Automobiles and Safety

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1 Introduction

According to traffic accident statistics compiled by the National Police Agency of Japan [(1)], the number of traffic accident fatalities (i.e., the number of fatalities that occurred within 24 hours of the accident) in 2012 was 4,411 people, a 5.4% reduction from the previous year (4,663 people in 2011). This figure is almost half that of ten years ago, representing a 47.5% drop from the 8,396 fatalities that occurred in 2002. The traffic accident fatality trend started to fall in 1993 and has continued for almost 20 years up to 2012, only briefly increasing twice, in 1995 and 2000.

The number of traffic accidents in 2012 was 665,138. Although this number has fallen for eight consecutive years, it still remains at a high level. Furthermore, a majority of traffic accident fatalities were people aged 65 or older (51.3%), a higher proportion than in Europe and the U.S. This underlines the importance of further measures to address this issue in Japan. In March 2011, the Japanese Government issued its 9th Fundamental Traffic Safety Program, which extends to 2015 [(2)]. In addition to road traffic, this program defines specific numerical targets for safety on railroads, level crossings, at sea, and in the air. For road traffic, the government is targeting the achievement of the world's safest road traffic environment, specifically (1) 3,000 or less traffic accident fatalities and (2) 700,000 or less traffic accident injuries and fatalities. To achieve a safer road traffic environment, there must be no let up in the evolution of vehicle safety, and technological development must adapt to the constantly changing face of society.

2 Traffic Accident Trends and Measures

2. 1. Traffic accident trends

In 2012, the number of traffic accident fatalities was 4,411 people, a 5.4% reduction from 2011. In addition, 46,665 people were seriously injured, a decrease of 4.1%. The number of traffic accidents decreased by 3.9% to 665,138 and the total number of injuries or fatalities fell by 3.4% to 825,396 (Fig. 1).

The following sections outline the salient characteristics of fatal accidents in 2012.

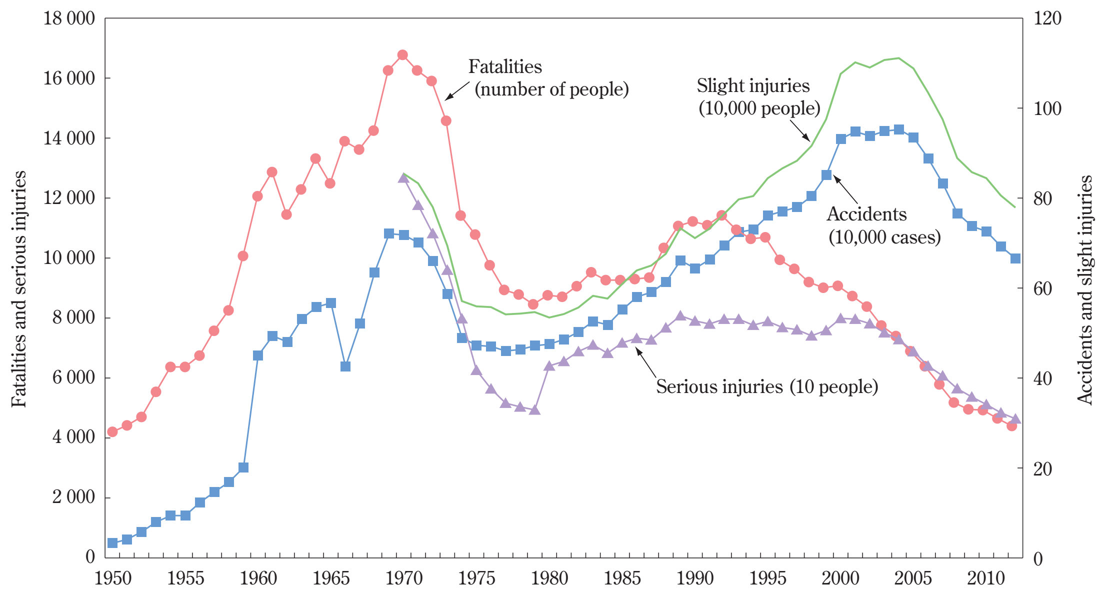
2. 1. 1. Number of fatalities per age group

In 2012, the number of fatalities aged 65 or older was 2,264 people, 51.3% of the total. Although the overall number of fatalities in all age groups continued to trend downward, this figure was slightly higher than in 2011. Furthermore, compared to the overall 47.5% reduction in fatalities in the ten years from 2002, the number of fatalities aged 65 or older fell by only 28.4%, a much slower rate of decline.

Based on the number of fatalities in each age group per 100,000 people, the figure for fatalities aged 65 or older was 7.61 people, more than twice the overall figure of 3.45. The fatality rate (i.e., the proportion of fatalities with respect to the total number of fatalities and injuries) was also extremely high, some 3.7 times the average for all age groups.

Elderly people accounted for 67.9% of pedestrian fatalities and 64.7% of cyclist fatalities. These two categories accounted for two-thirds of fatalities involving elderly people. This data underlines the fact that elderly people are vulnerable road users that make up a high proportion of traffic accident fatalities. However, even the number of fatalities per 100,000 driving license holders (for a motor-driven cycle or larger vehicle) determined to be the first party in an accident showed that elderly drivers (6.31 fatalities per 100,000) had the second highest number of fatalities after young drivers (8.52). This result indicates that measures must also be adopted to help prevent accidents caused by elderly drivers.

The category the traffic law violated in traffic accidents can be examined to shed some light on the causes of accidents involving elderly people. For people aged 65 or older, failure to ensure safety was the most common



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(1).

category (34.4%). This category was also the highest for all age groups (30.5%). For people aged 65 or older, accidents caused by failure to ensure safety or failure to stop at a stop sign were disproportionally higher than the overall proportions for all age groups. This result indicates the importance of measures or support for drivers failing to notice road signs, in addition to measures for slow judgment and misoperation, which become more prevalent with age.

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

Of the 4,411 traffic accident fatalities in 2012, pedestrians accounted for the largest proportion (1,634 people, 37.0% of the total). However, this number was 4.0% less than in 2011. The next highest total was vehicle occupants (1,417 people, 32.1% of the total, and 3.3% less than 2011), followed by motorcycle riders (788 people, 17.8% of the total, and 6.9% less than 2011), cyclists (563 people, 12.8% of the total, and 11.3% less than 2011), and others (9 people, 0.2% of the total, and 10% less than 2011).

It is particularly significant that vehicle occupant fatalities have declined by 59% in the ten years since 2002. In comparison, however, the reduction in pedestrian fatalities has only declined by 32%. Pedestrians have accounted for the highest number of accidents for five consecutive years and the proportion of pedestrians in the overall number of fatalities has risen for ten consecutive years.

Common fatality trends for age groups and road user status have been noted for several years. These trends highlight issues that remain to be solved even as the overall number of fatalities continues to improve. The 9th Fundamental Traffic Safety Program focuses on road traffic safety measures from three standpoints: ensuring the safety of elderly people and children, ensuring the safety of pedestrians and cyclists, and ensuring safety on residential and arterial roads. Measures to ensure the safety of elderly people and pedestrians are considered to be of particular importance.

2. 2. Traffic accident measures

The section on vehicle safety in the 9th Fundamental Traffic Safety Program issued in March 2011 describes measures to identify accident patterns and to protect pedestrians and elderly people utilizing information obtained from drive recorders and event data recorders (EDRs) as well as in cooperation with medical facilities. It also includes measures to help protect pedestrians and elderly road users, the encouragement of technological development to help prevent accidents in advance, measures related to the quietness of hybrid and electric vehicles, safety measures for lithium-ion batteries used in electric vehicles, safety measures for ultra-compact vehicles, and activities to develop and popularize Advanced

Safety Vehicle (ASV) technology.

Based on this Fundamental Traffic Safety Program, the Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT) formulated the 2012 MLIT Traffic Safety Work Plan [3]. This plan includes the following points relevant to vehicles: (1) promotion of improvements to standards and the like related to vehicle safety, (2) promotion of development and popularization of ASV technology, (3) provision of vehicle assessment information, (4) enhancement of vehicle insurance and inspection, and (5) enhancement and reinforcement of the recall system. The following sections discuss the areas of safety standards, ASV technology, and vehicle assessment.

2. 2. 1. Enhancement and reinforcement of safety standards

MLIT's traffic safety measures are based on a report drawn up in June 2011 by the Vehicle Traffic Subcommittee of the Land Traffic Committee under the Council for Transport Policy called Vehicle Safety Measures for Building a Society Free from Road Traffic Accidents [4]. This report describes the key actions for enhancing vehicle safety in the future, including measures in response to the declining birth rate and aging population, measures to help prevent accidents involving pedestrians and cyclists and to help alleviate injuries in these accidents, measures for new means of mobility, and measures to help reduce serious accidents involving heavy-duty vehicles.

Current standardization items include (1) measures related to the quietness of hybrid and other vehicles, (2) the safety of lithium-ion batteries, (3) preventative safety measures such as measures to help prevent rear-end collisions involving heavy-duty vehicles, and (4) international harmonization of safety standards for pedestrian protection and head restraints. Candidates for standardization in the future also include the formulation of technical guidelines and the like related to considerations for differences in vehicle occupant physiques, the safety performance of ultra-compact means of mobility, drive recorders, and EDRs.

2. 2. 2. Promotion of development and popularization of ASV technology

The development and popularization of ASV technology is being encouraged under the ASV Promotion Project under the auspices of MLIT. A series of five-year project phases started in 1991. The fifth project phase began in 2011 with the aim of achieving a safe and secure traffic environment based on harmony between people and vehicles. It consists of the following three study items: (1) studies related to the growing sophistication of ASV technology, (2) studies related to the promotion of technology for communication-based safety support systems, and (3) studies related to the awareness and popularization of ASV technology.

The studies related to the growing sophistication of ASV technology involve identifying and confirming technical issues of multiple driving support systems and the operation of these systems. These studies are also working to define concepts for over-confidence and dependence related to the expansion of safety support functions. One aim of these studies is to revise the concept of driving support drawn up in the third phase of the project. Another aim is to study driver behavior and to formulate basic performance guidelines for systems addressing abnormal driver states, which began in the fourth phase of the project.

The studies related to the promotion of technology for communication-based safety support systems involve work to revise the guidelines for communication-based safety support systems issued in phase four of the project. This includes the further development of studied applications, additional studies of safety applications, and additional considerations for practical system adoption. Feasibility studies for systems based on pedestrian-vehicle communication are examining the prediction of system effectiveness based on pedestrian accident analysis and the issues of separate pedestrian-vehicle communication specifications.

Activities related to the awareness and popularization of ASV technology are examining participation in showcase demonstrations at the 2013 ITS World Congress in Tokyo to help enhance social acceptance and to facilitate the practical application of communication-based safety support systems.

2. 2. 3. Vehicle safety assessments in Japan

The Japan New Car Assessment Program (JNCAP) for evaluating vehicle safety began in 1995. From 2000, JNCAP awarded a total score to new vehicles based on the results of three tests: full-lap frontal collision, offset frontal collision, and side collision tests. However, since then, additional tests have been added, including those for pedestrian head protection performance, neck injury protection performance in a rear-end collision [5], rear passenger's seat belt usability, passenger seat belt reminder performance, rear seat passenger protection performance in a frontal collision, and pedestrian leg protection performance. As a result, although JNCAP now evaluates safety under a wide range of collision conditions, the assessments became more difficult for users to understand. Therefore, since 2011 a new total score was introduced that added neck injury protection performance in a rear-end collision, pedestrian head and leg protection performance, and passenger seat belt reminder performance to the existing three test results. Since users no longer have to combine multiple test scores to make a judgment, this new total score is easier to understand. From 2012, the vehicle speed in the test to evaluate neck injury protection performance in a rear-end collision was increased, creating a more stringent evaluation of safety.

2. 2. 4. Trends of vehicle safety assessments outside Japan

As is the case with JNCAP, more vehicle safety assessments outside Japan are also using total scores calculated by combining the results from an increasing number of tests. Euro NCAP already uses a total score that combines the results of frontal, side, and pedestrian impact tests, with the performance of skid-prevention devices (i.e., ESC) seat belt reminders, and the like. In the U.S., the National Highway Traffic Safety Administration (NHTSA) carries out US-NCAP. In the past, US-NCAP assessed vehicles based on full-frontal crashworthiness, side-impact protection, and rollover resistance. However, in 2010, the assessment methods for the frontal and side-impact tests were changed and an overall score was introduced that combines the results of these three evaluations. Also in the U.S., the Insurance Institute for Highway Safety (IIHS) introduced the small overlap test that assesses a collision between the front corner of a vehicle and an object. The results of this small overlap test were integrated into the overall score from December 2012. At the same time, a new category called Top Safety Pick+ was added above the Top Safety Pick category to indicate the vehicles with the highest total assessment scores.

Another major trend in vehicle safety assessments is the expansion of regions adopting the NCAP method. Since the introduction of US-NCAP, similar assessments have been introduced in Japan, Europe, Australia, Korea, China, and Central and South America. ASEAN NCAP started in 2012 and announced the first test results in January 2013. India is also currently studying the introduction of NCAP, indicating that this trend is likely to continue in the future.

3 Research and Technology Related to Active Safety

The ultimate aim of the 9th Fundamental Traffic Safety Program is to build a society free from road traffic accidents, and it has defined specific numerical targets to achieve this aim. Among the issues to be resolved, the Program names the development and popularization of safety support systems for elderly drivers, the development and popularization of technology to help prevent accidents involving pedestrians and cyclists and to help alleviate injuries in these accidents, and measures to help reduce serious accidents involving heavy-duty vehicles.

Driver actions consist of repeated cognition/decision-making/operation processes. An accident may occur if an error occurs in even one of these processes. Systems to support driver actions show promise in helping to prevent accidents. However, it is important to consider driver over-confidence and dependence in these systems, measures to prevent interference with driving operations, and the acceptance of these systems by the driver and society. In contrast, it is also important to enable active system intervention to help compensate for the reduced driving capabilities of elderly drivers.

In the future, as active safety technology becomes more sophisticated, research will be required to identify the characteristics of elderly drivers and other driver actions, and to develop interface and vehicle coordination technologies that accurately transmit the state of system support and ideal driver actions.

3. 1. Sensor technology

Accurately identifying the state of the driver's vehicle is a key part of supporting safe driving. Typical sensors that recognize the vehicle environment include radar systems (radio wave or laser radars) and camera systems (monocular or stereo cameras). These sensors began to enter practical use in the second half of the 1990s. Conventionally, radar systems were mainly used to detect other vehicles ahead of the driver's vehicle and monocular cameras were used to detect lane markings.

Since stereo cameras are capable of simultaneously recognizing the distance to an object, as well as the size and shape of the object, these systems can also be applied to pedestrian and bicycle detection. The functionality of monocular cameras is also beginning to expand from lane marker detection to vehicle, road sign, and pedestrian recognition. Understanding the traffic environment is an important part of helping to reduce traffic accidents and the use and sophistication of camera systems is likely to increase even more in the future.

In addition, the detection of pedestrians and cyclists by radio wave radar requires the practical development of higher resolution onboard radars than existing units. Compared to narrowband 79 GHz millimeter wave radar and 24 GHz ultra-wide band (UWB) microwave radar, which has high resolution but a short detection range and limitations on use, wideband 79 GHz millimeter wave radar can detect and resolve objects in a wide range at both short and long distances. Since this type of radar can accurately detect and resolve objects in a range extending from a few tens of centimeters to several hundred meters, it is likely to be adopted as the radar for multi-range systems.

3. 2. Safety support systems

Safety support systems began to be adopted in vehicles from the second half of the 1990s as practical onboard radar and camera systems were developed. Various safety support systems were developed and adopted, including vehicle-to-vehicle distance warnings, lane departure warnings, adaptive cruise control (ACC), collision damage mitigation brakes (i.e., pre-collision brake systems), and the like.

Conventional collision damage mitigation brake systems functioned to help alleviate the damage caused by a collision by automatically braking the vehicle to help reduce speed. However, in recent years, systems have been developed that are capable of avoiding accidents at low speeds by combining more sophisticated forward recognition sensors and control devices. Various forward recognition sensors are have been adopted that utilize the characteristics of technologies such as laser sensors, millimeter wave radar, laser radar, and systems that combine millimeter wave radar with either a monocular or a stereo camera. In particular, systems that combine millimeter wave radar with either a monocular or a stereo camera have been developed to help avoid collisions with pedestrians as well as vehicles. The availability of such collision-avoidance systems must be increased to help further reduce accidents.

In Japan, almost 7,000 accidents a year are caused by mistaken pedal application in locations around car parks and shops, such as in multi-story parking structures, convenience stores, supermarkets, and the like. Most of these accidents are caused by sudden acceleration when the driver depresses the accelerator instead of the brake. A system to help prevent this type of accident pattern has been developed that detects objects using the sensors or ultrasonic sonar adopted by collision damage mitigation brake systems. When the driver depresses the accelerator pedal by more than the required amount, this system simultaneously warns the driver and reduces engine power to help prevent sudden acceleration.

In the future, safety support systems are likely to become more sophisticated and compatible with a wider range of accident patterns. However, an issue in this research is how to address concerns of interference between systems when multiple safety support systems are present.

4 Research and Technology Related to Post-Accident Safety

According to traffic accident statistics, traffic accident fatalities are also declining in developed regions such as the U.S. and Europe. This trend is the result of a complex combination of factors such as enhanced vehicle safety, traffic policies targeting infrastructure, drivers, cyclists, and pedestrians, as well as changes in social structures. Issues related to post-accident safety are also changing as a result of the introduction of new traffic policies and changes in social structures. Various research is already under way related to vehicle safety technology to further reduce the number of traffic accident victims and to adapt to these changes.

4. 1. Biomechanics and Crash Test Dummies

Crash test dummies that simulate vehicle occupants, and impactors that simulate the head and legs of pedestrians are important aspects of safety regulations and vehicle safety assessment collision tests. Various research is focusing on the development of more physically realistic dummies and impactors. Euro NCAP has used a child occupant dummy for some time. Studies examined replacing this dummy with the more biologically faithful new Q dummy [(6)], which finally occurred in 2013. Although side-impact tests around the world currently use various different dummies, the Worldwide harmonized Side Impact Dummy (WorldSID) is being developed as a global standard dummy [(7)]. The WorldSID physique has already been partially completed and studies are now examining test applications and the development of dummies with other physiques. Development of the Test Device for Human Occupant Restraint (THOR) is also making progress as a frontal collision dummy with enhanced biologically faithfulness [8]. In the case of leg impactors used for pedestrian protection evaluation, the new Flex PLI developed by the Japan Automobile Research Institute (JARI) and the Japan Automobile Manufacturers Association (JAMA) [9] was introduced into JNCAP in 2011. Discussions are being held about test applications with Euro NCAP and the World Forum for Harmonization of Vehicle Regulations (WP 29) under the auspices of the United Nations.

4. 2. Vehicle body development

In 2012, the IIHS in the U.S. started assessing safety using the small overlap test, which involves a collision between the front corner of a vehicle and an object. In this assessment, the deformation force applied to the vehicle cabin is greater than in conventional tests, thereby increasing the importance of vehicle body structures with higher cabin deformation resistance.

One of the results of designing safer vehicle bodies in reaction to this test is an increase in body weight. Therefore, technology that is capable of ensuring safety while also reducing vehicle weight is becoming even more important.

4. 3. Occupant protection systems

Seat belts and airbags are typical examples of occupant protection systems. Various technological innovations are being adopted to optimize occupant restraint forces in a collision, such as seat belt locking mechanisms on the buckle side, mechanisms that vary the propellant gas used for airbag deployment in accordance with the occupant, and so on. An example of a newly commercialized technology in 2012 is a pedestrian protection airbag that covers the front pillars and other structures at the front of the car when a pedestrian collision occurs to help soften the impact of the pedestrian.

4. 4. Rescue and relief systems

The 9th Fundamental Traffic Safety Program described above also describes the enhancement of rescue and emergency systems as a road traffic safety measure. Efforts on the technological front include automatic collision notification (ACN), which transmits the details of an accident automatically after it occurs. One commercial ACN service already available in Japan is called HELPNET. ACN devices can shorten the time required to communicate the accident details after an accident. In addition, it may also be possible to provide enhanced first aid services by sending information predicting the extent of injuries. In the U.S., a system has been developed that transmits information such as the location of the accident and the impact speed, and then uses this information to predict the extent of injuries. This advanced automatic collision notification (AACN) system is already starting to be adopted on vehicles. In Japan, research is examining a new system that uses transmitted information to predict injury and also judges whether an air ambulance helicopter should be dispatched to the scene.

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