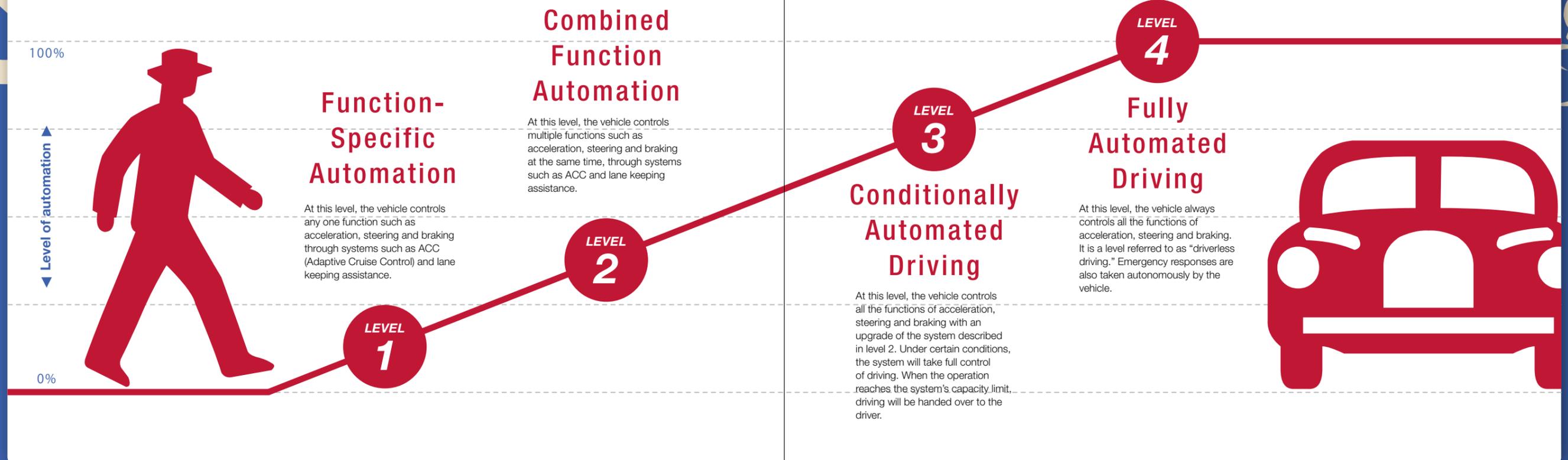


Autonomous Driving

Creating an optimal relationship between people and automobiles!

It may become possible for automobiles to judge situations autonomously and drive themselves to their destinations accurately. Technology for autonomous driving is being developed in various countries. How will it change the relationship between people and automobiles? Here we will focus on autonomous driving from various perspectives, including opinions from developers, advantages, and various issues.



An "automobile" is literally a vehicle that has been developed along with the history of "automation." Starting from the basic functions of moving forward, making turns and stopping, with various functions such as opening/closing of windows and doors being automated and electrically powered, automobiles have evolved as a convenient and comfortable means of transportation. Autonomous driving technology is an extension of this development process, and has been in the spotlight recently. Since last October, autonomous vehicles by different automobile manufacturers have been showcased in CEATEC JAPAN, electronics devices

exhibitions, ITS World Congress Tokyo 2013, and Tokyo Motor Show 2013. A test drive on a public road by Prime Minister Shinzo Abe in November also attracted much interest. While driverless driving tends to attract the most attention on the topic of autonomous vehicles, the ultimate goal is the realization of a society without traffic accidents. For instance, if the automobile can support steering and braking maneuvers according to the situation, it will be safe for elderly drivers or those with less confidence behind the wheel. Autonomous driving aims to realize a society that enables people and goods to move safely and comfortably by preventing traffic

accidents, alleviating traffic jams and by reducing environmental burdens through efficient driving. Therefore, as shown in the graphic below, the government has categorized the status of autonomous driving into four levels. The technology at level 1 has already been put into practical use, and the government has also begun consideration of measures to realize level 2 technologies. In addition to leading automobile manufacturers in the U.S. and Europe, major IT companies are also actively engaged in the development of autonomous driving. Global competition has already begun.



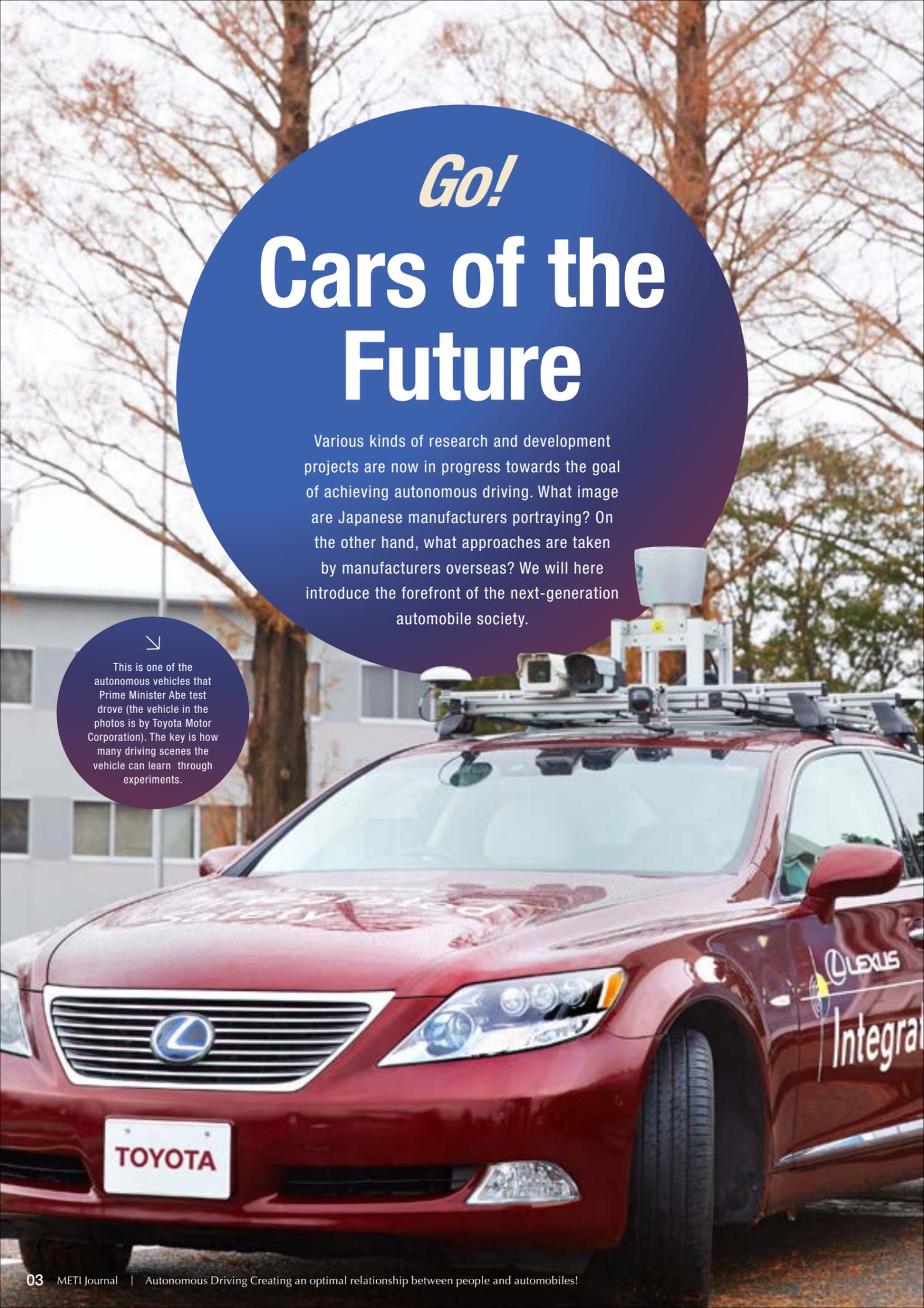
The goal of automated driving is to establish a comfortable relationship, like that between a horse and its rider

➔ **Susumu Umemura**
 General Manager, Future Project Division (as of December 2013)
 Higashi-Fuji Technical Center, Toyota Motor Corporation

Go! Cars of the Future

Various kinds of research and development projects are now in progress towards the goal of achieving autonomous driving. What image are Japanese manufacturers portraying? On the other hand, what approaches are taken by manufacturers overseas? We will here introduce the forefront of the next-generation automobile society.

↘
 This is one of the autonomous vehicles that Prime Minister Abe test drove (the vehicle in the photos is by Toyota Motor Corporation). The key is how many driving scenes the vehicle can learn through experiments.



In Higashi-Fuji Technical Center of Toyota Motor Corporation (Susono City, Shizuoka Prefecture), tests for automated vehicles are being implemented with an aim to put into practice the vehicles with the Intelligent Driver Support System installed, utilizing the technology of automated driving vehicles. The experimental vehicle driving through the course where intersections and signals are set up like public roads is a prototype based on the Lexus. Unlike the prototype that drove on the Metropolitan Expressway in the ITS World Congress, it is equipped with many cameras and sensors, showing a typical "under experiment" look. "It aims to collect a large amount of various kinds of data and utilize them in research and development. It is also used for specific product development, such as determining what form each sensor should take."

Mr. Umemura says, "Toyota has been researching automated driving technologies since the late 1990s. Some of the technologies used for cameras and sensors to recognize the surrounding environment are already being commercialized." One of such technologies is Lane Keeping Assist Technology. With this technology, the white lines drawn on the road are detected with a high precision camera to support maintaining the lane. In the demonstration drive on the Metropolitan Expressway, a device with a further evolved version of this technology was used. "C-ACC," which is a system to maintain the distance between cars in an even more precise manner, by newly mounting the communication technology, is also at the stage of practical use. Automated driving was realized with these latest systems.

Wheel speed sensor attached to the rear wheel. The sensor measures the rotating speed of the wheel and the running distance, and collects data for controlling driving.



A laser radar that surveys the three-dimensional shape of the automobile's surroundings, 360 degrees. It rotates at a high speed to detect vehicles and pedestrians.



A laser radar that monitors the surroundings, a high-resolution camera, a GPS (global positioning system) antenna, and other equipment are installed.



Reaching a new level through a public road experiment

However, Mr. Umemura emphasizes, "The system does not assume unattended driving. Drivers should always assume the leading role in driving. The mission of an automobile manufacturer is to allow people like the elderly and beginner drivers to drive safely, and realize a prosperous society both physically and mentally, free of traffic accidents."

Toyota is focusing its efforts in an infrastructure-cooperative type of automated driving, in collaboration with ITS, and has also recently started the development of autonomous-type driving, which is a system of driving cars according to information obtained by the vehicle through sensors. Following the public road experiment in Michigan, U.S.A. two years ago, a full-fledged experiment on a public road in Japan is also being initiated.

"On the test course, the results tend to be evaluated from the viewpoint of engineers. However, on an actual road, many things can be noticed from the viewpoint of drivers. What kind of vehicle is good enough for our customers to drive? It is a very important aspect also in the context of social acceptability." Mr. Umemura's vision for automated driving is the "relationship between a human and horse." "Just as the rider and the horse understand each other's conditions and exert their best performance, the driver and the automobile act in perfect collaboration to avoid danger and achieve comfortable driving." The development is now entering a new stage towards the ultimate goal for automated vehicles.

CLICK! ● Safety technology, Toyota Motor Corporation



Offering world-class “fun” while avoiding the “Galápagos syndrome”

Toshio Yokoyama
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Automobile R&D Center, Honda R&D Co., Ltd.

“Safe and secure, fun to drive, fun to use—this is the autonomous driving Honda is aiming to realize,” explains Mr. Yokoyama, who was responsible for the Honda exhibition booth at the ITS World Congress held last October. “How did visitors react to our autonomous vehicles at ITS? Well, it was generally as we expected,” he says with an expression of satisfaction. Honda conducted two different types of demonstrations of autonomous vehicles at the ITS World Congress - Auto Valet Parking and Cooperative Autonomous Driving. The former is a system for automated parking, in coordination with the camera at the parking site. The latter was a demonstration drive on a course resembling a public road, detecting other vehicles, pedestrians, motorcycles, and electric carts. “The Auto Valet Parking received a positive reception, to the effect that ‘It’s very helpful.’ On the other hand, as for autonomous driving on public roads, many people seemed to demand automobiles that offer optimum support according to the state of driving, rather

than allowing completely unattended driving.” That is, the development team including Mr. Yokoyama felt that “the majority of people want to enjoy the fun of moving under cooperation between the automobile and humans.” “We were able to confirm that our concept of fun to drive, fun to use is on the right track.” He also felt a positive response to the safety aspect of Cooperative Autonomous Driving, which prevents the occurrence of accidents by cooperating with DSRC* and pedestrians’ smartphones via wireless communication, in addition to the use of car-mounted cameras and radars.

International cooperation is also necessary to form the standards

That said, there are many issues to be solved. “One of the issues is the human machine interface, which means how to convey the vast amount of information coming in to the driver. If this is poorly

done, it will only confuse the driver.” Another “condition for the spread of autonomous vehicles” Mr. Yokoyama gives is the viewpoint of so-called global standards. “Even if we make an excellent product, we cannot beat the competition if you can only use it in Japan. We must absolutely avoid that kind of Galápagos syndrome. I also think that cooperative efforts between public and private sectors, including the international standardization of technologies, are also necessary.” Mr. Yokoyama holds an in-house “Class A License” as a test driver. He drives the test vehicles himself on the test course when conducting in-house appraisals of prototype vehicles. “I frequently use highways myself, so I cannot wait until this technology is put into use,” says Mr. Yokoyama. Because he knows how fun driving is, he is even more enthusiastic about the development.

CLICK! ● Honda Hearts Documentary on Safety



This is an Auto Valet Parking demonstration based on coordination with a fixed camera installed to monitor the parking lot. The advantage of the system is that you do not need any special equipment on board.



This is a driving demonstration simulating a public road. The system can respond even to the sudden appearance of pedestrians, with the use of a stereo camera, a millimeter-wave radar, and wireless communication with smartphones.



This is an autonomous driving vehicle based on the Leaf electric vehicle. Each vehicle is equipped with five cameras and a laser scanner for 360 degree monitoring.



Registration and a license plate are obtained for driving on public roads. Nissan is engaged in an actual driving experiment on Sagami Jukan Road.



Realize a crash-free car based on electricity and intelligence

Toru Futami
Engineering Director, Technology Planning Department, Planning and Advanced Engineering Development Division, IT & ITS Engineering Department, Electronic Engineering Development Division
Nissan Motor Co., Ltd.

“Zero emissions” (zero-emission of CO2) and “zero fatalities” (no traffic accidents) are the visions of Nissan Motor Co., Ltd. The technologies to achieve the vision combine electric and intellectual power. In this context, where is Autonomous Driving positioned? Mr. Futami explains as follows.

“Autonomous Driving is the most direct model for intelligent technology. Humans’ recognition, judgment and action are not always perfect. Human error is the cause of more than 90% of accidents. In order to reduce the number of traffic accidents, a mechanism to compensate for such errors will be necessary. In other words, our basic idea is that Autonomous Driving is a safety technology that first prevents accidents, and then supports operation.” At CEATEC JAPAN held last October, Nissan demonstrated Autonomous Driving based on the Leaf electric vehicle. What attracted people’s attention here was the movement of the autonomous driving vehicle which ran by sensing the movement

of other vehicles. The vehicle stops at intersections without signals and when there is a car parked on the road, and starts moving again after it judges the conditions to be safe. This was made possible with AI (Artificial Intelligence), which Mr. Futami refers to as the technology combined with intellectual power.

Behavior of insects and the wisdom of NASA

“Whether the vehicle can make movements as if a person is driving is an important point. In order to predict danger and avoid a crash, you need proper skills and driving experience. Knowledge of traffic rules such as traffic signs is also indispensable. AI assumes that role on behalf of humans. We are very much focusing on this AI and sensing technology.” Nissan has been focusing on the crisis prevention ability of bees in flight or a school of fish for some time. The company has implemented studies to analyze these behaviors and utilizes the results in the control of automobiles. Nissan also recruited former NASA

engineers at its development base in Silicon Valley, U.S., to incorporate their knowledge in studies. “Development of technology that leads to crash-free cars is making steady progress. On the other hand, we are also placing importance on whether the technology is viable in mass production. However excellent a technology is, a product using a sensor that costs several million yen cannot be commercialized. High-quality and mass-producible are the essential requirements.” Nissan made a declaration on marketing more than one type of autonomous driving vehicle by 2020. Experiments on public roads have already started also in Japan, on the Sagami Jukan Road (Kanagawa Prefecture). “I would definitely like to launch the autonomous driving vehicle of our company by the time of the opening of the Olympic Games in Tokyo, and appeal widely to the public.”

CLICK! ● Nissan’s idea of Autonomous Driving

Manage the movement of vehicles with a precision of error within 10 centimeters.

DENSO CORPORATION

DENSO CORPORATION is engaged in the development of advanced driving assistance system that assists the recognition, judgment and operation of drivers, in addition to the preventive safety system including a pre-crash brake system or Lane Departure Warning (LDW). The key to the realization of the technology is the recognition of surroundings and automatic position detection. In this end, the company is currently trying to establish fusion technology to improve recognition ability by combining multiple sensors, including cameras and radar. It is also developing high-precision positioning technology to a tolerance of 10 centimeters by utilizing signals from quasi-zenith satellites, in collaboration with NEC and JAXA. DENSO believes that a control center to manage the routes of automobiles and support smooth and

safe navigation will become necessary when automated vehicles are used widely. In the ITS World Congress, the company presented some of those ideas and technologies. One of the examples is a smart charging system, which moves automobiles to a designated place at a designated time for recharging according to instructions by the center. Studies to further improve the function and liability of sensing technology and ensure safety even when communication is lost, are now under way. "We will work on the development of products and technologies, and propose them to automobile manufacturers. We would like to contribute to the spread of automated driving by being the first to put into practice the advanced driving



You can recharge your vehicle, even if you are not in it, because it communicates with a wireless charging control system and parking space management system. Information such as the amount of recharging required and the timing can be sent via smartphone.

assistance technology. As for the next step, a demonstration experiment of automated driving controlled by a control center will start from 2014 with the cooperation of Kumejima Town, Okinawa Prefecture. We are planning to evaluate its convenience and acceptance by users." (DENSO CORPORATION)

CLICK! ● DENSO CORPORATION

Follow Up on Global Trends!
How far has the technology developed abroad? We asked a pioneering company.

What is the future mobility portrayed by the leading supplier?

Continental AG



Develop partially automated solutions by 2016, highly automated systems by 2020, and fully automated system by 2025— that is the plan drawn up by Continental AG, a global automotive industry supplier of tires and brakes, etc. Following approval by the Department of Motor Vehicles, the State of Nevada, U.S.A. in December 2012, the company received a test license for automated driving. The company is continuing research and testing activities on public roads to assess highly automated

driving. "The suitable systems on board will give drivers much more freedom. Drivers will in the future be able to decide whether to do the driving themselves or to let the vehicle take control and drivers will be able to concentrate on other activities." (Continental AG) The company has been participating in various projects including joint development with Mercedes-Benz. With enormous experiences and past achievements, they are working very

hard on the development of automated driving from every aspect of technology. "Automated driving is a core theme of the technology strategy at Continental. We will be investing billions of euros in research and development over the next few years to help smooth the path to the mobility of the future."

CLICK! ● Continental AG

The establishment of autonomous driving

Before/after

For example, autonomous driving will enable dramatic increase in travel distance per day, or allow those who used to have difficulty in driving automobiles to enjoy driving again, or it will help the lives of the elderly. If the burden of drivers can be reduced with support from advanced autonomous driving, it may not only reduce the number of accidents, but also result in discovering a new type of enjoyment or the creation of new businesses. This technology unlocks potential in various fields. Let's take a look at some of the changes that can be realized.

Automatic parking



Parking an automobile in a garage or parallel parking might be troublesome for many people. With autonomous driving, you can easily park a car in a designated space. The driver's stress is relieved and there will be no worries about collisions.

Dead-man devices

When it becomes difficult to continue driving due to a sudden health disorder, the automobile will automatically stop or wait at a safe place when the driver switches the device on. It will prevent secondary damage such as crashes or rear-end collisions.



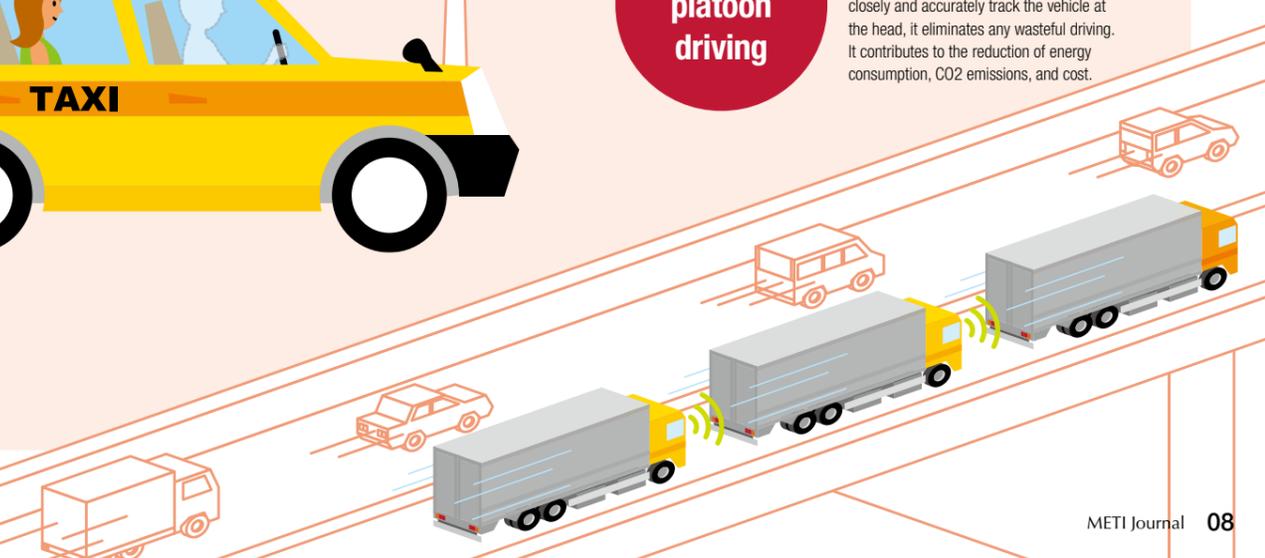
Driverless taxi

If driverless taxis are put into use, they will take you to your destination for the optimum price along the best route. Because it is compatible for even long distance travel, it may help create a new style of sightseeing tours.



Automated platoon driving

Transportation efficiency can be improved by automating platoon driving of trucks and buses. Because the following vehicles can closely and accurately track the vehicle at the head, it eliminates any wasteful driving. It contributes to the reduction of energy consumption, CO2 emissions, and cost.



\ Under discussion / Issues to be solved before putting these technologies into practice

As autonomous driving becomes a part of everyday life, and accidents or traffic jams all become a thing of the past—such an automobile society cannot be realized only with the progress of technology. It will become necessary to reestablish rules from different viewpoints from the past, such as the development of laws and regulations suitable for autonomous vehicles, or defining responsibilities when unexpected problems arise. Here are some of the major issues that must be solved in the future.

Awareness of surrounding environment

There may be cases where the lines on the road are faded, or the pedestrians and traffic signs are hard to see due to rain and snow. It is necessary to develop more highly precise sensors and improve road conditions responding to the needs of autonomous driving in every situation.



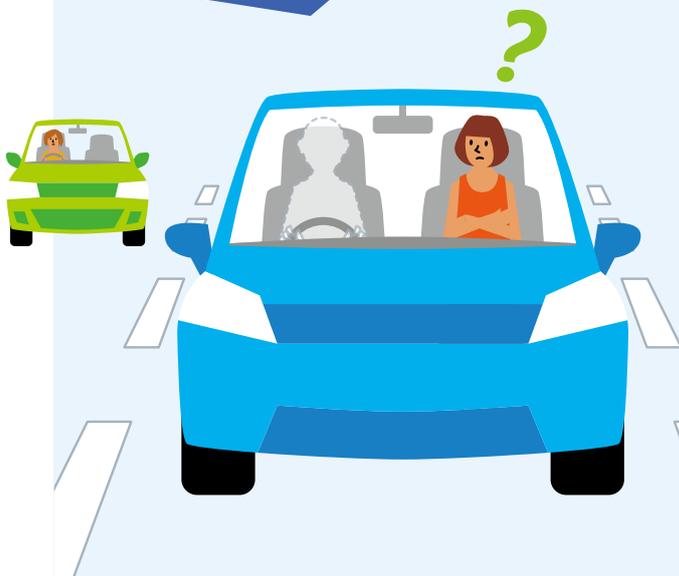
Danger prediction

On public roads, there are many unpredictable events, including children suddenly running into streets and bicycles in blind spot of automobiles. AI (Artificial Intelligence) that is able to read various signals and predict "unseen danger" is being developed.



Whether it is right or wrong to drive on public roads

The current law stipulates that there must be a driver in the driver's seat. So would it be possible for an unmanned autonomous vehicle to drive on public roads? It is necessary to further deepen the debate on this issue.



Responsibility in case of an accident

If the definition of "driver" remains unclear, it may also be unclear where the responsibility lies if a traffic accident occurs. It is possible that not the owner of the automobile but the manufacturer of the automobile or the parts may be regarded as holding responsibility.

