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# CHASSIS, CONTROL SYSTEMS AND EQUIPMENT

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## 1 Introduction

The global spread of COVID-19 In 2020 had an impact on all industries. Nevertheless, social expectations placed on the automotive industry for automated driving, safety, and environmental performance have been growing, and automakers are competing fiercely in conducting research and development.

Efforts to spread automated driving are intensifying, with North America and Europe holding field tests and trial services of driverless automated driving (robotaxis) projects, and the media reporting plans to increase the number of automated vehicles in new vehicles sales to half by 2025 in China. Activities are also being stepped up in Japan, with the establishment of safety standards for automated driving systems that will allow Level 3 automated vehicles meeting certain conditions to drive on public roads.

With respect to safety, revised standards (safety regulations) promulgated in Japan on January 31, 2020 make the installation of advanced emergency brake systems (AEBS) on new models starting in November 2021, and on existing vehicles starting in July 2026, mandatory.

On the environmental front, the deadline to achieve the SDGs looms only ten years ahead, and countries and regions are accelerating their efforts to strengthen environmental regulations to solve climate change and global warming. The Japanese government has similarly set the goal of net zero domestic greenhouse gas emissions by 2050 (carbon neutrality), and announced a policy of eliminating pure gasoline-powered vehicles from the Japanese new vehicle market by the mid-2030s, setting a course that could bring the automotive industry to a major turning point.

The year 2020 also marked increased importance placed on software as the Japanese government formulated its Integrated Innovation Strategy 2020. Advances in communication technology are enabling the purchase

and update of additional software over-the-air, and there is growing demand for improved performance and the retrofitting of optional functions.

This article introduces the main new models and technologies launched in and outside Japan in 2020, and describes chassis and vehicle control trends, as shown in Table 1. However, technologies such as electronic stability control (ESC) that are mandatory in various countries, and warning functions that are part of active safety technologies, have been omitted.

## 2 Suspension

### 2.1. Base suspensions

As the summary in Table 1 shows, there have been no changes in suspension type trends, with many vehicles using the MacPherson strut or, in the medium class and above, the double wishbone for front suspensions. For rear suspensions, the torsion beam in the compact class and below, and the double wishbone or multi-link type in the higher classes remain the prevalent choices.

Many vehicles with a dedicated battery electric vehicle (BEV) platform were released in 2020, and a large proportion of them use a rear-wheel drive layout, which allows for a larger front-wheel steering angle compared to the front-wheel drive layout, and results in, for example, a minimum turning radius of 4.3 m in the Honda e. Automakers are also taking approaches such as adopting a strut rear suspension to secure battery and motor mounting capacity. As BEVs become more widespread, the suspensions emphasizing battery capacity and interior space seen in some MaaS vehicles may become more popular.

Although many vehicles continue to use aluminum for component parts to keep weight down, some low-priced BEVs, such as the Mini EV from SAIC-GM-Wuling Automobile, make a clear choice to use a large number of steel parts.

In terms of performance, the adoption core technolo-

**Table 1** Chassis and Vehicle Control Systems of New Vehicles Launched in 2020

Market	Manufacturers	Name of vehicle model	Drivetrain type	Drive system	Suspension type Front/Rear ( ): suspension for AWD layout	Vehicle control systems
Japan	Daihatsu	Taft	ICE	FWD/AWD	MacPherson strut/torsion beam (3-link)	Collision-avoidance support brakes/Erroneous Start Prevention Function with Brake Control/Lane Departure Preventive Control/ACC with Full-speed Following Function/Lane Keeping Control (LKC)
	Honda	Fit	ICE/HEV	FWD/AWD	MacPherson strut/torsion beam (De Dion)	Collision Mitigation Braking System (CMBS)/Acceleration Control/Backward Collision Mitigation/short-range collision mitigation brakes/Pedestrian Collision Mitigation Steering/Road Departure Mitigation/Adaptive Cruise Control (ACC) with Low-Speed Follow/Lane Keeping Assist System (LKAS)
		Accord	HEV	FWD	MacPherson strut/Multi-link	Collision Mitigation Braking System (CMBS)/Acceleration Control/Pedestrian Collision Mitigation Steering/Road Departure Mitigation/Adaptive Cruise Control (ACC) with Low-Speed Follow/ Lane Keeping Assist System (LKAS)/ False Backward Start Prevention
		e	BEV	RWD	MacPherson strut/strut	Collision Mitigation Braking System (CMBS)/Acceleration Control/Backward Collision Mitigation/short-range collision mitigation brakes/Pedestrian Collision Mitigation Steering/ Road Departure Mitigation/Adaptive Cruise Control (ACC) with Low-Speed Follow/ Lane Keeping Assistance System (LKAS)/Motion Adaptive EPS/ Emergency Stop Signal/Hill Start Assist/Electronic Parking Brake/ Auto Brake Hold/Single Pedal Control/drive mode switch/Deceleration Paddle Selector
	Mazda	Flair Cross-over	HEV	FWD/AWD	MacPherson strut/torsion beam (isolated trailing link)	Dual-camera brake support/False start prevention (forward)/ Brake support when reversing/Acceleration control when reversing/Lane departure control/Adaptive cruise control (ACC) with all-speed tracking/Snow mode/Hill descent control /Grip control
		MX-30	HEV	FWD/AWD	MacPherson strut/torsion beam	AT Acceleration Control/Hill Launch Assist (HLA)/ Emergency Lane Keeping Support (ELK)/Lane Keeping Assist System (LAS)/ Mazda Radar Cruise Control (with all-speed tracking)/Smart Brake Support (SBS)
	Mitsubishi	eK Space/Custom	HEV	FWD/AWD	MacPherson strut/torsion beam (torque arm 3-link)	Forward Collision Mitigation System (FCM)/ Emergency Assist for Pedal Misapplication/ Lane Departure Warning (LDW) & Lane Departure Prevention Assist (LDP)/Adaptive Cruise Control (ACC)/ Lane Keeping Assist (LKA)
		Eclipse Cross PHEV	PHEV	AWD	MacPherson strut/Multi-link	Active Yaw Control (AYC)/Forward Collision Mitigation System (FCM)/Radar Cruise Control System (ACC)/False Start Prevention (forward and reverse)/Blind Spot Warning with Lane Change Assist (BSW/LCA)/Hill Start Assist (HSA)
	Nissan	Roox	HEV	FWD/AWD	MacPherson strut/torsion beam (torque arm 3-link)	Intelligent Emergency Braking/Emergency Assist for Pedal Misapplication/Pro Pilot/Intelligent LI/Hill Start Assist
		Kicks	ICE	FWD	MacPherson strut/torsion beam	Intelligent Emergency Braking/Intelligent Lane Intervention (LI)/Emergency Assist for Pedal Misapplication/Intelligent Trace Control (cornering stability enhancement system)/Hill Start Assist
		Note	HEV	FWD/AWD	MacPherson strut/torsion beam	ProPilot (with navigation link)/Hill Start Assist/Intelligent Emergency Braking/Emergency Assist for Pedal Misapplication/ Intelligent LI (Lane Departure Prevention Assist System)/ Intelligent Blind Spot Intervention (BSI)/Intelligent Trace Control (cornering stability improvement system)
	Subaru	Levorg	ICE	AWD	MacPherson strut/double wishbone	Pre-Collision Braking/Forward Pre-Collision Braking/Pre-Collision Steering Assist/Reverse Automatic Braking/AT False Start Prevention/AT False Backward Start Prevention/Touring Assist/ Cruise Control with All Speed Tracking/Constant Speed Cruise Control/ Lane Departure Prevention/EyeSight Assist Monitor
	Suzuki	Hustler	ICE/HEV	FWD/AWD	MacPherson strut/torsion beam (isolated trailing link)	ESS/Hill Hold Control/Hill Descent Control/Grip Control/Snow Mode/False Start Prevention/ACC (all-speed tracking)/Reversing Brake Support/False Backward Start Prevention/Dual Camera Brake Support
Solio		HEV	FWD/AWD	MacPherson strut/torsion beam (isolated trailing link)	Dual-Camera Brake Support/False Start Prevention/Adaptive Cruise Control (ACC) (with all-speed tracking)/Reversing Brake Support/False Backward Start Prevention/Hill Hold Control	
Toyota	Yaris	ICE/HEV	FWD/AWD	MacPherson strut/torsion beam (double wishbone)	Pre-Collision Safety/Lane Tracing Assist (LTA)/Radar Cruise Control with Brake Control/Secondary Collision Braking (SCB)/Drive Start Control/Hill Start Assist Control/Rear Cross Traffic Auto Brake /Toyota Teammate (Advanced Park)/Spring Damping Control	
		Harrier	ICE/HEV	FWD/AWD	MacPherson strut/double wishbone	Hill Start Assist control/ACA control/Spring Damping Control/ Brake Override System/Pre-Collision Safety (collision avoidance assist with pedestrian (day/night) and cyclist (daytime) detection/ millimeter wave radar + monocular camera system)/Lane Tracing Assist (LTA)/Radar Cruise Control (with all-speed tracking)/Rear Cross-Traffic Auto-Brake (Parking Support Brakes (for vehicles approaching from the rear))

**Table 1** Chassis and Vehicle Control Systems of New Vehicles Launched in 2020 (cont.)

Market	Manufacturers	Name of vehicle model	Drivetrain type	Drive system	Suspension type Front/Rear ( ): suspension for AWD layout	Vehicle control systems
Japan	Toyota	Mirai	FCEV	RWD	Multi-link/multi-link	Pre-Collision Safety (collision avoidance assist with pedestrian (day/night) and bicyclist (day) detection). Pedestrian Alert, and Active Steering Assist with millimeter wave radar + stereo camera)/Lane Tracing Assist (LTA)/Lane Change Assist (LCA)/Emergency Driving Stop System/Radar Cruise Control (with all-speed tracking and curve management)/Intelligent Clearance Sonar (with Parking Support Brakes (Stationary Objects))/Rear Cross Traffic Auto Brake (Parking Support Brakes (vehicles approaching from the rear, Parking Support Brakes (pedestrians approaching from the rear)))/Drive Start Control/Hill Start Assist Control/Plus Support (sudden acceleration suppression)
Outside Japan	Audi	A3	ICE/HEV/PHEV	FWD	MacPherson strut/torsion beam (4 -link)	Audi Drive Select/Lane Assist/Adaptive Cruise Control/Park Assist/Audi Hold Assist/Audi Pre-Sense Front (steering avoidance assist)
	BMW	4	ICE	FWD/AWD	MacPherson strut/Multi-link	Driving Assist Professional: Active Cruise Control with Stop & Go (ACC)/Steering & Lane Control Assist/Active Side Collision Protection /Collision Avoidance and Mitigation Braking with accident avoidance assist/Park Distance Control (PDC)/Park Distance Control (front and rear, with visual display)/Parking Assist/Reverse Assist/Reverse Steering Assist/Hands-Free Assist in Highway Congestion/Emergency stop assist/Adaptive M-suspension/Servotronic (power steering adjusted to vehicle speed)
	Citroën	DS 9	PHEV	FWD/AWD	MacPherson strut/Multi-link	DS Active Scan Suspension/DS Drive Assist/DS Sensorial Drive/Extended Emergency Braking System
		C4	ICE/BEV	FWD/RWD (EV)	MacPherson strut/torsion beam	Highway Drive Assist/Active Cruise Control (with Stop & Go function)/Active Safety Brake/Progressive Hydraulic Cushion (PHC)
	Ford	F-series	ICE	RWD/AWD	Double wishbone/leaf spring rigid	BLIS® (Blind Spot Information System) with Trailer Coverage/Lane-Keeping System/Pre-Collision Assist with Automatic Emergency Braking/Adaptive Cruise Control with Stop & Go
	Genesis (Hyundai)	GV80	ICE	RWD/AWD	Multi-link/multi-link	Road active noise cancellation/Genesis adaptive control suspension/Evasive steering assist (ESA)/Smart cruise control (SCC)/Preview ECS/Forward Collision Avoidance Assist
	Mercedes-Benz	GLA	ICE	AWD	MacPherson strut/4 -link	Active Distance Assist Distronic (with automatic restart)/Active Brake Assist (with pedestrian/jumping out detection)/Pre-Safe/Pre-Safe Plus (collision warning system with damage mitigation braking)/Emergency Avoidance Assist System/Congestion Emergency Braking/Active Blind Spot Assist/Active Brake Keeping Assist/Crosswind Assist/Adaptive Brake (hold, hill start assist)/Attention Assist/Drive Away Assist/Dynamic Select/Off-Road Engineering Package/Downhill Speed Regulation (DSR)
		S	ICE/HEV	AWD	Double wishbone/multi-link	Active Distance Assist/Distronic (with automatic restart)/Active Steering Assist (Active Lane Changing Assist/Active Emergency Stop Assist)/Emergency Avoidance Assist System/Congestion Emergency Braking/Active Lane Keeping Assist/Active Blind Spot Assist/Pre-Safe Impulse Side/Active Parking Assist (parallel & perpendicular parking)/Airmatic Suspension/Rear Axle steering/Active Brake Assist (with detection of pedestrians, jumping out, and oncoming vehicles when turning right)
	Porsche	Taycan	BEV	AWD	Double wishbone/multi-link	Adaptive Cruise Control/Adaptive Lane Assist/Traffic Jam Assist/Lane Change Assist/Night Assist/Active Parking Assist/Swerve (object avoidance) Assist/Active Aerodynamics System/Adaptive Air Suspension/Smart Lift/Rear Axle Steering/Torque Vectoring Plus/Dynamic Chassis Control System Sport
	B A I C Group	ArcFox a -T	BEV	FWD/AWD	MacPherson strut/Multi-link	Advanced Driver Assistance System ( a -Pilot)/Adaptive Cruise System (ACC)/Lane Centering (LCC)/Traffic Jam Assist (TJA)/Intelligent Cruise Assist (ICA)/Highway Assist System (HWA)/Cornering Brake Control (CBC)/Road Departure Protection (RDP)/Smart Parking System Road Departure Protection (RDP)/Smart Parking System/Lane Change Assist (LCA)/360 -degree Panoramic Visual Parking Assist System/Automatic Emergency Braking (AEB)/Electric Parking Brake (EPB)/Automatic Parking (Auto-HOLD)/Hill Departure Control (HHC)/Hill Descent Control (HDC)
Chery	eQ5	BEV	RWD	MacPherson strut/strut	Automatic Emergency Braking (AEB)/Lane Keeping Assist (LKA)/Adaptive Cruise Control (ACC)/Automatic Parking Assistant (APA)	
Great Wall Motor	HiPhi X	BEV	AWD	Double wishbone/multi-link	Body stability system/Active safety system/Front rear parking radar/Adaptive Cruise (ACC)/Automatic parking/Parking brake type EPB/Automatic parking (AUTOHOLD)/Uphill Assist (HAC)/Steep descent (HDC)	
SAIC-GM-Wuling Automobile	Mini EV	BEV	RWD	MacPherson strut/torsion beam	—	

gies such as shock absorbers with progressive hydraulics cushions (PHC) and a fluid stopper that uses hydraulic pressure in the Citroën C4 has been observed.

## 2.2. Suspension Controls

No notable changes were observed in suspension control systems, with electronically controlled suspensions being adopted especially in high-priced luxury vehicles.

The Mercedes Benz S-Class and Porsche Taycan use a three-chamber air suspension that ensures comfort with a low spring rate in normal use, while also serving to reduce body roll by controlling capacity during cornering, as well as to control the vehicle height. Raising the vehicle height when going over bumps prevents interference with the road surface, and lowered it when traveling at high speeds improves stability by reducing aerodynamic drag and lowering the center of gravity. There are also many examples of using an air suspension in some MaaS vehicles to make getting in and out of the vehicle easier.

As seen in the Subaru Levorg and Honda Accord, the adoption of electronically controlled shock absorbers is gradually becoming more widespread.

## 3 Steering

Electric power steering (EPS) has long been used to reduce steering force and improve fuel efficiency, and has now become essential in improving steering feel and lane keeping assist functions. Collision avoidance systems have also been making use of EPS, and a growing number of vehicles offer better passive safety not only for occupants but also for other vehicles and pedestrians. In 2020 automakers released new models featuring emergency avoidance steering control that assists with steering when the driver takes evasive action steering due to a high probability of colliding with a pedestrian, cyclist, or other vehicle, and also contributes to securing vehicle stability and preventing lane departure (Toyota Mirai and others), Pedestrian Collision Mitigation Steering (Honda Fit and others), which assists steering operations when the vehicle deviates from the next to pedestrians and there is a risk of collision, a and collision avoidance and damage mitigation braking (with collision avoidance steering) system (BMW 4 Series and others), which intervenes with steering when a collision cannot be avoided by automatic braking.

Adoption of EPS, which previously centered on light- and medium-duty vehicles, has been expanding to heavy-duty vehicles. As the electrification of drivetrains pro-

gresses, electric steering is also becoming necessary in trucks and other heavy-duty commercial vehicles, and electro-hydraulic power steering (EHPS) or other systems combining hydraulics and electric motors are being adopted. There are currently no examples of EPS use in those vehicles, but high power EPS for heavy-duty trucks was announced by ZF in 2018 and Nexteer in 2020, and such systems are expected to find their way in heavy-duty trucks in the near future.

At the same time, the functions required for driving operations are beginning to change in anticipation of automated driving. Tesla has announced an unconventionally shaped steering wheel (U-shaped, without no top half), said to be optimized for automated driving, in its Model S. In addition, at CES 2020, Audi presented a concept car that retracts the steering wheel during automated driving, and Nexteer and other manufacturers are proposing the mass production of retractable steering columns, which may be commercialized sometime in the future.

## 4 Brakes

The successive announcements of the Green Growth Strategy for carbon neutrality in 2050, and the policy of no new gasoline vehicles sales by the mid-2030s by the government are spurring an intensified automotive industry-wide transition to HEVs, PHEVs and BEVs. In response, electric servo brakes that do not use negative pressure are increasingly replacing vacuum brakes that rely on negative pressure from the engine. At the same time, BEVs, sports cars and other vehicles with high acceleration performance require brakes that support corner braking. Emissions regulations are also being established, and a copper brake pad regulation in North America to ban the use of brake pads with a copper content exceeding 5% starting in 2021 has been set. The number of emission-related regulations is expected to continue to increase and upcoming trends will be monitored closely.

Safety-wise, the formulation of international standards covering automated driving technologies, including automated driving systems and safety regulations, along with the installation of collision mitigation braking systems becoming mandatory for vehicles sold in Japan starting in November 2021, is making the adoption of automatic brakes more widespread. The development of automated driving, automatic parking, and other automation aspects

of CASE is progressing rapidly, and brakes are playing an increasingly important role in the context of advanced safety and advanced functions.

These circumstances create a need for high precision and highly responsive control systems (devices) for brakes. At the same time, systems must feature redundancy to provide a backup in automation. The development of two box systems (devices) providing two control units is expected to intensify while making effective use of existing technologies.

These trends in electrification and automation tie in directly related to the MaaS capitalizing upon them, and all manufacturers are expected to further step up their technical development efforts.

## **5 Vehicle Controls**

In Japan, safety standards for automated driving systems were formulated in March, and enacted on April 1, 2020. Complying with these safety standards allows automated driving level 3 vehicles to drive on public roads speeds of up to 60 km/h on highways. A new authorization system for software updates has also been established, requiring prior permission for any updates that may affect compliance with the security standards. In addition, guidelines for that system aimed at promoting the development, commercialization, and widespread use of last-mile automated vehicles have been established.

Honda, which became the first company in the world to obtain the Ministry of Land, Infrastructure, Transport and Tourism type designation required for the Level 3 automated driving, announced it would install an automated driving device called Traffic Jam Pilot on the Legend. The Traffic Jam Pilot system monitors the vehicle ahead and other nearby traffic conditions, and operates the car on behalf of the driver to remain in the same lane and follow the preceding vehicle during congestion on the expressway. Under certain conditions, this frees the driver from the need to monitor surrounding traffic conditions, and is expected to reduce the driving burden.

The European New Car Assessment Programme

(NCAP) has added reversing and right turns at intersections as AEBS evaluation items. That decision is expected to result in an increase in sensors covering a wide angle and in 360-degree detection systems, as well as to make such systems more widespread.

New models released in 2020 were all equipped with AEBS in anticipation of its mandatory installation in Japan starting in November 2021. The expansion of ACC with all-speed tracking to the compact class and mini vehicles (Suzuki Hustler and other models) was also observed. In addition, the Subaru Levorg and BMW 4 Series were equipped with a system that enables hands-free following driving in congestion on the expressway. All models of the Toyota Yaris feature the latest Toyota Safety Sense with AEBS as standard equipment, as well as Advanced Park, a world-first advanced parking assist system with a memory function enabling assistance even in spaces without line markings.

At the same time, services that retrofit functionality to vehicles already on the market are becoming more common. In Japan, Toyota started to provide software updates for its pre-collision safety systems in September 2020. The number of accidents caused by elderly drivers stepping on the wrong pedal is also becoming a social issue, and is spurring more widespread sales of retrofit systems that suppress sudden acceleration due to pedal misapplication. Parts and accessories manufacturers, as well as automakers have been announcing such systems. The aging of the population in Japan is creating expectations for the technical development of systems providing support for elderly drivers is expected, and activities in that regard will continue to gather close attention. On a different note, Porsche announced a software update with new features in 2021 for users of the 2020 Taycan everywhere in the world. These include improved driving dynamics and the ability to set the charge needed to reach a destination. It is expected that vehicles development will increasingly include software updates as a prerequisite, and that retrofit systems will be offered for existing models.