AUTOMOBILES AND SAFETY

1 Introduction

The number of people injured in traffic accidents has been on the decline for fifteen consecutive years from 2005 to 2019. In 2019, 3,215 people died (within 24 hours), which is fewer than the lowest number of fatalities recorded in 2018 according to the statistics taken and held by the National Police Agency since 1948. Despite this trend, reducing fatalities from traffic accidents to 2,500 or fewer in 2020—the target set by the government in its Tenth Fundamental Traffic Safety Program—is unlikely. Achieving the target will require cooperation between the public and private sectors, as well as even faster adoption of integrated three-part measures that incorporate people, vehicles, and society.

2 Traffic Accident Trends and Measures

2. 1. Traffic Accident Trends

The number of traffic accidents and the number of people injured in traffic accidents peaked in 2004, and declined to 381,237 cases (11.5% from 2018) and 461,715 people (12.2% from 2018), respectively, in 2019, a level comparable to the early 1960s.

Traffic accidents killed a record 16,765 people in 1970. With the subsequent upgrading of road traffic infrastructure such as traffic lights and guardrails, fatalities were almost halved, dropping to 8,466 in 1979. Later, as vehicles became widely available, fatalities rose again, reaching 11,452 in 1992 due to factors such the worsening of driving conditions and higher driving speeds. Only drivers were obliged to wear a seat belt before 1985, but doing so also became mandatory for occupants in the passenger seat from that year. Such stricter traffic regulations led to a decrease in fatalities after 1993. Fatalities from traffic accidents continued to decline because of improved vehicle safety performance, following traffic rules and enforced regulations. Although the pace of reduction has been slowing since 2009, fatalities fell to a postwar low for three straight years from 2017 (Fig. 1)[1].

The characteristics of fatal traffic accidents in 2019 are presented below.

(1) Number of Fatalities per Road User Status

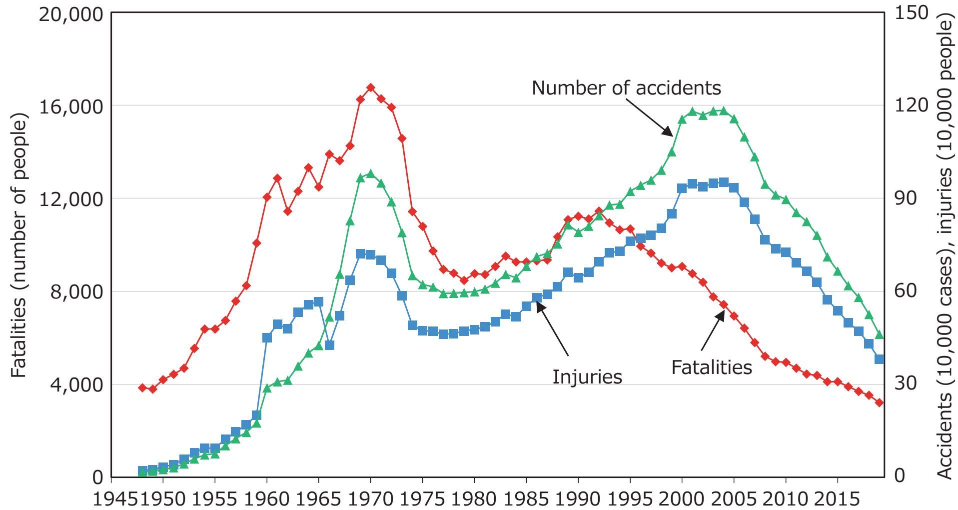
The total number of fatalities was 3,215, breaking down into: 1,176 pedestrians (82 fewer than in 2018), 433 cyclists (20 fewer than in 2018), and 1,083 vehicle occupants (114 fewer than in 2018). The number of fatalities declined remarkably compared to 2009, dropping by 554 people (32%) for pedestrians, who are vulnerable road users, and by 279 people (39%) for cyclists (Fig. 2)[2]. This is attributed to the integrated three-part safety measures that incorporate people, vehicles, and society. The measures included efforts to promote compliance with traffic rules such as amendments to the provisions for cyclists in the Road Traffic Act, activities to raise the safety awareness for pedestrians, police crackdowns on obstruction against pedestrians, the spread of active safety technologies such as collision mitigation braking systems, and improvements to roads and other infrastructure.

(2) Number of Fatalities per Age Range

The number of fatalities from traffic accidents by age bracket is given below. People aged 65 or more account for 55.4% (1,782 people) of the total fatalities. This figure is slightly lower than the largest proportion of 55.7% observed in 2018, but the ratio remains high. Compared to 2009, the number of fatalities in that age bracket decreased by 701 people (28%). Nevertheless it has continued to rise since that year, when it accounted for 49.9% of the total fatalities, and has been hovering at the high level of about 55% since 2015 (Fig. 3)[2].

2. 2. Traffic Accident Measures

The government released the Tenth Fundamental Traffic Safety Program[3] in March 2016. The program aims to achieve 2,500 or fewer fatalities within 24 hours of a traffic accident by 2020 to realize the world's safest road traffic and reduce the number of dead and injured to 0.5 million people or fewer. To achieve the targets,



Note 1: Until 1971, these statistics did not include Okinawa Prefecture.
Note 2: Until 1965, these statistics included the number of property damage accidents.
Note 3: Until 1959, these statistics did not include minor accidents (injuries lasting less than eight days, material loss of 20,000 yen or less).

Fig. 1 Traffic Accident Trends (1948 to 2019)

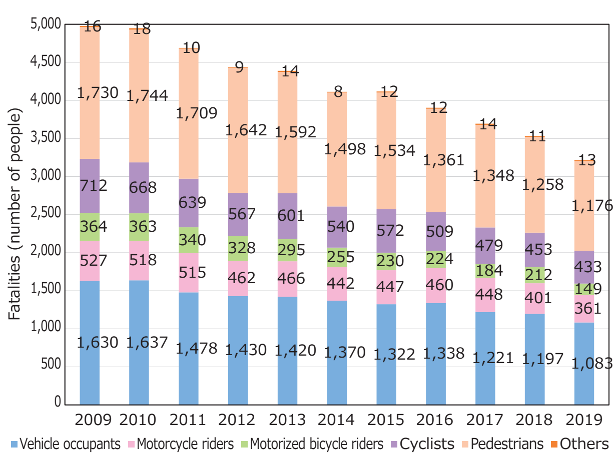


Fig. 2 Fatalities per Road User Status

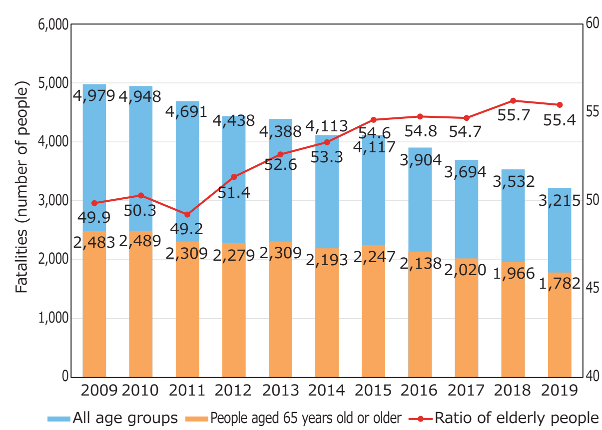


Fig. 3 Fatalities among the Elderly and All Age Groups

various traffic safety measures have been taken, such as maintenance of road traffic environment, making the idea of traffic safety become common, and enhancing rescue and emergency services. For vehicle safety measures, the Ministry of Land, Infrastructure Transport and Tourism (MLIT) released in June 2016 the Vehicle Safety Measures for Building Society Free from Road Traffic Accidents[4]. It had the following four pillars: (1) safety measures for children and elderly people, (2) safety measures for pedestrians and cyclists, (3) measures against grave accidents involving heavy-duty vehicles, and (4) adaptation to new technologies such as automated driving. Activities related to the four pillars are explained below.

(1) Safety Measures for Elderly Drivers

The number of traffic accidents caused by all motor vehicle drivers including drivers of motorized bicycles has dropped in half over the last ten years. However, the number of traffic accidents caused by elderly drivers has been almost constant. This is likely due to the fact that the number of elderly people who hold a driving license almost doubled in the last ten years. In 2017, the government defined vehicles equipped with collision mitigation braking systems, devices that suppress unintended acceleration in accidents involving pedal misapplication, advanced lighting, and similar systems as safe driving support vehicles, nicknamed "Safety Support Car S"[5], as part of traffic accident prevention measures for elderly drivers. From March 2020, the government also started to offer safety support car subsidies for elderly drivers aged 65 years old or older who purchase vehicles equipped with pedestrian-aware collision mitigation braking and sudden unintended acceleration suppression systems.

(2) Safety Measures for Pedestrians and Cyclists

Increasing mutual recognition between drivers, pedestrians and cyclists and adopting collision prevention technologies are effective ways of reducing accidents involving pedestrians and cyclists. Consequently, automakers are developing and deploying technologies such as advanced headlights that automatically use high-beams and quickly alert the driver to pedestrians and cyclists at night, as well as collision mitigation braking systems with a broader scope of detection and response scenarios.

(3) Safety Measures for Heavy-duty Vehicles

Accidents caused by buses, trucks or other heavy-duty vehicles are likely to lead to serious damage, and thus it is important to prevent such accidents. In addition to making the installation of a collision mitigation braking system and a dashboard camera to store data mandatory, the government formulated a guideline(7) for an emergency response system that pulls the vehicle over to the road shoulder if the driver's condition changes suddenly, and a driver emergency detection system that uses onboard cameras and sensors to automatically identify an anomalous driver condition as part of Phase 6 of the Advanced Safety Vehicle (ASV) Promotion Project (2016 to 2020)(6) that promotes the development of ASVs. In response, heavy-duty vehicle manufacturers have introduced and expanded the use of a driver emergency response system that initiates an emergency stop when the emergency button in the cabin is pressed or when an anomalous driver condition is detected using the onboard cameras.

(4) Adaptation to New Technologies such as Automated Driving

The MLIT issued the guideline for autonomous driving safety technologies(8) in September 2018. The guideline clearly identifies ten safety requirements and presents the basic ideas underlying the development and commercialization of safe self-driving cars until international standards are formulated. An amendment to the Road Trucking Vehicle Act was promulgated in May 2019, adding autonomously operated devices to the devices covered under the national safety regulations. The amendment also stipulates that autonomously operated devices have an operating state recorder, and that the Minister sets the conditions in which the autonomously operated devices may be used (driving environment conditions). The Road Traffic Act was also amended around the same time. The amendment focused on defining autonomously operated devices and including them in the Act, establishing the recording requirements for operating state recorders, and allowing the use of mobile phones or watching of images on display devices under certain conditions. With the updates to the legal framework, Japan is preparing for the commercialization of autonomous driving technologies.

2. 3. Vehicle Safety Assessment Trends

Vehicle safety assessments are designed to promote the development and dissemination of safety technologies by making vehicle safety evaluation results public. First introduced in Japan, the U.S., and Europe, assessments have also been implemented in Australia, China, Korea, the ASEAN nations, and Latin America, and there has been growing demand for them to cover active safety performance in addition to passive safety performance.

(1) Trends in Japan

The Japanese vehicle assessment, JNCAP, evaluates collision and active safety performance. Various items have been added to JNCAP in recent years, including a broader scope of detection targets in collision mitigation braking system assessments, acceleration control systems to prevent sudden unintended acceleration, and automatic incident reporting systems. Starting in fiscal 2020, the assessment will be updated to produce a comprehensive evaluation of collision and active safety performance. Furthermore, from 2021 forward, the assessment of acceleration control systems to prevent sudden unintended acceleration will be improved. In addition, collision mitigation braking system assessments involving bicycles and pedestrians at intersections will be introduced for active safety, and a test method simulating accidents between vehicles will be introduced for passive safety(9).

(2) Global Trends

Euro NCAP (ENCAP), the world's most advanced vehicle assessment that serves as a model for assessments in other other regions, is planning to expand its active safety evaluations. In 2020, it will introduce evaluations for driver monitoring, and collision mitigation braking systems with support for backing up and recognizing pe-

Table 1 List of Retrofitted Unintended Acceleration Prevention Control Systems Individually Certified in Advance (Announced on December 17 , 2019)

Category	System Name	System Manufacturer
Control system with obstacle detecting function to prevent unintended acceleration due to pedal misapplication	Pedal Misapplication Acceleration Control System	Toyota Motor Corporation
	"Tsukutsuku Boshi", safety device to prevent sudden unintended acceleration caused by pedal misapplication	Daihatsu Motor Co., Ltd.
Control system with obstacle detecting function to prevent unintended acceleration due to pedal misapplication	S-Drive Improper start Suppression System 2 (for standard-sized vehicles, for mini-vehicles)	Sun Automobile Co., Ltd.
	JARWA_S-DRIVE (SD0102 S, SD0104 S)	Japan Autobody Repair Work Association
	Pedaru no mihariban II (Pedal Lookout II)	Datasystem Co., Ltd.
	Akuseru mimamoritai (Accelerator Watch Team)	
Control system with obstacle detecting function to prevent unintended acceleration due to pedal misapplication	One pedal	Naruse Machinery Co., Ltd.

destrians at intersections. In 2022, evaluations will be further extended to collision mitigation braking system that recognize motorcycles and oncoming vehicles. For passive safety, tests to simulate accidents between vehicles and evaluate passive safety of an occupant in the seat opposite the impact will be introduced in 2020. The introduction of virtual assessments using simulations is also under consideration. Other regions are using ENCAP as a model to develop and introduce assessments tailored to local conditions.

3 Research and Technology Related to Active Safety and Autonomous Driving

The Tenth Fundamental Traffic Safety Program[3], which defines the framework for traffic safety measures in Japan, discusses "ensuring vehicle safety" and "making every effort to prevent traffic accidents, including accidents mainly caused by operation errors or other human factors, through measures based on vehicle structure". Accordingly, the evolution of active safety technologies and of attendant autonomous driving technologies is seen as crucial to improving vehicle safety. Throughout 2019, many trends were observed in the research and technology conducted in these fields.

3. 1. Active Safety Technology Trends

Automakers have been introducing collision mitigation braking systems and new technologies, as well as reducing their cost, to further popularize active safety technology. In addition to the technologies intended for new models, they have started to introduce acceleration control systems, which can be retrofitted to already sold vehicles, to prevent sudden unintended acceleration. In conjunction with promoting use of the above mentioned safe driving support vehicles, the MLIT established a system to certify that collision mitigation braking systems meet a given level of performance in 2018. This was followed by a certification system for the retrofitting of acceleration control systems to prevent sudden unintended acceleration in 2019. In December 2019, the MLIT announced the advance individual certification of seven devices in three categories (Table 1)[10].

Information on vehicles and devices certified as safe is posted on the MLIT website, and is also used in promotions by vehicle manufacturers, thus allowing users to learn about nationally certified safe vehicles.

3. 2. Autonomous Driving Technology Trends

The government formulated the Public-Private ITS Initiatives/Roadmap in 2014 as a government-wide strategy for ITS and autonomous driving. The roadmap sets the goal of building and maintaining a society with the world's safest and smoothest road transport by 2030, and is revised every year. In response to growing social expectations concerning autonomous driving and mobility services, the 2019 revision of roadmap was approached from the perspectives of technical development and the legal framework[11]. The revision focused on the three main items of (a) defining clear initiatives to commercialize autonomous driving on schedule in 2020, (b) studying and establishing a sustainable business model to implement autonomous driving in society and, (c) presenting a future vision for the integration of autonomous driving into the rapidly developing field of MaaS.

With respect to technical development, research and development in cooperative areas is underway through government-industry-academia collaboration as part of the autonomous driving systems theme of the Strategic Innovation Promotion Program (SIP) promoted by the

Cabinet Office. Large-scale field tests on the social implementation of sophisticated autonomous driving coordinated with the infrastructure started in autumn of 2019. The testing is being carried out on public roads in the mixed traffic environment of the Tokyo Rinkai area. In cooperation with the Japan Automobile Manufacturers Association (JAMA), 29 Japanese and foreign organizations are participating in the testing. Moreover, long-term field tests performed at roadside rest areas in various regions of Japan have served as the basis for the social implementation of mobility services provided by low-speed vehicles using autonomous driving technologies in some regions.

4 Research and Technology Related to Post-Accident Safety

The types of accidents that can be avoided with the advancement of active safety technology are rapidly expanding. However, real world accidents are varied and active safety technology cannot respond to all cases. Consequently, passive safety performance remains important. Authorities, research institutions, and automakers in various countries are analyzing accidents in detail to minimize damage in the event of an accident, assessing more effective technological countermeasures, and continuously studying test and measurement methods.

4.1. New Test Methods and Measurement Devices

New test methods and measurement devices are continuously being researched in various countries based on surveys of real world accidents to further decrease the number of fatalities and injuries. There are movements to adopt these test methods and measurement devices for the assessment evaluations described above.

The U.S. is evaluating the introduction of an oblique test that simulates oblique frontal collisions and is stricter than conventional offset collision tests. In Europe, an MPDB test was developed to improve reproducibility of accidents through vehicle-to-vehicle collision simulations, and will be introduced in 2020. The test evaluates not only the protective performance of a test vehicle but also that of a counterpart vehicle (compatibility). A far-side impact test will also be introduced in 2020 to evaluate the safety of an occupant in the seat opposite the impact side.

In the area of measurement devices, next-generation dummies are being developed and adopted. They allow the damage to an occupant in a collision to be measured with greater precision as they mimic human body responses more faithfully and rely on multi-point sensors. For frontal collisions, THOR dummies will be adopted for oblique tests in the U.S. and MPDB tests in Europe. For lateral collisions, WorldSID dummies will be adopted for conventional tests and the far side lateral collision test. Both THOR and WorldSID 5th percentile female dummies representing small female occupants are being developed. They will replace currently used dummies in the future. It is anticipated that more precise injury evaluations will be possible by measuring injury resulting from head rotation and performing multipoint displacement measurements for the chest with the THOR and WorldSID dummies. For pedestrian protective performance tests, JAMA and JARI are taking the initiative in developing an advanced pedestrian legform impactor (aPLI) with improved reproducibility of lower body behavior to solve problems found in the currently used FLEX-PLI legform impactors. In response to the global standardization of the aPLI by the ISO, Europe and China are giving its use in safety assessments serious consideration.

4.2. Protection Systems

Protection systems are also subject to research and development aimed at expanding the scope of protection and improving its performance to cover various accident conditions, boarding positions, and physiques found in the real world.

Research on air bags is focusing on front air bags with an improved shape and larger size to improve restraint performance in the event of an oblique collision, on side air bags adapted to far side collisions to prevent a collision with the occupant in the seat on the other side in the event of such an accident, and on front air bags for rear seats that protect occupants there. A pedestrian protection air bag which covers rigid parts of the vehicle such as the lower part of the windshield and the pillar to mitigate impact to the head and reduce damage in the event of a pedestrian accident has been commercialized.

Technology that uses active safety technology sensors to optimize the occupant's posture by winding the seat belt and correcting the seat position before a collision, as well as technology that optimizes timing for the triggering of air bags and seat belt pretensioners to improve occupant protection, have been available for some time. The interlinking of advanced technologies such as those for active safety and connected cars is anticipated to proceed at an even faster pace in coming years.

4. 3. Automatic Accident Notification Systems

Reducing the time needed to provide advanced medical care to people seriously injured in an accident significantly improve survival rates. Consequently, systems that automatically transmit the location of a traffic accidents in the event of a collision (automatic collision notification: ACN) have been introduced and put in operation all over the world. ACN installation has already become mandatory in Europe. Malaysia and UAE are considering following suit. With the establishment of an international standard for ACN by the World Forum for Harmonization of Vehicle Regulations (WP.29) of the United Nations Economic Commission for Europe, new models equipped with ACN in Japan after 2020 will be required to meet that standard[12].

Furthermore, advanced ACN (AACN) systems are becoming widespread in the U.S. and Japan. These systems transmit vehicle information (e.g., collision direction, deceleration speed, whether the occupants were wearing seat belts, and whether there were multiple impacts) when an accident occurs. A doctor is dispatched to the scene if the assessment of that information indicates severe injuries to occupants. In cooperation with base hospitals with emergency medical helicopters, Japan launched an AACN known as D-Call Net in June 2018. As of December 2019, about 730 fire stations and 60 hospitals in 43 prefectures are ready to respond to notifications from the system[13].