce such a bumper requires advanced extrusion techniques. Further weight reduction has been gained by using the 7000-series high-strength aluminium alloy extruded shapes newly developed by UACJ.



◀ CAE for bumper beam

The deformation mechanism of the front bumper beam was analyzed using CAE to examine the cross-section that feature sufficient strength and energy absorption properties.

▼ Material properties required for bumper reinforcement



▼ Front bumper for MX5 (ND)

The MX-5 (ND) marked MAZDA’s first employment of aluminium alloy. UACJ 7000-series high-strength aluminium alloys were used.

▼ Front bumper for MX5 (NC)

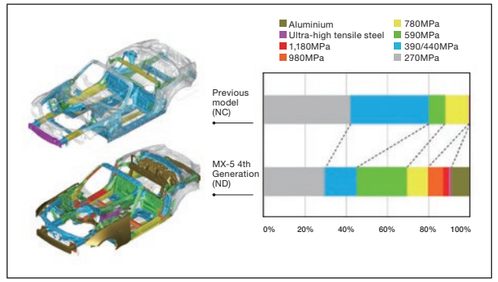
With a view to better protecting passengers in front crash, the MX (NC) used hot stamping steel.

▼ Front bumper for MX5 (NB)

The MX-5, produced in 1998 to meet the crash standards at that time, was a simple structure without a crash box.

▼ Comparison of material compositions of MX5

Aluminium alloys have been widely used in the MAZDA MX-5 to create a lightweight but highly rigid body.



▼ Aluminium alloy power plant frame (PPF)

The PPF is press-formed member made of 6000 series high-strength aluminium alloy plate for structures produced by UACJ.

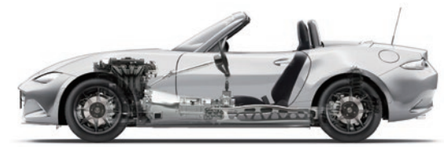
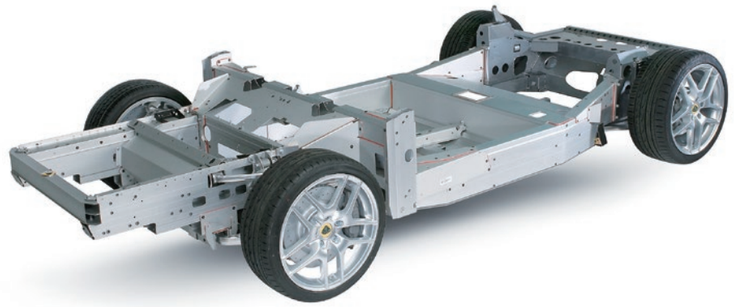


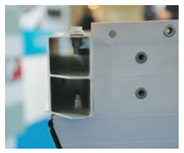
PHOTO: ©MAZDA

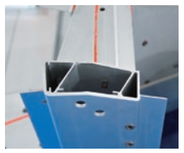
Aluminium extrusion technology

Extruded shapes

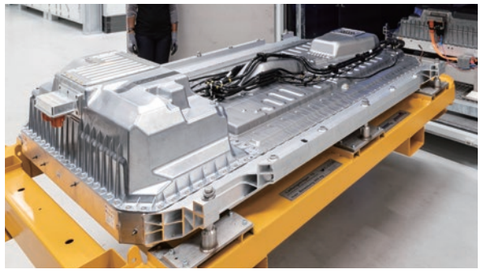
The Lotus Evora utilizes an aluminium space frame with a central aluminium tub and an aluminium front subframe. 6000-series aluminium alloy extruded shapes were used for the Evora space frame. It's very clear that their cross-sectional shapes differ according to the part they are used for. Realization of these kinds of shapes is a strong point offered by extrusions. Self-piercing rivets and adhesive are used to bond the extruded shapes.







← The Lotus Evora uses a lot of adhesive for its aluminum chassis. It's shown in red in this photo. Lotus has considerable experience with lightweight structures.

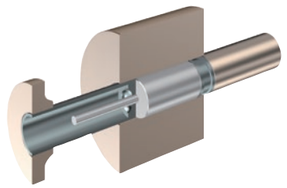


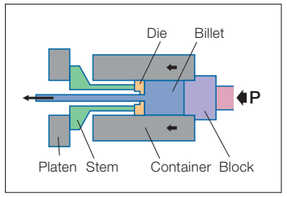
Aluminium alloy extruded shapes are used for the EV battery housing because it must have sufficient strength and impact resistance to protect the battery modules from damage, to dissipate heat, and to provide stable support for the components. (Photo: Mercedes Benz EQC)

As the battery module for all electric vehicles built on the MEB platform, the Volkswagen ID. 3 battery housing is loaded with the battery cells, cooling system and electric circuit. It's made from aluminium extruded shapes with an integrated crash frame.

Aluminium alloy extrusion

Using extrusion, it's possible to produce complex shapes featuring a high degree of precision. In order to continuously manufacture products with the desired cross-sectional shapes during the extrusion process, cylindrical billets heated to 400~500°C are pushed through dies with a variety of cross-sections and extruded with strong pressure using an extruder. The various shapes that can be created include hollow shapes and solid shapes.





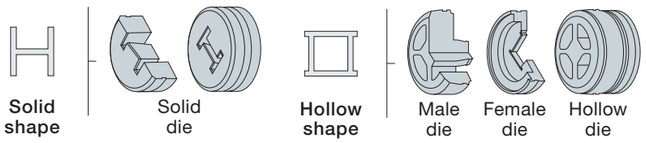
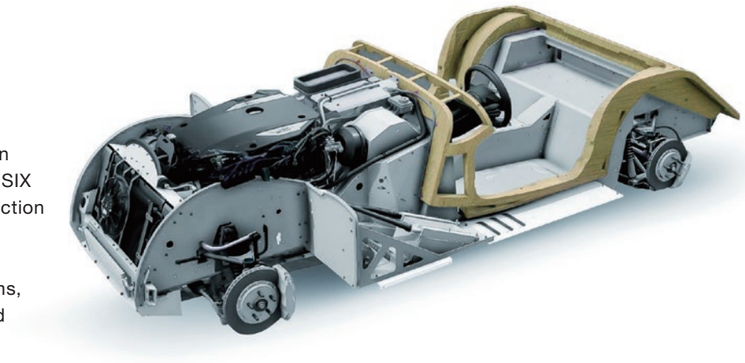


PHOTO: ©LOTUS / DAIMLER / VW

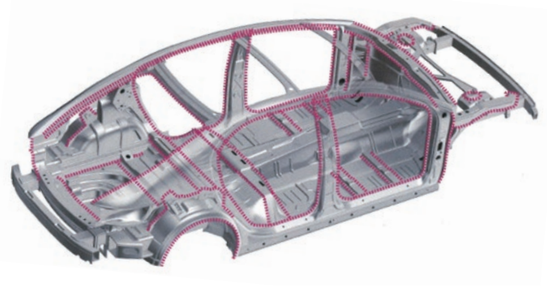
Adhesive and joining technology

Adhesion

Thanks to the newly developed adhesion structure, the CX Generation aluminium bonded platform produced by the Morgan Motor Company in the U.K. for the PLUS SIX features enhanced ride comfort and reduction of NVH. This was achieved by increasing torsional rigidity by 100% and realizing a structure weighing less than 100 kilograms, which made it ultra-lightweight compared with conventional aluminium platforms.



adhesive bonding lines

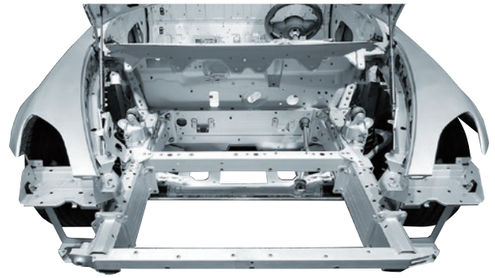


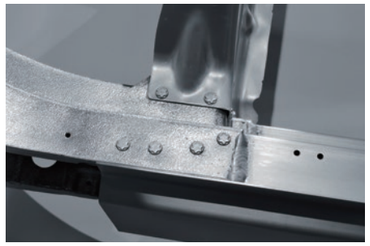
Structural adhesives

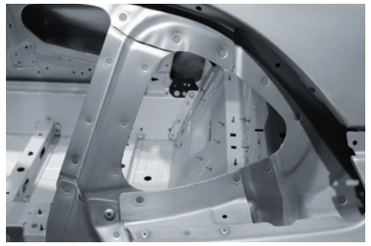
Recent trends in vehicle manufacture such as lightweighting and improving fuel efficiency increase the need for joining dissimilar materials. When a structural adhesive is used for the surface contact of panels, it enhances the bonding strength and improves body rigidity. This contributes to an improvement of steering response and reduced vibration and noise. Structural adhesives are used to bond dissimilar materials, including aluminum alloy, steel and CFRP in multi-material structures.

Mechanical joining

Mechanical joining techniques are widely used for multi-material structures. There has also been an increase in the use of hybrid joining, which combines mechanical joining with structural adhesives, laser welding, Friction Stir Spot Welding (FSSW), etc. However, it's necessary to consider the issues that exist between dissimilar materials, including a variable thermal expansion coefficient and galvanic corrosion. Here we see self-piercing rivets (SPR) (left photo), flow-drilling screws (middle photo), and combined use of rivets and adhesives (right photo).







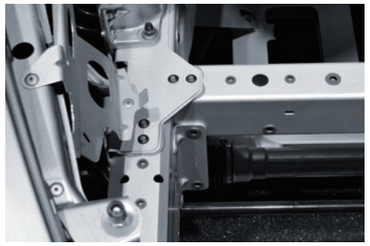


PHOTO: ©MORGAN / CEMEDAIN / Haruya KATADA

Aluminium for lightweight structures

Body Panels

The F-150 is the best-selling model in North America and the core model of the Ford F-Series of pickup trucks. In 2015, in response to the Corporate Average Fuel Efficiency (CAFE) standards in North America, Ford switched to using aluminium body panels for the upper body of the F-150. As a result, the vehicle's weight was reduced by a stunning 320 kilograms. Influenced by this success, GM started using aluminium alloys for its key pickup truck, the Chevrolet Silverado, in 2018. That also helped to reduce vehicle weight by more than 200 kilograms.

The Toyota Lexus LS has the latest structure that uses a considerable amount of aluminium alloy sheet in the body panels, and ultra-high tensile strength steel in the frame. In addition to the bonnet, trunk lid and front fender, aluminium sheet is used for the doors. As a sedan has four doors, this produces a greater weight reduction effect. The application of aluminium for the body panels has reduced the total body weight by 25% compared to the previous all-steel model. 6000-series aluminium alloy sheet is used for both the inner and outer panels.

High-speed blow forming for body panels

By combining hot crash forming and high-speed blow forming, Tesla has developed a technology to form aluminium alloy sheets at high speed. Using 5000-series aluminium alloy sheet, the trunk lid of the Model S is created as a one-piece molding using the high-speed blow forming technique.

Guidelines for aluminium alloy selection

The aluminium sheets typically used as body panels often include non-heat-treatable 5000-series alloys and heat-treatable 6000-series alloys for the reasons of strength, formability and corrosion resistance. As for formability, the 5000 series excels the 6000 series.

				Features required for aluminium alloy						Major alloy for choice
				Strength	Formability	Corrosion resistance	Arc weldability	Spot weldability	Extrusion performance & Forgeability	
Classification and Uses		Sheets	Panels (outer panels)	✓	✓	✓		✓		5000/6000
			Structural parts	✓	✓	✓	✓	✓		5000/6000
			Non-structural parts		✓	✓		✓		1000/3000/5000/6000
		Extruded shapes	Structural parts	✓	✓	✓	✓	✓	✓	6000/7000
		Forged products	Structural parts	✓	✓	✓			✓	6000
Alloy	Non-heat-treatable	1000 series	Pure aluminium	C	A	A	A	A	A	
		3000 series	Al-Cu	C	A	A	A	A	A	
		5000 series	Al-Mg	B	A	A	A	A	C	
	Heat-treatable	2000 series	Al-Cu	A	C	C	C	C	B	
		6000 series	Al-Mg-Si	B	B	A	B	B	A	
		7000 series	Al-Zn-Mg	A	C	C	B	C	B	

Alloy evaluation

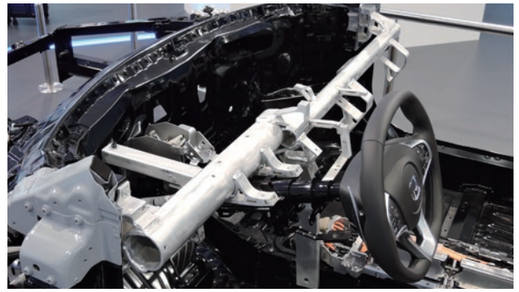
✓✓: Very good
✓: Good

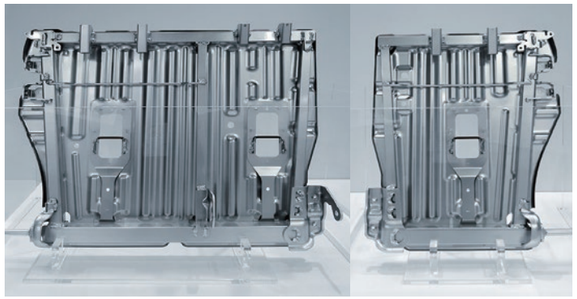
A: Good
B: Standard
C: Inferior

PHOTO: ©FORD / TOYOTA / TESLA

Cross car beam

The cross car beam installed in the instrument panel section holds parts such as the steering wheel, airbags and other components. It acts as an interior cross member, protecting the cabin space in the event of side impact. To make it both lightweight and highly rigid, all-aluminium construction or integral forming of resin brackets and aluminium shapes, is employed. The cross car beam plays an important role in the reduction of noise vibration and harshness (NVH).





Seat frames

NHK SPRING CO., LTD. displayed these rear seat back frames completely made of aluminium alloy at the Tokyo Motor Show. These are produced by welding 5000-series aluminium sheet on to 7000-series aluminium extruded shapes. The parts were produced with optimized shapes and thickness based on stress analysis. This ensures a safety level equivalent to that of steel as well as a weight reduction of 35%. The ability to reduce weight while meeting various second seat arrangement designs is a significant feature.

Brake calipers

Endless develops and supplies high performance brake pads, brake calipers, brake rotors and discs. Its newly developed brake calipers newly developed by ENDLESS in the right photo have been designed using topology optimization and manufactured on a 3D metal printer. The brake caliper in the left photo is produced by high-temperature high-strength aluminium forging alloy produced by UACJ. As SUVs get larger, there's an increasing demand for lightweight aluminium forged parts with high rigidity.

Drum brakes for EVs

A lightweight aluminium drum brake for EVs was developed based on Continental's innovative concept. With EVs, the load applied on each of the brake components is reduced because of regenerative braking, making the use of aluminium drums possible that are 30% lighter than steel. (Left photo).
The ultimate shape of the Bionic Caliper that resembles the bone structure of the human torso (right photo) was determined by carrying out a combination of topology optimization and 3D printing.

PHOTO: ©CONTINENTAL / Haruya KATADA

Shaping the Future of Mobility

Predicting changes in mobility architecture and services, Daimler announced its concept of CASE (Connected, Autonomous, Shared and Services, Electric) at the 2016 Paris Motor Show. The tremendous advances in automotive technologies and services, ranging from micro-mobility to large-scale trucks and buses, suggest the CASE era is arriving. Commercial vehicles will surely play an important role in helping particularly to solve the issues related to inner-city traffic and the movement of people and things between cities, bringing dramatic changes to transportation systems. The demand for aluminium is expected to expand greatly in the field of commercial vehicles.

New eMobility Concept

[Renault **TWIZY**]

The Twizy is a two-seater electric microcar designed and marketed by Renault. The total number of sales from its release in Europe in 2012 until the end of 2019 was about 30,000 units, the highest figure in this category. It's 2.338 meters long, 1.234 meters wide, and 1.454 meters high, and the body weighs 450 kilograms. An electric motor with a maximum power of 13 kW is loaded on the 6.1 kWh battery. It has a maximum speed of 80 kph and a range of 100 kilometers.

[**Triggo** electric light vehicle]

The Polish company Triggo has unveiled an innovative urban electric vehicle featuring variable chassis geometry. Its foldable suspensions allow the track width to shift from 148 centimeters in 'cruise mode' to 86 centimeters in 'manoeuvering mode'. The 148-centimeter width ensures greater body stability, realizing a maximum speed of 90 kph. The replaceable 8 kWh battery and two 10 kW electric motors give the Triggo a range of 100 kilometers per charge.

[Micro Mobility **Microlino**]

The Microlino two-seater electric microcar has inherited the Isetta bubble car concept developed by ISO in the 1950s. It's 2.413 meters long, 1.5 meters wide and 1.45 meters high. A lot of aluminium alloy is used for its chassis, and the body weighs 513 kilograms. Power is provided by an 11 kW rear electric motor with two lithium-ion battery options (8 kWh or 14.4 kWh), which provide a range of 125 or 200 kilometers respectively. Maximum speed is 90 kph.

[Citroën **AMI**]

Citroen's two-seater electric microcar AMI is 2.41 meters long, 1.39 meters wide, 1.52 meters high and weighs 490 kilograms. Its 7.2-meter turning diameter is perfect for urban driving. Loaded with a 5.5 kWh micro-lithium-ion battery housed flat under the floor and powered by a 5 kW electric motor, it has a maximum speed of 45 kph. Charging via a conventional 220V socket can be completed within three hours, and a one-time charge is sufficient to travel 70 kilometers.

PHOTO: ©RENAULT / TRIGGO / MICRO MOBILITY SYSTEMS / CITROEN

New eMobility commercial vehicles

[**TIER** E-Scooters]

Thanks to sharing services, the use of electric scooters (E-scooters) is rapidly expanding. Based in Berlin in Germany, TIER produces E-scooters with a solid framework. The all-aluminium modular platform has reinforced suspension that ensures a comfortable ride even on European roads paved with cobblestones. In addition to E-scooters, TIER is starting to build its multimodal offering and is entering the market for E-moped sharing.

[Schaeffler **Bio-Hybrid**]

The Schaeffler Bio-Hybrid is a 4-wheel electrically assisted vehicle using a modular platform. It comes in two versions: two-seater passenger and cargo. Fitted with a 48 V battery with a capacity of approx. 1.2 kWh, it can travel up to about 50 kilometers at a maximum speed of 25 kph with electrical assistance. The eco-friendly sustainable mobility it provides is expected to contribute to the solution of urban traffic issues.

[**GACHA** Autonomous Shuttle Bus]

Trial public operations of GACHA, the world's first electric self-driving all-weather shuttle bus have started in Helsinki, Finland. 4.5 meters long, 2.5 meters wide and 2.8 meters high, the 4-wheel-electric-drive vehicle has 10 seats and can travel 100 kilometers at a maximum speed of 40 kph. GACHA's excellent positioning, navigation and obstacle detection features enable autonomous driving all year round, regardless of the weather.

[VOLKSWAGEN **ID.BUZZ CARGO**]

VW's eMicrobus ID. Buzz is scheduled to go on sale in 2022. ID. BUZZ CARGO, the commercial version, uses MEB XL, an extended version of the MEB modular platform for electric vehicles. 5.048 meters long, 1.976 meters wide and 1.963 meters high, the vehicle is equipped with a lithium-ion battery of either 110 kWh or 48 kWh. Its maximum range is over 550 kilometers and it has a loading capacity of 800 kilograms.

[Mercedes-Benz **eActros / eCitaro-G**]

With the aim of achieving zero CO_2 emissions, Mercedes-Benz is working on the electrification of buses and trucks. The eCitaro G is an 18.1-meter-long all-electric articulated bus that can accommodate up to 145 passengers. The eActros heavy-duty truck has two electric motors, each with an output of 126 kW, and the energy is stored in lithium-ion batteries with a capacity of 240 kWh. It has a range of 200 kilometers.

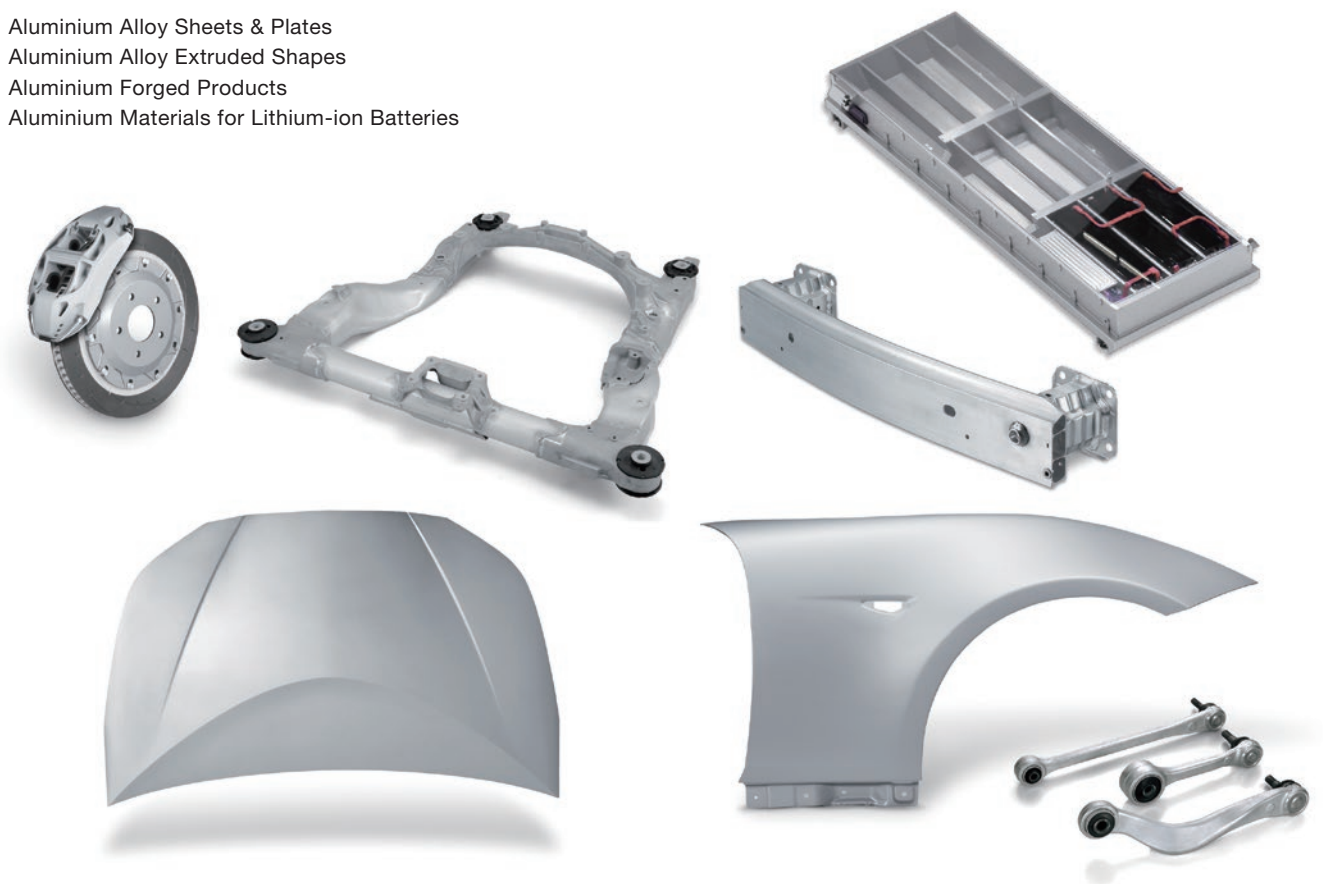
PHOTO: ©TIER MOBILITY / SCHAEFFLER / JUSTUS HIRVI, BONZU & MUJI / Haruya KATADA / DAIMLER

UACJ

Advanced Aluminium Technology for the Automobiles of the Future

UACJ was born as a major global aluminium group originating in Japan in October 2013, when Furukawa-Sky Aluminium Corp. and Sumitomo Light Metal Industries Ltd. integrated their business operations.
Automotive weight reduction technology is indispensable for improving automotive fuel efficiency in order to reduce CO_2 emissions.
As a major company in the field of aluminium, UACJ is actively involved in the R&D of aluminium materials as well as the technological development required for promoting their utilization. And UACJ has an extensive global network system to supply products worldwide.

Aluminium Alloy Sheets & Plates
Aluminium Alloy Extruded Shapes
Aluminium Forged Products
Aluminium Materials for Lithium-ion Batteries



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ATZ Extra Issue Motor Fan illustrated vol.166 Special Edition
Created by SAN'EI Publishing, printing and distributing by Springer Fachmedien Wiesbaden GmbH.

Motor Fan illustrated ATZ Extra Issue
SAN'EI PUBLISHING CO., LTD Shinjuku East Side Square, 6-27-30 Shinjuku, Shinjuku-ku, Tokyo 160-8461, JAPAN
Publisher: Kunihisa HOSHINO Editors-in-chief: Hirofumi NOZAKI (Japanese); Haruya KATADA (English)