1

TRAFFIC SAFETY

1.1 TRAFFIC SAFETY FACTS

Six million crashes involving over 10 million motor vehicles occur on average every year in the United States. In 2009, an estimated 5,505,000 motor vehicle crashes occurred, leading to 33,808 fatalities and 2,217,000 injured people, averaging 93 deaths every day or one every 16 minutes [NHTS11]. Vehicular accidents are the leading cause of death for people between the ages of 3 and 34 in the United States [NHTS09]. These figures account only for police-reported crashes and therefore the actual number of motor vehicle crashes is likely even higher.

A significant percentage of accidents occur at road intersections. In 2007, there were an estimated 2,392,061 intersection crashes, accounting for 39.7% of all crashes in the United States [FHWA09]. Of these accidents, 8061 were fatal and 1,711,000 caused injuries. It has been estimated that, on average, 250,000 accidents every year involve vehicles running a red light and colliding with another vehicle crossing the intersection from a lateral direction [NHTS07].

A recent study estimates the costs of crashes for metropolitan areas of different sizes and populations in the United States [Kitt10]. According to this study, the average annual costs of crashes per person in small, large, and very large metropolitan areas are $1946, $1579, and $1392, respectively. In addition to lost lives, motor vehicle crashes place a heavy economic burden on the

Vehicle Safety Communications: Protocols, Security, and Privacy, First Edition. Luca Delgrossi and Tao Zhang.

society, including increased costs of medical care, disability, insurance, and property damage. In 2000, the annual economic cost to society due to motor vehicle crashes was estimated at around $230 billion in the United States, roughly equivalent to 2.3% of the country's gross domestic product (GDP) in the same year [NHTS02].

Motor vehicle crashes significantly affect traffic mobility as well. The U.S. Federal Highway Administration (FHWA) estimated that approximately 25% of traffic slowdowns are related to crashes and other traffic incidents. The estimated average annual costs of traffic congestion per person in small, large, and very large metropolitan areas in the United States are $214, $407, and $575, respectively [Kitt10].

1.1.1 Fatalities

Based on historical data published by the U.S. National Highway Traffic Safety Administration (NHTSA) and FHWA, motor vehicle accidents have been responsible for over 3,300,000 fatalities in the United States alone since 1899 [NHTS10]. As the automobile came into greater use, the fatalities increased sharply each year from 1899 to 1931. After remaining stable for a few decades, the annual death rate rose again until peaking at 53,543 in 1969 (Figure 1.1). Since then, the annual number of fatalities has held fairly steady, or even decreased somewhat, due to significant advances in automotive safety measures. With an increasingly mobile society, reducing traffic fatality has become a more difficult task to achieve.

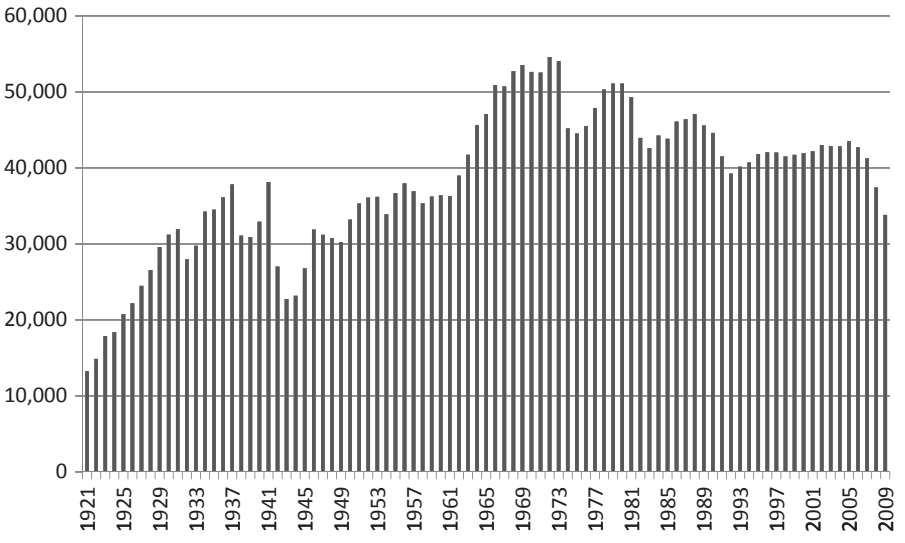

Figure 1.1. Total annual fatalities in the United States

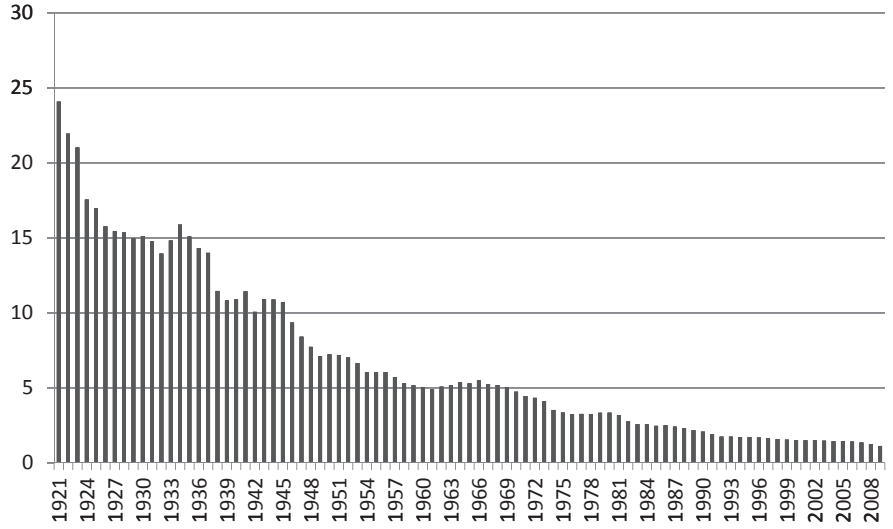

Figure 1.2. Annual fatality rate per 100 million VMT in the United States

The number of fatalities alone does not paint a complete picture of automotive safety. Since 1899, market penetration of automobiles has continued to increase significantly and the annual number of vehicle miles traveled (VMT) has exploded from 100 million in 1900 to over 3 trillion by 2007, according to FHWA statistics [FHWA07]. The number of fatalities per VMT has actually decreased. In 1921, the United States saw 24 fatalities per 100 million VMT, which were more than 21 times the record low 1.13 deaths per 100 million VMT in 2009.

Broader adoption of effective automotive safety systems, along with improved safety legislation and increased driver education efforts, has powered the reduction of fatalities and injuries despite the growing number of vehicles on the road and the distances traveled. As people continue to travel more, innovations become increasingly crucial to minimize traffic fatality (Figure 1.2).

1.1.2 Leading Causes of Crashes

According to NHTSA, the three most common causes of vehicle crashes are: control loss without prior vehicle action, lead vehicle stopped, and road edge departure without prior vehicle maneuver. In 2004, crashes under these circumstances accounted for an estimated 1 million lost functional years and $40 billion in direct economic costs in the United States [NHTS07].

Understanding the events that lead up to a motor vehicle crash is crucial to prevent future crashes. In 2008, the U.S. Congress authorized NHTSA to

conduct a National Motor Vehicle Crash Causation Survey [NHTS08]. A representative sample of crashes from 2005 to 2007 was investigated. During the data collection process, the research team was granted timely permissions by local law enforcement and emergency responders to be on the crash scenes. Arriving on the scene before the crash was cleared by law enforcement gave the researchers access to relatively undisturbed information pertaining to the crashes and factors which led to these crashes. It allowed the researchers to discuss the circumstances of the crash with the drivers, passengers, and witnesses while the event was still fresh in their minds. The researchers were able to immediately and accurately reconcile the physical evidence with witness descriptions. Using this and other data, the researchers were able to assess the critical events that preceded the crash, the reasons for this event, and other factors that may have played contributing roles.

Ninety-five percent (95%) of the time, driver error was the critical reason for an accident. Driver errors can be classified into several categories: recognition, decision, performance, nonperformance, and other or unknown driver errors:

- Recognition errors accounted for 40.6% of all accidents due to driver error. Inadequate surveillance and driver distraction played a significant role in reorganization errors, accounting for 20.3% and 10.7% of driver error accidents, respectively.
- Decision errors accounted for 34% of all driver error accidents. The causes for decision errors were more numerous and varied than for recognition errors. Fast speeds were the most significant, being identified as a critical reason for 13.3% of crashes due to driver error.
- Performance errors constituted for 10.3% of all driver error crashes. The primary causes of performance errors are overcompensation and poor directional control. Noticeably, fatigued drivers were twice as likely as nonfatigued drivers to make performance errors.
- Miscellaneous nonperformance errors accounted for 7.1% of all driver error crashes. These included sleeping or having medical emergencies such as heart attacks while driving.
- Unknown driver errors accounted for the remaining 7.9% of all driver error crashes.

To prevent vehicle crashes, it is also important to understand prominent precrash events. The study has found that 36.2% of all accidents occurred while a vehicle was turning at or crossing an intersection. Traveling off the edge of the road is the second most frequent precrash event, accounting for 22.2% of all crashes. Traveling over the lane line constituted the critical precrash event for 10.8% of all collisions. A stopped vehicle served as the critical precrash event in 12.2% of all cases. Prevention and mitigation of these common causes of accidents therefore take top priority in safety research.

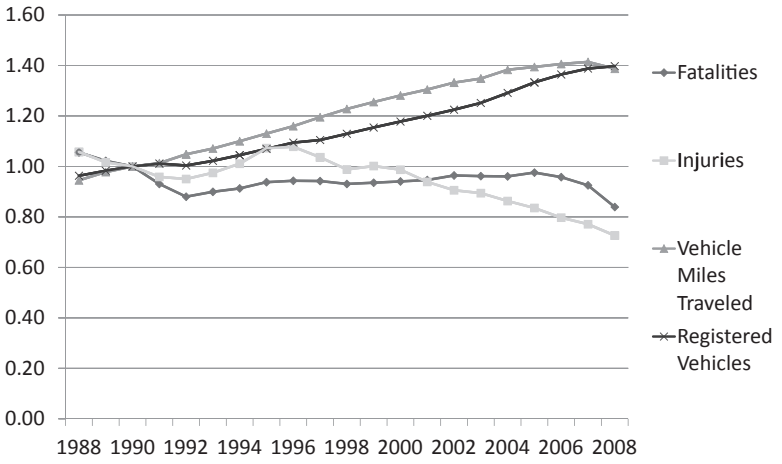

Figure 1.3. Traffic safety statistics in the United States (1988–2008)

1.1.3 Current Trends

Figure 1.3 shows traffic safety statistics in the United States between 1988 and 2008, including the number of registered vehicles, VMT, injuries, and fatalities. In this chart, each value is expressed as relative to the correspondent value for year 1990. Fatalities and injuries, although declined in recent years, have remained at high levels and the declines have been slow. This raises a concern that we are reaching the point where existing vehicle safety systems are not going to sustain the same rates of reduction in fatalities and injuries as they have in the past. The continuous rise in the number of vehicles on the road and in VMT calls for continuing innovations in vehicle traffic safety technologies.

1.2 EUROPEAN UNION

Countries in the European Union have been following a similar trend of increasing automotive safety as shown in Figure 1.4.

Germany has seen a significant long-term decline in fatalities, with a 79% reduction from 21,332 fatalities in 1970 to only 4477 fatalities in 2008. In addition, the annual number of crashes that caused injuries decreased from 414,362 to 320,614 in the same time period, an improvement of 23%. Remarkably, these declines in fatalities and injuries have been accomplished while the number of vehicles on the road nearly tripled [IRTA10]. These improvements were made possible by a combination of advances in safety technology, a highly developed road infrastructure, an advanced legal framework, and a highly sophisticated penalty point system. Stringent laws concerning

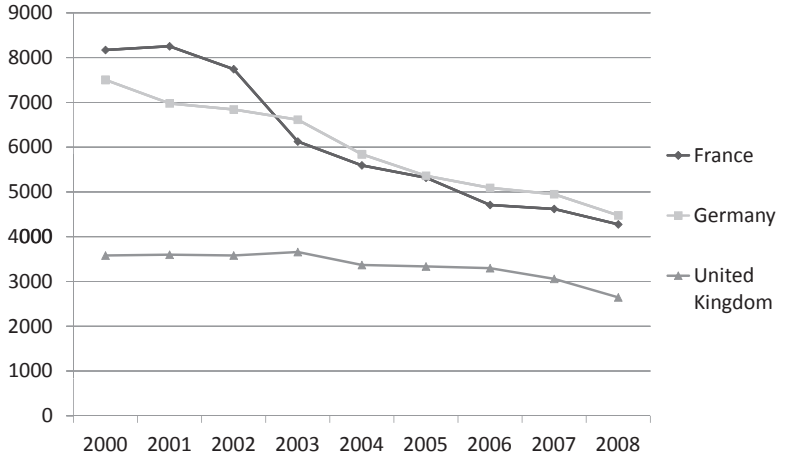

Figure 1.4. Annual fatalities in Germany, United Kingdom, and France (2000–2008)

intoxicated driving, speeding, and seat belt usage have all contributed to the long-term reductions in accidents and fatalities as well.

Traffic fatalities have also declined significantly in the United Kingdom. Between 1970 and 2008, the annual number of fatalities declined by 66% and the annual number of injury crashes declined by 35%, while the average distance traveled increased by 10% [IRTA10]. These percentages represent a decline from 7771 fatalities in 1970 to 2645 fatalities in 2008 and from 272,765 injury crashes in 1970 to 176,723 in 2008. The United Kingdom's traffic fatality rate is currently the lowest in the European Union, with 4.3 fatalities per 100,000 people [IRTA10]. As with Germany, the United Kingdom's improved traffic safety has largely been achieved through advances in safety technology, investments in road infrastructures, and enforcement efforts designed to curb excessive speeding and intoxicated driving. The United Kingdom has likewise placed a significant emphasis on educational programs to raise awareness of high-risk driving behaviors and the sanctions imposed for such behaviors.

France has also seen a significant long-term decline in the overall traffic fatality rate. Between 1970 and 2008, the number of fatalities decreased by 74% (from 16,445 in 1970 to 4275 in 2008) and the number of injury crashes by 68% (from 235,109 in 1970 to 74,487 in 2008) while the number of vehicles on the road tripled. The numbers are even more impressive when you consider the decline in fatalities per billion vehicle-kilometers, which fell from 90.36 in 1970 to a mere 8.1 in 2008, for a total improvement of 91% over that time period [IRTA10]. Further improvements continue to be made. Since 2002, France has implemented a focused road safety policy which includes effective measures regarding speed management, intoxicated driving, seat belt use, and strengthening of the demerit point system, all of which continue to impact traffic safety positively.

As in the United States, the reductions in traffic fatalities and injuries in the European Union countries have slowed down over the recent years (Figure 1.4), which suggests similar diminishing returns achievable through traditional vehicle safety technologies and calls for new thinking and innovation in vehicle safety technologies.

1.3 JAPAN

During the 1960s, the rapid increase in automobile traffic outpaced road constructions in Japan. The resulting increase in motor vehicle accidents became a public concern, prompting the government to take measures to reduce vehicular crashes. In 1970, following enactment of the Traffic Safety Policies Law, the Central Committee on Traffic Safety Measures was established and the first Fundamental Safety Program was formulated. Since 1971, the Central Committee on Traffic Safety Measures has continued to produce 5-year Fundamental Traffic Safety Programs which set forth the fundamental principles and goals for comprehensive and long-term measures for the safety of land, maritime, and air transport based on the Traffic Safety Policies Law.

A cornerstone of Japan's efforts to improve traffic safety has been a significant investment in road infrastructure enhancement. Safer roads have been achieved through improvements in expressways, bypasses, beltways, intersections, road lighting, road signs, and traffic signals. Safety measures were also enacted for pedestrians, including installation of sidewalks, development of shared pedestrian and bicycle paths, and addition of pedestrian overpasses and underpasses. As a result, pedestrian fatalities have decreased sharply, from 2794 in 1996 to 1943 in 2007, an improvement of approximately 31% [IATS08].

Japan's traffic fatalities have reduced significantly since the adoption of the first Fundamental Traffic Safety Program. Between 1970 and 2008, the annual number of fatalities decreased by 72% even though the number of injury crashes increased by 7% [IRTA10]. The annual number of fatalities in proportion to distance traveled decreased over that same time span by a remarkable 91% [IATS08]. The declining fatality rate has been sustained in recent years, despite a threefold increase in the numbers of vehicles and VMT. The fatality rate continues to decline as advancements continue to be made in automotive safety, decreasing by approximately 42% between 2000 and 2008 [IRTA10]. This is particularly remarkable and difficult to sustain due to the very high population density in Japan.

1.4 DEVELOPING COUNTRIES

While developed countries have been benefiting from declining traffic fatality rates, this has not been the case in many developing countries such as China

and India. Developing countries currently account for 90% of the disability-adjusted life years lost to traffic injuries and deaths worldwide. This problem continues to escalate especially in Asia. It is projected that by 2020, vehicular deaths will increase by 80% in developing countries [KoCr03]. This includes fatality rate increases of almost 92% in China and 147% in India. Injuries due to vehicular crashes are the root cause of a significant portion of medical care sought in developing countries, accounting for up to one-third of the acute patient cases in many hospitals and between 30% and 86% of trauma admissions [OdGZ97]. Besides the toll on human lives, the economic cost of vehicular crashes in developing countries has been estimated at around US$65 billion, a heavy burden on the economy and a financial drain on national health-care systems [PSSM04].

A significant reason that developing countries have not experienced the same reduction in fatality rates as developed nations is that their road infrastructures are unable to keep pace with the sharp increases in the number of vehicles on the roads. This results in unsafe driving conditions and massive traffic congestions. Poor traffic conditions contribute to the prevalent fatalities of vulnerable road users such as pedestrians, bicyclists, and people using carts, rickshaws, mopeds, and scooters. This is in contrast to developed countries, where drivers and passengers are the primary victims [PSSM04]. Vehicles in developing countries are also significantly more likely to be involved in fatal crashes, 200-fold more likely in some cases, than in more developed countries [AATJ10].

Therefore, developing innovative automotive safety technologies is of utmost importance for the world as a whole, not merely for developed countries.

To reduce fatalities and injuries despite the rising number of vehicles and VMT, we must continue to discover new ways to prevent motor vehicle crashes and mitigate their damages.

REFERENCES

[AATJ10] G. Jacobs, A. Aeron-Thomas, and A. Astrop: “Estimating Global Road Fatalities,” Department for International Development (DFID), ISSN 0968-4107, Transport Research Laboratory, Report 445, 2000.

[FHWA07] Federal Highway Administration: “Highway Statistics 2007: Public Road Mileage, Lane Miles, and VMT 1900-2007,” Table VMT-421, 2011.

[FHWA09] Federal Highway Administration: “The National Intersection Problem,” FHWA-SA-10-005, 2009.

[IATS08] International Association of Traffic and Safety Sciences: “Statistics 2007: Road Accidents Japan,” Traffic Bureau, National Police Agency, 2008.

[IRTA10] International Traffic Safety Data and Analysis Group (IRTAD): “Annual Report 2009,” Organization for Economic Cooperation and Development (OECD) International Transport Forum (ITF), 2010.

[Kitt10] M. J. Kittelson: "The Economic Impact of Traffic Crashes," Georgia Institute of Technology, 2010.

[KoCr03] E. Kopits and M. Cropper: "Traffic Fatalities and Economic Growth," World Bank Development Research Group, Infrastructure and Environment, Policy Research Working Paper 3035, 2003.

[NHTS02] National Highway Traffic Safety Administration: "The Economic Impact of Motor Vehicle Crashes, 2000," DOT HS 809 446, 2002.

[NHTS07] National Highway Traffic Safety Administration: "Pre-Crash Scenario Typology for Crash Avoidance Research," DOT HS 810 767, 2007.

[NHTS08] National Highway Traffic Safety Administration: "Motor Vehicle Traffic Crashes as a Leading Cause of Death in the United States," DOT HS 810 936, 2008.

[NHTS09] National Highway Traffic Safety Administration: "Traffic Safety Facts 2008," DOT HS 811 170, 2009.

[NHTS10] National Highway Traffic Safety Administration: "An Analysis of the Significant Decline in Motor Vehicle Crashes in 2008," DOT HS 811 346, 2010.

[NHTS11] National Highway Traffic Safety Administration: "Traffic Safety Facts 2009," DOT HS 811 402, 2011.

[OdGZ97] W. Odero, P. Garner, and A. Zwi: "Road Traffic Injuries in Developing Countries: A Comprehensive Review of Epidemiological Studies," Tropical Medicine and International Health, vol. 2, pp. 445–460, 1997.

[PSSM04] M. Peden, R. Scurfield, D. Sleet, D. Mohan, A. Hyder, E. Jarawan, and C. Mathers: World Report on Road Traffic Injury Prevention, World Health Organization, United Nations, Geneva, Switzerland, 2004.