AUTOMOBILES AND SAFETY

1 Introduction

The number of traffic accidents and injuries in Japan in 2015 fell for the 11th consecutive year. However, the number of fatalities increased slightly to 4,117, the first increase for 15 years since the number of fatalities started to decrease in 2002. 54.6% of these fatalities were elderly, aged 65 or over, highest percentage of fatalities. The expanding population of elderly who are more likely to be seriously hurt in a collision, is seen as one reason for this increase. Pedestrians accounted for the highest percentage of traffic accident fatalities involving elderly the following is vehicle occupants. This suggests that there is a limit to the effectiveness of vehicle-based countermeasures to help resolving this issue. As the aging of Japanese society continues, the development of specific countermeasures to help reducing accidents involving elderly is now an urgent task. It will be necessary to further accelerate cooperation between the public and private sectors and to adopt integration of three-part measures, pedestrians, drivers, and the traffic environment.

2 Traffic Accident Trends and Measures

2. 1. Traffic accident trends

Annually, the number of traffic accident fatalities (within 24 hours of the accident) 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 11,452 in 1992. Since then, the number of fatalities fell at an increasingly gradual trend, reaching 4,113 in 2014. The trend eventually reversed for the first time in 15 years, increasing to 4,117 in 2015. As a result, the target established by the Japanese Government's Ninth Fundamental Traffic Safety Program in 2011 of reducing the number of fatalities within 24 hours of an accident to less than 3,000 by 2015 was unfortunately not attained.

In contrast, the number of traffic accidents and injuries has fallen since reaching a peak in 2004. In 2015, the number of injuries fell to 670,140. Although this is below the 2015 target of 700,000 established by the Ninth Fundamental Traffic Safety Program, it still represents a very high level (Fig. 1)[(1)].

The following sections outline the significant characteristics of fatal accidents in 2015.

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

The total number of traffic accident fatalities in 2015 was 4,117. Of these, 1,534 were pedestrians (up 2.4% from 2014), a proportion of 37.3%. Since 2008, the number of pedestrian fatalities has exceeded the number of vehicle occupant fatalities, which reached 1,322 in 2015 (down 3.5%), a proportion of over 32.1%. The highest increase within this total was the number of cyclist fatalities, which rose by 5.9% to 572. This outlines the increasing 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 2015, the number of fatalities aged 65 or older accounted for 54.6% of the total. Pedestrians accounted for around half of these elderly fatalities (47.6%), much higher than the overall percentage for all age ranges (37.3%). In addition, the percentage of elderly people in the cyclist and pedestrian categories of fatalities was extremely high at 69.8% and 65.0%, respectively (Fig. 3)[(2)].

The accident fatality rate for elderly people aged 65 or over was 2.2%, much higher than that of people aged under 65 (0.33%). This shows that elderly people had a fatality risk 6.6 times that of younger people. One reason for this increased probability is the drop in impact tolerance in accordance with age. As Japan's society continues to age, it is likely that this trend will become even more significant. In addition to government-led measures to enhance traffic safety with courses for elderly drivers and providing better support for elderly drivers returning their licenses, initiatives on the vehicle side, particu-

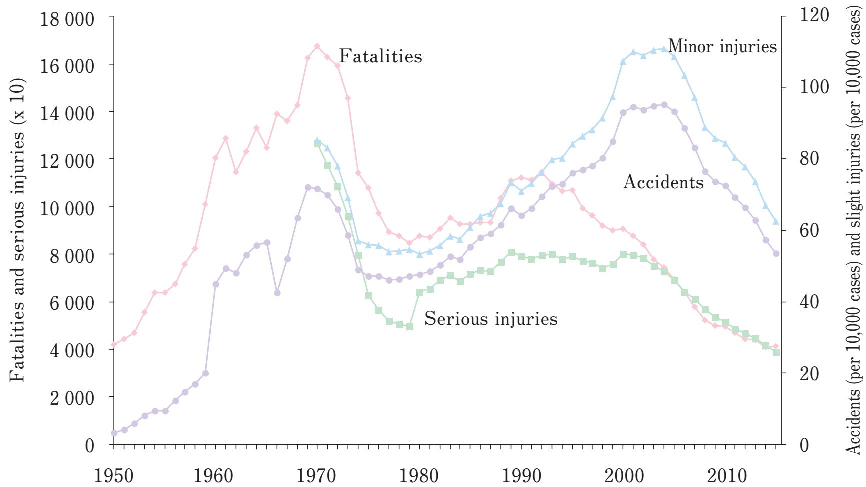

Fig. 1 Traffic accident trends (1950 to 2015)(1)

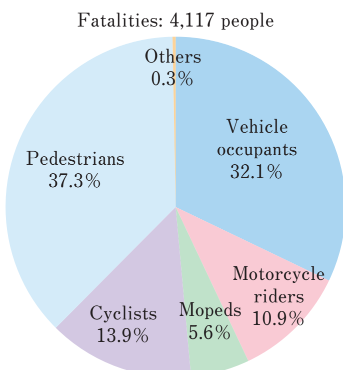

Fig. 2 Fatalities per road user status (2015)(1)

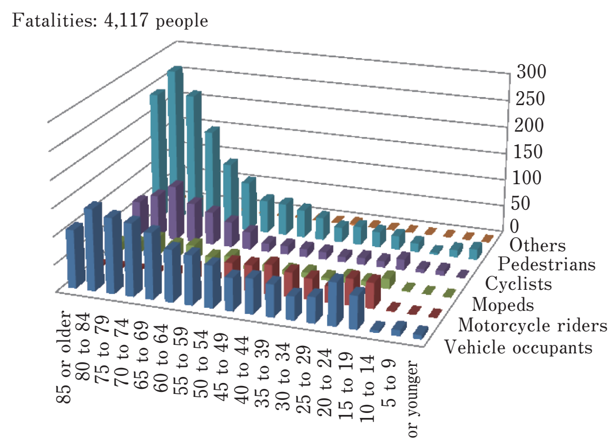

Fig. 3 Fatalities per age range and road user status (2015)(2)

larly related to active safety, are also becoming more and more important.

2. 2. Traffic accident measures

In 2016, the Japanese government introduced the Tenth Fundamental Traffic Safety Program[3], which included a target to reduce the number of traffic accident fatalities and injuries to 2,500 and 500,000, respectively by 2020. Similar to the ninth program, 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 investigative research. Based on these measures, the following items related to vehicle safety are being promoted as part of the 2015 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) Initiatives to help realize automated driving systems
(4) Provision of vehicle assessment information
(5) Enhancement of vehicle insurance and inspection
(6) 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 the MLIT to study vehicle safety standards is promoting standardization of various items. These standards are to help protect elderly female vehicle occupants in frontal collisions (UN Regulation No. 137), enhance the safety of child seats in side impact collisions (R129), protect vehicle occupants in pole side-impact collisions using the Worldwide harmonized Side Impact Dummy (World SID) (R135), and the harmonization of international standards related to the safety of fuel cell vehicles (FCVs). The committee also study future standardization, the prevention of accidents involving elderly pedestrians or cyclists and the mitigation of injuries caused by these accidents, measures for new forms of mobility, standards to help prevent serious accidents involving heavy vehicles, and further occupant protection measures. New measures for these items are being studied based on the idea of benefit evaluation.

Safety standards are also being studied to help prevent serious accidents caused by large buses. The technical issues and requirements (such as internal and external notification methods) of systems that activate when a driver abnormality occurs are being studied as part of the fifth phase of the Advanced Safety Vehicle (ASV) project. This year, guidelines are due to be formulated that will help bring these systems closer to practical application.

2. 2. 2. Promotion of development and popularization of ASV technology[4]

The fifth phase of the ASV project (2011 to 2015) examined the following three topics[5].

(1)Further sophistication of ASV technologies
(2)Development and promotion of communication-based driver assistance systems
(3)Proper understanding and popularization of ASV technologies

Study fields related to the sophisticated of ASV technology, systems that respond to driver abnormalities, driver overconfidence, and combinations of different driving support were examined.

Study fields related to the promotion of the development of communication-based driving support systems, included the further development of support systems using vehicle-to-vehicle communication as studied in the fourth phase, new support systems, and the examination of cooperative systems with feasible application on a global basis, scenarios for the widespread adoption of these system were examined. This topic also studied support systems using pedestrian-to-vehicle communication.

ASV project demonstrate various systems for the promotion of ASV technologies through the 2013 ITS World Congress in Tokyo[6]. A total of six types of support systems were demonstrated using vehicle-to-vehicle and pedestrian-to-vehicle communication.

2. 2. 3. Vehicle safety assessments in Japan

The Japan New Car Assessment Program (JNCAP) started vehicle safety assessments in 1995 and, 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 2016, the collision speed for the pedestrian protection head injury assessment was raised from 35 to 40 km/h. JNCAP also plans to change the dummy chest injury criterion in the full-lap and frontal offset impact tests from deceleration to deflection.

Active safety assessments were added in 2014, starting with automatic emergency braking (AEB) and lane departure warning systems (LDWS). In 2015, rear view information provision devices (back cameras) were added to the assessment. The performance of each system is awarded a score, and the total is graded in two levels: ASV and ASV+. In 2016, a new score will be awarded to vehicles installed with automatic braking systems for helping to avoid pedestrian collisions.

2. 2. 4. Trends of vehicle safety assessments in other coutries

Government organizations and insurance institutes in North America, Europe, China, South Korea, Australia, Latin America, and ASEAN also assess vehicle safety performance. In 2015, major changes were made to Euro NCAP. A new full-width frontal test was introduced with an H-III AF05 dummy placed on the rear seats, the barrier in the side impact collision test was replaced with the Advanced European Mobile Deformable Barrier (AE-MDB), the side pole impact was changed from a right-angle test at 29 km/h to an impact at an angle of 75 degrees and a speed of 32 km/h, and the ES2 dummy was replaced with the World SID AM50, which has enhanced biofidelity. The child dummies placed in the rear seat were also changed from infants (1.5 and 3 years old) to larger children (6 and 11 years old), requiring stronger performance with various types of occupants. In addition, C-NCAP in China scrapped the chest deceleration assessment for frontal impacts in 2015, added a viscous criterion (VC), and toughened the required score to achieve a five-star rating, with the aim of popularizing safer vehicles. NCAP in North America is also planning an upgrade from 2018.

Furthermore, in advance of plans to start up an NCAP program in India in 2017, the collision test results of some vehicles assessed under Global NCAP have been published starting in 2014. Active safety assessments have also started in other countries around the world, and the Insurance Institute for Highway Safety (IIHS) in the U.S. started a lighting assessment in 2016.

3 Research and Technology Related to Active Safety

Many technical reports were published in 2015 about automated driving. There are various definitions of automated driving technologies, and the level of realization of these technologies also differs depending on the timing of commercialization. The United Nations regulation R79 is an international regulation governing vehicle steering systems. This regulation permits automated steering without the driver touching the steering wheel only up to 10 km/h. As a consequence, commercialization of this technology has been limited to parking support systems. Therefore, UNR79 will have to be revised to allow automated driving by automated steering systems at or above 10 km/h. This revision is planned for around 2017, which means that automated driving systems launched on the market before that time cannot allow hands-off driving. Systems planned to be launched by around 2020 are aiming to permit hands-off driving, assuming the revision of R79 which limited this function to certain situations only.

In contrast, there has been a spate of announcements of specific models and launch dates for systems that do not permit hands-free driving.

In the U.S., Tesla has updated its automated driving software, including for vehicles already on the road. The latest Autopilot system permits automated driving mainly on highways and other roads on which only motorized vehicles are permitted. It also includes an automatic lane change function that changes lanes when the driver engages the turn signal, and an automatic parking system that allows the vehicle to parallel park itself and back into spaces at right angles[7]. Although a type of driving support, the lane change function performs automatic steering between lanes.

Other automakers have also announced the planned launch of automated driving systems, mainly for highways.

A number of other announcements have described systems that permit hands-off steering, assuming launch dates after the revision of R79. Toyota Motor Corporation, Nissan Motor Co., Ltd., and Honda Motor Co., Ltd. held demonstration events of these systems for the media on the Metropolitan Expressway and ordinary roads in Tokyo during the 2015 Tokyo Motor Show[8].

In addition to the research and development efforts of these automakers, public-private research into automated driving systems is also extremely active around the world. In Japan, one of the themes covered by the Strategic Innovation Promotion Program (SIP) administered by the Cabinet Office in Japan is the promotion of research into automated driving systems[9]. The aim of the SIP is to commercialize a semi-automated driving system (level 2) by the year 2017, a semi-automated driving system (level 3) by the first half of the 2020s, and a completely automated driving system (level 4) from the second half of the 2020s.

This program is particularly promoting research in areas of possible collaboration between manufacturers. Automakers and suppliers in Japan are hoping that this approach will enable greater focus on competitive areas.

The installation of active safety equipment is connected to the expansion of NCAP-related active safety assessments and the purchasing preferences of ordinary customers. As a result, automakers are developing high-performance collision damage mitigation brake systems and promoting the standardization of active safety equipment by reducing costs. To help provide further impetus to this trend, the National Highway Traffic Safety Administration (NHTSA) in the U.S. is leading a consortium of ten automakers who have voluntarily agreed to make collision damage mitigation brake functions standard equipment. Since these ten automakers account for around 57% of new vehicle sales in the U.S., this initiative represents the largest push to enhance safety since the installation of airbags as standard equipment in the 1980s.

4 Research and Technology Related to Post-Crash Safety

In addition to long-term initiatives related to passive safety, regulations and assessments have been steadily introduced in recent years related to active safety systems that aim to help prevent traffic accidents from occurring in the first place. However, since current active safety technology is not entirely effective in all circumstances, it is unfeasible to rely on these systems to reduce the number of traffic accidents to zero. For this reason, helping to enhance safety after an accident occurs remains a critical issue. Research institutions around the world are analyzing injury causes and countermeasure technologies from various standpoints based on accident conditions. Studies are also continuing into new test methods and measurement devices to evaluate the effectiveness of this research.

4. 1. Crash test dummies, human FE models, and injury criteria

Vehicle crashworthiness can be evaluated by accident analysis or simulation. Accident simulations are an indispensable part of safety technology development. Crash test dummies and human finite element (FE) models are used as tools to measure the effects of accidents on the human body.

In recent years, the next generation dummies have been developed with greater biofidelity and measurement capability including World SID (50M) for side impacts and the Q dummy series for child injury assessment. These are now used by Euro NCAP and in international standards. NHTSA developed the THOR-M[10] dummy for frontal impacts and discussions are under way about adopting this dummy in NCAP assessments in the U.S. and in Europe.

The next-generation of dummies is more accurately simulate the shape of human body than conventional dummies. These dummies also have a greater capability to reproduce and repeat physical responses deformation or load generated in an impact, and can more accurately measure injury parameters. In contrast, since these dummies have complicated structures of plastic and soft materials, there are many issues remaining to be resolved related to durability, reproducibility and repeatability. Therefore, before these dummies be introduced into NCAPs and regulation dummy users and manufacture need to solve these issues by communicating each others. The World SID Technical Expert Group (TEG) has been set up under the direction of the UN to revise regulation and discuss on the specification of dummy used in the standards at the same time. The World SID TEG is working to resolve these technical issues and harmonize specifications on an international basis.

In developed countries, the number of fatal and severe injuries [i.e.,head or chest injuries, or bone fractures rated as 3 or more on the Abbreviated Injury Scale (AIS)] are steadily decreasing in accordance with the increase in seat belt usage rates and wider use of airbags and other protection systems. The, the next issue for the future is prolonged and moderate-rated injuries (AIS 2 or more) with a high social cost, which are falling more slowly. NHTSA has proposed new injury criteria using the THOR-M dummy, such as brain rotational injury criterion called BrIC[11], multi point chest deflection, acetabulum load, and ankle load as a part of measurements to upgrade U.S. NCAP.

BrIC is a new injury criterion that is based on angular verocity velocity and is measured at the dummy's head CG (Center of Gravity). Compared to the current head injury criterion (HIC), which is based on translational acceleration, and representative as typical injury mechanisms such as skull fractures in an impact, BrIC is representative with injury mechanisms caused by strain on of the brain that may occur without a skull fracture, such as diffuse axonal injuries (DAI).

Dummies are built with an emphasis on durability and are not entirely suitable for analyzing injury mechanisms that exceed elastic limits (i.e., human bone fractures). However, human FE models, such as THUMS Ver. 4 are capable of analyzing injury risks by creating detailed models of soft tissue (such as internal organs, muscles, and blood vessels) and analyzing deflection[12]. Recently, a range of occupant models has been created, including the elderly women, children, and obese, to help identify the effects of physical responses with and without muscular tension in the legs and neck when a warning notification is made or not made before a collision. These FE models have been applied in accidents simulated under various conditions (for example : pedestrian vs. vehicle and bicycle vs. vehicle). As the processing capability of supercomputers increases, it should be possible to simulate even more diverse accidents in the future.

4. 2. Protection systems

Typical examples of occupant protection systems are seat belts and airbags. Various enhancements have been adopted in these technologies to further optimize the restraint forces applied to occupants in a collision. However, in recent years, the field of protection systems has been expanded from occupant protection to the protection of all injured parties such as pedestrians. These include pop-up hood systems, which raise the hood after a collision to create more space between the pedestrian and hard components in the engine compartment.

Pedestrian airbag helps to mitigate head injuries

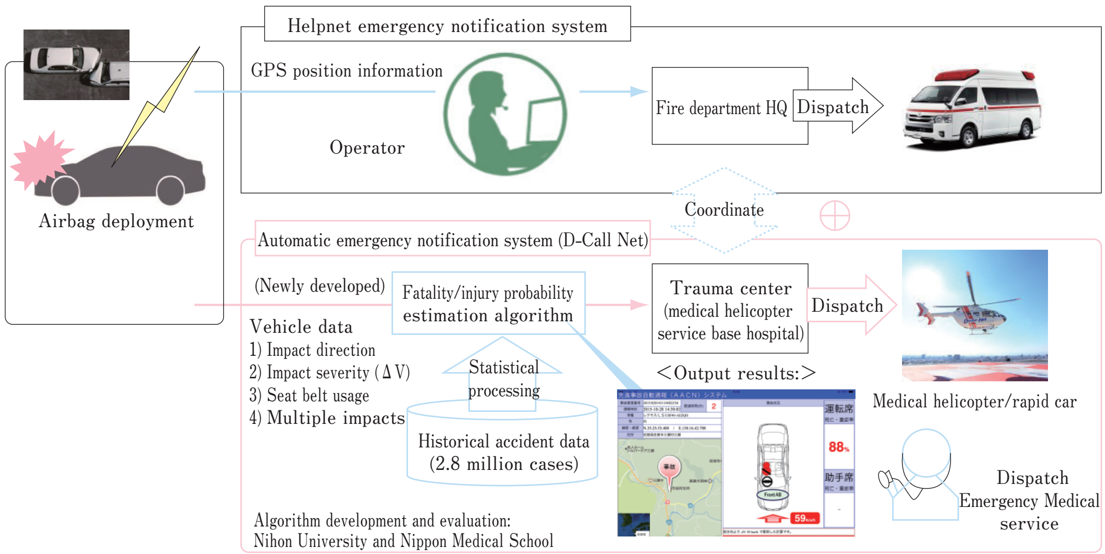

Fig. 4 Automatic emergency notification system (D-Call Net).

caused by impact to the front pillars, which are part of the vehicle framework that is difficult to make weaker.

In addition, other initiatives have been started to explore the possibility of enhancing the effectiveness of occupant protection and reducing secondary injuries through coordination of passive and active safety systems. For example, technology is being added that uses active safety sensors to tighten the seat belts or adjust the seat positions before a collision to create a more appropriate occupant posture, and to optimize the timing of seat belt pretensioners and airbags. Other examples include technology that activates the automatic braking system using airbag activation signals to help reducing the possibility of additional injuries from secondary impact. In the future, the development of technology to coordinate between passive and active safety systems is likely to further accelerate as active safety sensors become more accurate.

4. 3. Automatic accident 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 about the accident automatically immediately 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 legislation are underway to mandate installation in the future. Russia plans to make these systems compulsory in 2015 and Europe in 2018. UN working party (WP) 29 is leading discussions to create an Economic Commission for Europe (ECE) standard to achieve international harmonization of these systems. Japan has also started examining the possibility of adding these systems to JNCAP assessments in 2017.

Furthermore, in November 2015, Japan started trial operation of an emergency notification system called D-Call Net. This system transmits the change in speed of a vehicle involved in an accident, whether the occupants were wearing seatbelts, and predicts the injury probability of the occupants based on historical accident data. These results are then dispatched to the base hospital of the nearest medical helicopter service to speed up the decision to send doctors to the scene (Fig. 4)[13]. This is regarded as a promising system after trial results found that it would save the lives of 282 people each year if installed on every vehicle in Japan[14]. To enable full-scale adoption of this system in two years' time, the cooperation of the fire services and hospitals is also required, as well as preparations on the vehicle side.

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