AUTOMOBILES AND SAFETY

1 Introduction

Traffic accident fatalities in Japan in 2014 fell for the 14th consecutive year to 4,113, one-quarter of the 1970 peak of 16,765. In addition, the number of traffic accidents and injuries also fell for the 10th consecutive year, with the number of people injured in a traffic accident falling to 710,000. However, the human and economic impacts of traffic accidents remain a cause of intense social concern.

The Ninth Fundamental Traffic Safety Program issued by the Japanese government established a target of less than 3,000 fatalities within 24 hours of an accident by 2015. However, despite the downward trend, achieving this target will be extremely difficult. Furthermore, since social changes, such as the rapid aging of society in Japan is having major changes on the traffic environment (for example, the high proportion of traffic accident fatalities made up of elderly people aged 65 or more), further measures to improve safety are still urgently required.

2 Traffic Accident Trends and Measures

2. 1. Traffic accident trends

Annually, the number of traffic accident fatalities peaked at 16,765 in 1970, before falling to 8,466 in 1979 due to a range of measures to enhance safety. Traffic accident fatalities then began to trend back upward, peaking again at 11,451 in 1992. Since then, the number of fatalities gas fallen gradually, reaching 4,113 in 2014.

In contrast, the number of traffic accidents and injuries steadily increased from 1977, reaching a peak in 2004, and then falling drastically in 2014 to 570,000 and 710,000, respectively. Although the number of injuries is very close to the 2015 target of 700,000 established by the Ninth Fundamental Traffic Safety Program, this still represents a very high level (Fig. 1) (1).

The following sections outline the salient characteristics of fatal accidents in 2014.

2. 1. 1. Number of fatalities per road user status

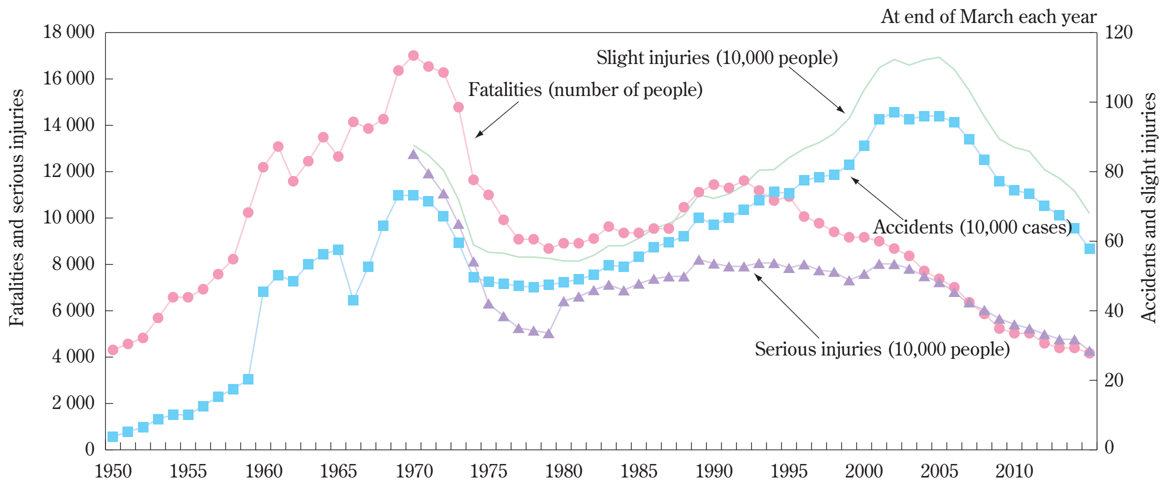
The total number of traffic accident fatalities in 2014 was 4,113. Of these, 1,498 were pedestrians (down 5.4% from 2013), a proportion of 36.4%. Since 2008, the number of pedestrian fatalities has exceeded the number of vehicle occupant fatalities, which reached 1,370 in 2014 (down 3.2%), a proportion of 33.3%. The total number of fatalities involving people riding a motorcycle or bicycle was 1,237 (30.1%), a drop of around 9% from 2014. However, the fall in the number of cyclist fatalities only fell by around 4.1%. This outlines the importance of introducing measures to enhance the safety of cyclists and motorcyclists (Fig. 2) (1).

2. 1. 2. Increase in the number of elderly fatalities

In 2014, the number of fatalities aged 65 or older accounted for 53.3% of the total (Fig. 3) (1). Pedestrians accounted for more than half of these elderly fatalities (53.3%), much higher than the proportion for all ages ranges (36.4%). From the standpoint of the accident type, elderly people accounted for 71% of all pedestrian fatalities and 63.9% of all cyclist fatalities, both extremely high proportions. Since between 70 and 80% of these elderly fatalities involve people without a driving license, one possible cause for this may be unfamiliarity with the behavior of vehicles.

In addition, the number of elderly vehicle occupant fatalities is showing no signs of falling and has remained at approximately 240 people every year since 2011. The accident fatality rate for elderly people aged 65 or over is 2.04, much higher than that of people aged under 65 (0.32). This shows that elderly people have a fatality risk 6.5 times that of younger people if involved in an accident. One reason for this is probably the drop in impact tolerance in accordance with age.

As Japan's society continues to age, it is likely that the proportion of elderly vehicle occupant fatalities will also increase. This may be explained by the higher



Notes: (1) Until 1959, these statistics did not include the number of slight injuries (injuries recognized within 8 days from the accident and causing damage property valued at 20,000 yen or less).
(2) Until 1965, these statistics also included accidents involving damage to property only.
(3) Until 1971, these statistics did not include Okinawa Prefecture.

Fig. 1 Traffic accident trends.

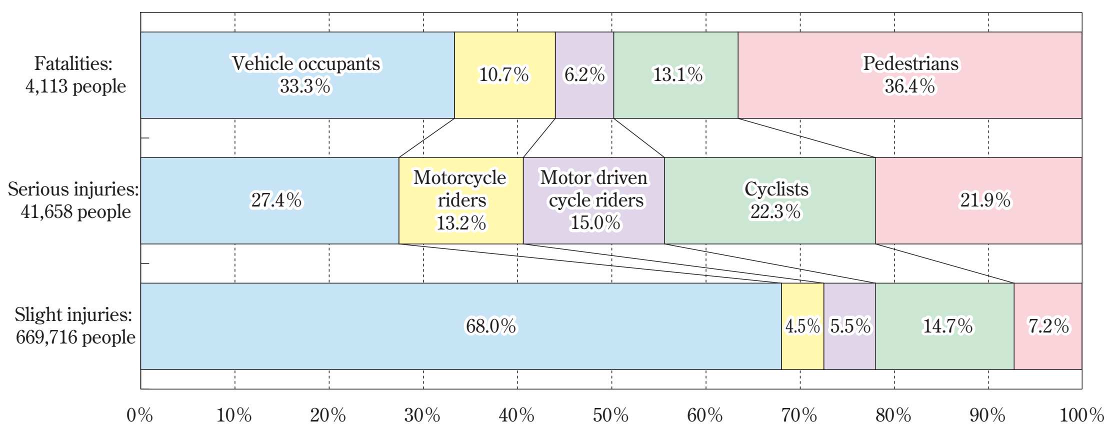


Fig. 2 Fatalities per road user status (2014).

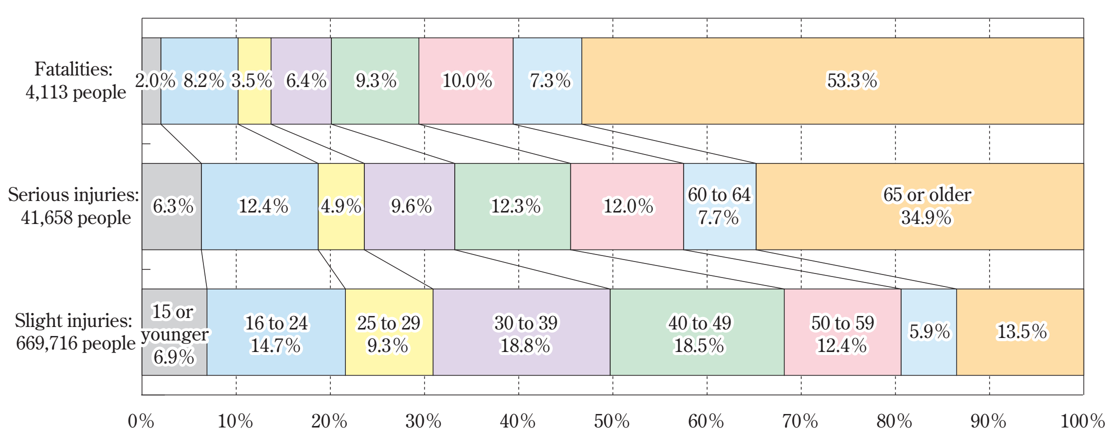


Fig. 3 Fatalities per age range (2014).

proportion of accidents caused by driving or judgment errors by elderly drivers. For example, elderly drivers are more likely to cause an accident due to road traffic law violations such as disregarding traffic signals (3.8%), failing to proceed safely into an intersection (7.0%), failing to stop (6.0%), or an inappropriate driving operation (7.7%). Therefore, it will be important to also incorporate measures directed at both pedestrians and cyclists to help prevent accidents involving elderly people.

2. 2. Traffic accident measures

In 2011, the Japanese government introduced the Ninth Fundamental Traffic Safety Program (2), which included a target to reduce the number of traffic accident fatalities to 3,000 by 2015. The main measures to achieve this target are: (1) improving the road traffic environment, (2) ensuring thorough awareness of road safety, (3) ensuring safe driving, (4) enhancing vehicle safety, (5) maintaining an orderly traffic situation, (6) enhancing rescue and emergency services, (7) improving victim support, particularly by optimizing the system of damage compensation, and (8) improving research and development as well as analytical research. Based on these measures, the following items related to vehicle safety are being promoted as part of the 2013 Ministry of Land, Infrastructure, Transport and Tourism (MLIT) Traffic Safety Work Plan.

(1) Promotion of improvements to standards and the like related to vehicle safety
(2) Promotion of development and popularization of Advanced Safety Vehicle (ASV) technology
(3) Provision of vehicle assessment information
(4) Enhancement of vehicle insurance and inspection
(5) Enhancement and reinforcement of the recall system.

The following sections discuss the items related to safety.

2. 2. 1. Standards related to vehicle safety

The committee organized by MLIT to study vehicle safety measures is promoting various items related to standardization. These include measures to enhance the safety of child seats in side- or pole side-impact collisions, and harmonizing international standards related to fuel leaks in rear impact collisions. In addition, possible candidates for future standardization include the prevention of accidents in a society with a declining birthrate and aging population, accidents involving pedestrians or cyclists, measures for new forms of mobility, measures to help prevent serious accidents involving heavy vehicles, occupant protection measures, and road accident pre-prevention measures. New measures for these items are being studied based on the concept of benefit evaluations. Safety measures are also being studied to help prevent serious accidents caused by large buses on highways. Lane departure warning devices have been mandated as standard equipment in Japan from 2017. Potential future measures include systems that monitor the driver state and systems that stop the vehicle by automatic braking when the driver state is not normal.

Activities to harmonize international standards include the establishment of a specialist International Whole Vehicle Type Approval (IWVTA) committee under the auspices of Working Party 29 (WP 29: World Forum for Harmonization of Vehicle Regulations) at the United Nations (UN) (3). WP 29 is working to establish individual UN regulations (new and revised regulations) to enable mutual type approval between the countries that signed the 1958 UN agreement. WP 29 is currently in its final phase toward achieving this goal in 2016. As a result, mutual type approval related to vehicles should encourage the unification of design standards and part standardization between participating countries, thereby simplifying certification procedures and reducing costs. Ultimately, these efforts should benefit the customer.

2. 2. 2. Promotion of development and popularization of ASV technology (4)

The fifth phase of the ASV project that started in 2011 has been studying the following three topics leading up to the final year of the phase in 2015. The first topic is the rapidly growing sophistication of ASV technology. Study fields include systems that respond to driver abnormalities, driver over-confidence, combinations of different driving support systems, and the promotion of technological development to enhance safety measures for heavy duty vehicles. The second topic is the promotion of the development of communication-based driving support systems. Study fields include pedestrian-to-vehicle communication systems, next-generation communication-based driving support systems, and benefit evaluations of communication-based driving support systems. Topic three is the awareness and popularization of ASV technology, which is being promoted in the same way as before.

2. 2. 3. Vehicle safety assessments in Japan

The Japan New Car Assessment Program (JNCAP) for evaluating vehicle safety began in 1995. It currently includes tests for full-lap frontal collisions, offset frontal collisions, side-impact collisions, pedestrian protection performance, rear seat passenger protection performance (offset side-impact collisions), neck injury protection performance in a rear-end collision, rear passenger seatbelt usability, passenger seatbelt reminder performance, high-speed braking performance, and child seat performance.

Since 2011, vehicles have been given an overall assessment that combines passenger injury and pedestrian protection performance. The overall collision safety of the vehicle is assessed and the information provided to customers. In addition, from 2014, new active safety assessments were added, starting with automatic emergency braking (AEB) to help mitigate damage in a collision, and lane departure warning systems (LDWS). The performance of each system is awarded a score, and the total is graded in two levels: ASV and ASV+. Thirty-seven models were tested in 2014 and the scores of each model were released in turn after the tests. In 2015, rear view cameras (back cameras) were added to the assessment. In 2016, a new overall score will be awarded for active safety including aspects such as braking systems for mitigating pedestrian injuries. JNCAP is also studying assessing braking systems that help to mitigate pedestrian injuries at night.

2.2.4. Trends of vehicle safety assessments outside Japan

Outside Japan, government organizations and insurance institutes in North America, Europe, China, South Korea, and Australia also assess vehicle safety performance. Assessment items are increasing every year, with the inauguration of the Latin America version of NCAP in 2010 and ASEAN NCAP (incorporating the eight ASEAN countries) in 2012. Social awareness of safety performance is increasing, prompting automakers to increase their efforts. As a result, these assessments are helping to increase the number of safe vehicles around the world, particularly in developed nations. India plans to start up its own NCAP program in 2017 and the collision test results of some vehicles were already published in 2014. In addition, following the lead of JNCAP, Euro-NCAP and the Insurance Institute for Highway Safety (IIHS) in the U.S. have also introduced active safety assessments.

3 Research and Technology Related to Active Safety

Under the Ninth Fundamental Traffic Safety Program, the ultimate aim of achieving a traffic accident-free society is not simply a matter of reducing fatalities and serious injuries. Another important aspect of traffic safety measures is to reduce the number of actual accidents (570,000 in 2014) to help lower the total of 700,000 injuries every year. In addition, as Japan's society continues to age rapidly, the numbers of elderly pedestrians as victims and elderly drivers as causers of accidents are also likely to increase. Therefore, it will be important to enhance the performance and of active safety technologies, which are capable of preventing accidents in advance and alleviating the severity of accidents that cannot be avoided, as well as to make these technologies more widely available. From the standpoint of preventing accidents in advance, these systems must be capable of accurately communicating the risk of an accident in high-risk situations, and supporting driver actions to help avoid an accident or lower collision speeds when a collision is inevitable.

3.1. Research into human cognition, judgment, and operation characteristics

Most traffic accidents are caused by the driver making an error in the cognition/decision making/operation process. Therefore, to reduce traffic accidents, it is necessary to accurately identify the conditions and factors between driver errors, and then adopt suitable measures. A wide range of research has already been conducted into detecting objects around the driver's vehicle for application in collision damage mitigation brake systems that aim to help prevent accidents in advance or reduce accident damage. This research has led to the commercialization of various driving support systems in recent years. Since the fundamental purpose of these systems is to support the driver, these systems must not lead to over-confidence or over-reliance. Therefore, in addition to driving support systems that provide direct assistance to the driver, research into detection of driver states is also making progress in anticipation of the automated and advanced driving support systems of the future (7).

3.2. Support systems for driver cognition and judgment processes

Key elements in the prevention of traffic accidents caused by errors in the driver cognition/decision making/operation process include the recognition of risks in the environment surrounding the driver's vehicle and the appropriate communication of those risks to the driver, and the implementation of appropriate avoidance maneuvers by the system if the driver is unable to do so.

In addition to conventional forward detection systems using millimeter wave radar or camera images to detect objects in front of the vehicle, which help to avoid collisions with preceding vehicles or pedestrians and to lower collision speeds, systems have also been commercialized that perform automatic braking with respect to an oncoming vehicle in more complex road environments, such as intersections (7). As well as pedestrians, systems have also been commercialized to help reduce bicycle accidents, which have accounted for a growing proportion of accidents in Japan in recent years. In this way, the evolution of external detection technologies is helping to promote the development of technologies that cover a wider range of accident scenarios.

Another important factor is the widespread availability of safety systems. Damage mitigation brake systems, which were mainly only found on luxury vehicles, have now become widely available as standard equipment on mini-vehicles. This trend is due to greater awareness of these systems by consumers as well as lower system costs. However, since active safety systems such as damage mitigation brakes help to compensate for driver errors, it is important these systems do not invite overconfidence. Therefore, it is critically important that consumers are given correct information about safety systems.

Automakers are also actively researching automated driving systems that use active safety technology to further boost support to the driver. Automated driving systems in current use include advanced driving support systems such as adaptive cruise control (ACC), which sets the speed of the vehicle and distance to the preceding vehicle, and lane keeping assistance systems (LKAS). It is hoped that more advanced versions of these systems will have a major effect on accident prevention. Other aspirations for these systems include the environmental benefits of reduced traffic congestion, and helping to vitalize the lifestyles of elderly people as society ages. Vigorous discussions are taking place from a wide range of standpoints.

The informal group in charge of conventional intelligent transportation systems (ITS) under UN WP 29 has established a new informal group for automated driving. This group has started to examine technical standards, with Japan and the UK selected as joint chairs. Japan is hoping to demonstrate leadership in this field. Conventionally, vehicles were developed under the premise that the driver would always remain in control. However, in the case of automated driving systems, it is possible to envision scenarios in which the vehicle takes over control from the driver. Research is progressing from a number of standpoints, including the allocation of responsibility if an accident occurs when the system is in control, system reliability, the concept and conditions for the hand-over of control from the system to the driver if the system fails, and data security since these systems rely on communication technologies.

Under this background, the ITS World Congress was held in Detroit in September 2014 to showcase various technological exhibits, driving demonstrations, and discussions. The commercialization of automated driving technologies will require the interpretation and adjustment of legal systems around the world. Despite this, the practical adoption of these technologies has been announced before 2020 and active discussions are continuing about every aspect.

4 Research and Technology Related to Post-Accident Safety

Although restricting the number of traffic accidents is a critical aspect in helping to reduce the number of fatalities and injuries, it will be difficult to totally eliminate traffic accidents through current active safety technologies alone. For this reason, measures to further improve safety after an accident are highly important. Japan has reduced the number of traffic accident fatalities to a little over 4,000. However, analysis of the causes of injuries and research into the more effective countermeasures are continuing based on a wide-ranging traffic accident analysis.

4. 1. Biomechanics and crash test dummies

Various crash test dummies are already used in collision performance assessments. However, since the fidelity of these dummies with respect to the human physique has a major effect on safety, research is continues to focus on developing improved dummies.

Although the Hybrid III dummy is the main dummy currently used in frontal collisions, the National Highway Traffic Safety Administration (NHTSA) in the U.S. is leading a project to develop the next-generation THOR dummy (THOR: abbreviation for "Test device for Human Occupant Restraint"). After repeated prototypes and refinements, including the development of each component unit and the overall dummy, and the involvement of research institutes around the world in verification tests, the THOR-M dummy (8) has been released and is now undergoing final verification at each institute. Euro-NCAP has already included the THOR dummy in its 2020 Roadmap (8) and NHTSA is using it in research of frontal collision standards.

In addition, two different types of side-impact dummies are currently in use, one in North America and one in Japan and Europe. The development of the Worldwide harmonized 50th percentile Side Impact Dummy (WorldSID) is now in its final phase. Verification tests of its physical fidelity have been completed and the WorldSID dummy promises a major upgrade compared to the current side-impact dummies. This dummy should enable more accurate verification of occupant injuries in a collision. Basic design of a smaller female dummy (the 5th percentile WorldSID dummy) has also been completed and each research institute is moving onto the verification phase. Plans are being formed to use the WorldSID dummies in NCAP assessments around the world in a wide variety of regulations.

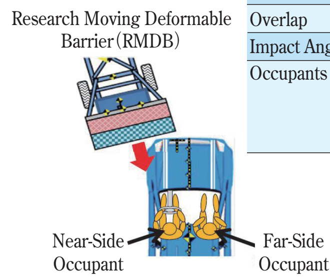
In addition to adult dummies, various types of child dummies have been adopted, including the Hybrid III dummy. These child dummies will be harmonized into the Q-series. The 1.5-year old (Q1.5) and 3-year old (Q3) dummies have almost been completed and the Q6 and Q10 dummies are now in the final development phase. It is planned to use these dummies both in child seat assessments and in a wide range of frontal and side-impact tests.

4. 2. Vehicle body development

Safety assessments such as those carried out by NCAP around the world focus on both the absorption of impact force applied to occupants in full-lap tests and the restriction of vehicle body deformation to ensure an occupant survival space in offset impacts. Currently, most vehicles achieve the highest rating in these assessments. The development of crashworthy bodies has helped to greatly reduce the number of fatalities among vehicle occupants.

However, since various types of collisions occur in the real world, the IIHS introduced the small overlap test in 2013 as a new collision test mode. Unlike the conventional 40% overlap test, this assessment adopts a frontal impact outside the frame of the vehicle. This causes the barrier to directly intrude into the occupant compartment, requiring sweeping changes to the vehicle structure and strength. Initially, although few vehicles obtained a high score in this assessment, results have gradually begun to improve.

Furthermore, NHTSA is continuing research into an oblique test for introduction as a new assessment standard in the future (Fig. 4) (9). Although most vehicles achieve good scores in the full-lap and offset tests performed by NCAP, the number of occupant fatalities in the real world has not decreased greatly. One of the reasons for this is insufficient interaction between the frames of the vehicles involved in the collision. As a result, frames that function well in current barrier tests do not function adequately in real-world accidents, and the new test is aiming to help remedy this situation. To achieve this aim, NHTSA is examining a new test mode in which a moving deformable barrier weighing 2,490 kg is crashed into the front left corner of a stationary vehicle at an angle of 15° and a speed of 90 km/h. It also plans to use THOR dummies.



RMDB Speed	56 mph (90 kph)	
Overlap	35 percent	
Impact Angle	15 degrees (PDOF=345)	
Occupants	Near-side (Driver)	THOR Mod Kit 50th Male
	Far-side (Passenger)	THOR Mod Kit 50th Male

Fig. 4 NHTSA oblique test.

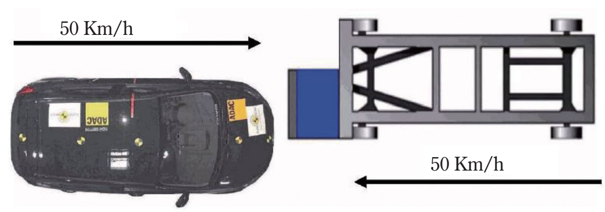


Fig. 5 ADAC moving progressive deformable barrier (MPDB) test.

In Germany, the Allgemeiner Deutscher Automobil-Club e.V. (ADAC) is researching a new vehicle-to-vehicle compatibility test that assesses the aggressiveness of vehicles in a collision (Fig. 5) (10). The approach behind this type of research is to help resolve the issue of vehicle-to-vehicle compatibility in real-world collisions, which cannot be fully assessed under current NCAP test conditions. Particularly in collisions between vehicles of different weights, a key element is to reduce the aggressiveness of large vehicles while ensuring the self-protection performance of small vehicles. For this reason, it is hoped that an assessment method will be established as quickly as possible.

4. 3. Occupant protection systems

Front airbags are obviously a critical part for occupant protection in frontal collisions. However, virtually no vehicles have been equipped with airbags in the rear seats due to concern about possible injuries to children or the presence of child seats when the airbag deploys. Different to conventional airbags, one proposal to help resolve this issue is to deploy airbags from the headlining or the front seats (12). This technology has the potential to protect rear seat occupants using airbags, something that is currently only possible using child seats.

In side impacts, the main subject of research has been protecting the occupant on the side of the collision. However, discussions have started to include protecting the occupant on the opposite side as well. In these cases, the collision forces the occupants into the center of the vehicle, creating a potential secondary impact with other occupants, seats, or interior parts. Therefore, airbags that deploy from the center of the vehicle, between the occupants are also being studied. The Euro-NCAP 2020 Roadmap is considering this as a new assessment item.

4. 4. Emergency notification systems

The number of accidents in which vehicle occupants require emergency treatment even after safety measures have functioned properly remains high. In these cases, the time in which emergency treatment can be applied has a major effect on survival rates. Emergency notification systems that communicate the location of an accident and other information automatically after a collision are attracting attention as a means of shortening this time. Some vehicles in Japan, the U.S., and Europe are already equipped with these systems, and moves are underway to mandate installation in the future. Russia plans to make these systems compulsory in 2015 and Europe in 2018. UN WP 29 is leading discussions to create an Economic Commission for Europe (ECE) standard to achieve international harmonization of these systems.

In addition to the automatic notification of accident locations, a system has also been commercialized that transmits the change in speed of the vehicle involved in the accident and whether the occupants were wearing seatbelts. This allows the emergency services to estimate the potential severity of injuries to the vehicle occupants and make a judgment about the level of emergency treatment required (12). As well as measures on the vehicle side, these systems also require wide-reaching cooperation with the emergency service dispatching infrastructure and medical institutions.

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