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NASS: The Glass is Half Full

Abstract

The National Accident Sampling System (NASS) was born in the late 1970s. It was based on a substantial amount of experience and analysis of what was needed in the United States to understand the safety challenges of our highways. This work also showed how to collect high quality and useful crash data efficiently. Unfortunately, when Ronald Reagan – a President who believed in limited government – was elected, any hope of full funding for NASS was lost. The concept of 75 teams investigating about 18,000 serious crashes in detail annually was never realized. The system got up to 50 teams, then was cut to 36, and finally to 24 teams investigating fewer than a quarter of the originally anticipated number of crashes per year.

Despite this, the NASS investigations provide a rich source of data, collected according to a sophisticated statistical sampling system to facilitate detailed national estimates of road casualties on our nation's highways and their causes. In addition, changes have been made in recent years to increase the number of more serious crashes of recent model vehicles to make the results more relevant to improving vehicle safety.

A recent, detailed examination of hundreds of rollovers has provided considerable insight into rollover casualties and into what can be done to reduce them. Some of these results will be presented that show the value of the NASS system.

Our experience with NASS and the Fatal Accident Reporting System (FARS) suggests a number of improvements that could be made in the United States' crash data systems. It also provides justification for a doubling or tripling of our national expenditures on crash data collection.

Introduction

I first met Dietmar Otte in the 1970s when we were young and optimistically trying to save people from the ravages of automobile crashes. We were far less successful than I would have imagined a third of a century ago. At that time, in the U.S. we were trying to get air bags into cars, and that took far longer than we had imagined. Volkswagen had developed the automatic safety belt, and Mercedes-Benz advocated only a small head protection air bag (arguing that in Germany everyone already wore safety belts). As often happens, the result was a compromise. In both countries we were trying to find the best way to get sufficient crash data to show the best way to reduce crash casualties.

An adequate body of the right kind of crash data is the fundamental fodder for our research [Figure 1]. It is critical to diagnosing safety hazards and to making intelligent improvements in vehicle safety. Without it, we are driving in the dark with no lights.

Conducting crash investigations and reconstructing crashes can very satisfying work. Each crash is different and many present challenging puzzles: what precipitated the crash? How was an occupant injured? Who or what performed well or poorly? What could have prevented the crash or ameliorated the injuries? But we must not forget that our ultimate aim in this grizzly business is to learn how we can put ourselves out of business by making our automobile transportation even safer than rail or air transport.

Of course, the problem is difficult because automotive transportation is the original amateur hour: at least in the U.S., there are no professional requirements to be an automotive engineer. Anyone can be an auto mechanic. And then there are the drivers.

Vehicle Crashes:
a Public Health Challenge

- Crash data is critical to diagnosing why vehicles crash and how people are being hurt.
- Sampling is necessary to assess the epidemiology of crash injury.
- The cost of collecting high quality crash data is trivial compared with the benefit that can come from the insights it can provide.

Figure 1

Some History of U.S. Crash Data Systems

In the United States, one of the earliest programs to conduct serious investigations of crashes was initiated in the 1950s by the brilliant safety pioneer, Hugh Dehaven, at Cornell Aeronautical Laboratories' Automotive Crash Injury Research program [Figure 2]. The data collected in his program led to a better understanding of how people were hurt in crashes. The Public Health Service's Multidisciplinary Accident Investigation program was modeled on the Cornell program.

NHTSA made various attempts to understand specific aspects of, or types of crashes including programs on pedestrian accidents, restraint performance, crash avoidance, and fatal crashes. In the late 1970s, the agency settled on two basic systems: the Fatal Accident Reporting System (FARS) – basic data on a census of fatal crashes – and the National Accident Sampling System (NASS) which provides detailed data on a statistical sample of all crashes occurring across the country [Figure 3]. FARS conducts no independent investigations, relying essentially on police reported data.

Early Crash Investigation Programs

- Automotive Crash Injury Research of Cornell Aeronautical Laboratories (Hugh DeHaven)
- Multidisciplinary Accident Investigation Program (MDAI – Public Health Service)
- Tri-Level Studies: National Crash Causation Study and National Crash Severity Study
- Restraint System Evaluation Project, Pedestrian Injury Causation Studies, etc.

Figure 2

Current NHTSA Programs

- Fatal Accident Reporting System (FARS)
- National Accident Sampling System (NASS)
  - Crashworthiness Data System (CDS) – detailed investigations of a sample of crashes
  - General Estimates System (GES) – police data only on a larger sample of crashes
- Special Investigations
- State Data Systems and Programs
- Crash Injury Research and Engineering Network

Figure 3

National Accident Sampling System

NASS was a design using a sophisticated statistical sampling model that ensured that the data could be used to make national estimates of what was happening on our nation's roads [Figure 4]. It provided for a crash investigation team of two to four investigators in each Primary Sampling Unit (PSU). There was to be a PSU representing each of the 75 geographic and demographic levels defined by the Census Bureau. NASS teams sample crash reports at a set of police agencies, and an algorithm is used to decide which to investigate. Each investigator would conduct detailed investigations of two crashes per week: documenting the scene and vehicle with measurements and photographs, interviewing the people involved in the crash, and reviewing and coding data from medical records.

Unfortunately, when Ronald Reagan was elected, any hope of full funding for NASS was lost. The concept of 75 teams investigating more than 18,000 serious crashes in detail annually was never realized. The system got up to 50 teams, then was cut to 36, and now only 24 teams investigate a

National Accident Sampling System

Original NASS Design

- 75 teams – a Primary Sampling Unit in each Census Bureau geographic/demographic stratum
- 2 to 4 investigators in each PSU each investigating 2 crashes per week
- Crashes selected by a statistical sampling algorithm to provide a representative sample
- Over sampling of later models, more severe crashes.
- Detailed characterization, photos of vehicle and scene, interviews with people, review of medical records, reconstruction of crash, coding of all data.

Figure 4

Current NASS

- Only 24 teams investigating fewer than 5,000 crashes per year
- Concentrates on light vehicles, generally ignores pedestrians, heavy trucks, etc.
- Improved selection of cases
- Improved training, protocols, data elements, . . .
- New special studies being added
- All data is available on the web:

http://www-nrd.nhtsa.dot.gov/departments/nrd-30/ncsa/

Figure 5

quarter of the anticipated number of crashes per year [Figure 5].

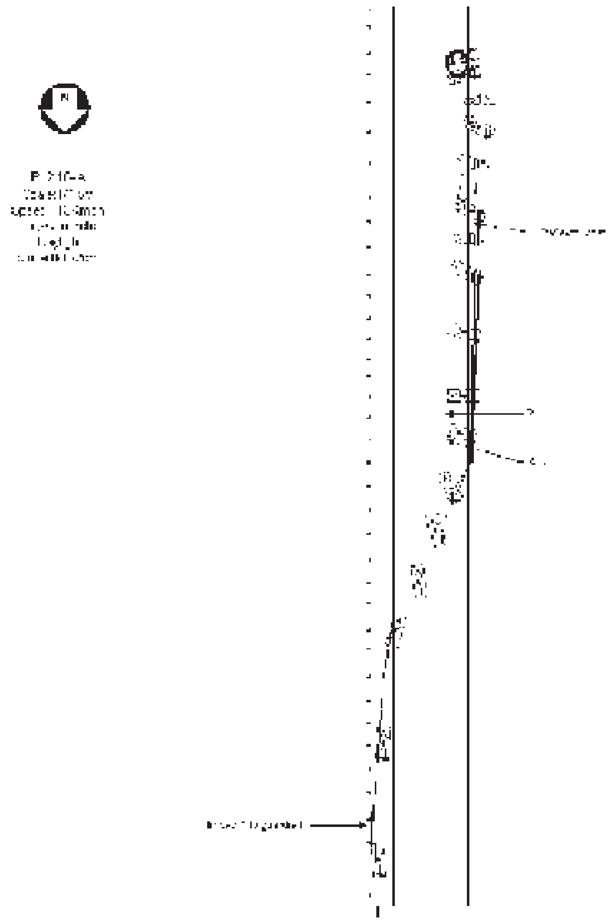
Despite this, the NASS investigations provide a rich source of data, collected according to a sophisticated statistical sampling system to facilitate detailed national estimates of road casualties on our nation's highways and their causes. Changes have been made in recent years to increase the number of more serious crashes of recent model vehicles to make the results more relevant to improving vehicle safety and to improve the relevance, quality and completeness of NASS data [Figure 6].

All of the NASS and FARS data have been public from the beginning except for information that would permit specific identification of the individuals involved so as to protect their privacy. For several years, all of the NASS data have been more readily available on the NASS web site [Figure 7].

Case Number: 2001-12-164

Summary:

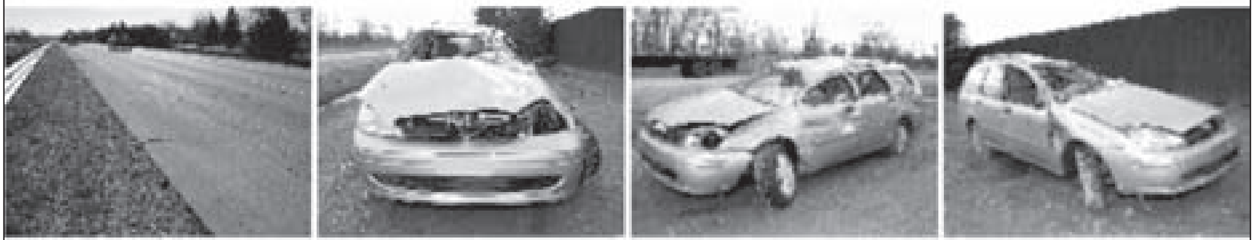
Vehicle 1 was travelling southbound on a 2 lane, dry concrete expressway with a divided traffic median with positive barrier. Vehicle 1 was traveling in the fast lane and gradually departed the left shoulder striking the median guandrail with its left side. The path of the vehicle then continued forward reentering the roadway crossing all traffic lanes. The driver overcorrected by steering left to avoid departing the roadway into a ditch off the right roadside. In doing this, the vehicle yawed counterclockwise and with the back wheels of the vehicle on the grassy roadside, and the front wheels still traveling on the paved shoulder. The right wheels gouged into the grass tripping the vehicle causing a right rollover sequence (six quarter turns) coming to rest on it's top. During the rollover, the driver was partially ejected from the left front glazing which caused fatal injuries to the head and neck. The driver was partially entrapped underneath the vehicle at final rest. All occupants had been restrained. All occupants were transported to a trauma facility for treatment of injuries. The vehicle was towed from the soene due to damage. During the crash sequence, the left side airbag deployed, no other airbags deployed, no pretensioners fired.



Vehicle	Body type	Make	Model	Year	Occ. #	Age	Occupant's sex	Maximum known occupant ais
1	STATION WAGON	Ford	Foccus	2001	1	46	MALE	2=Moderate
1	STATION WAGON	Ford	Foccus	2001	2	46	FEMALE-NOT PREG	1=Minor
1	STATION WAGON	Ford	Foccus	2001	3	15	FEMALE-NOT PREG	1=Minor
1	STATION WAGON	Ford	Foccus	2001	4	15	FEMALE-NOT PREG	0=None
1	STATION WAGON	Ford	Foccus	2001	5	15	FEMALE-NOT PREG	1=Minor

Figure 6 A NASS rollover case – crash description and scene diagramm

Occupant: 2001-12-164-1-1



Rollover Characteristics

Number of Events	3
Rollover Initiation Type	TRIP-OVER
Location of Rollover Initiation	ROADSIDE/MEDIAN
Rollover Initiation Object Contacted	GROUND
Location on Vehicle where Principal Tripping Force was Applied	WHEELS/TIRES
Direction of Initial Roll	ROLL RIGHT

Crash Severity

Nr. Quarter Turns	6 QUARTER TURNS
Impact Speed	999
Total, Longitudal, and Lateral ΔV	999 999 999
Est. ΔV with sequence number	SEVERE 2
CDC	0 T D D O 5
Damage (C1-C6)	0 0 0 0 0 0
Crush (L and D)	0 0
Object Contacted 1	ROLLOVER-OVERTURN
Object Contacted 2	Other BARRIER

Pre-Crash Environment

Traffic Flow	DIVIDED/W/BARRIER
Number of Travel Lanes	TWO
Roadway Alignment	STRAIGHT
Roadway Profile	LEVEL
Roadway Surface Type	CONCRETE
Roadway Surface Condition	DRY
Light Conditions	DAYLIGHT
Atmospheric Conditions	No ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	No ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Ford Focus
Year	2001
Class	
Body Type	STATION WAGON
Weight	119

NASS Weighting Factor

Weighting factor	33.915

Pre-Crash Driver Data

Accident Type	6
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	OFF EDGE-LEFT
Attempted Avoidance Maneuver	No AVOIDANCE
Pre-impact Stability	TRACKING
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	46	Height	180	Weight	82
Gender			MALE		
Ejection			PARTIAL EJECTION		
Ejection Area			Left FRONT		
Entrapment			ENTRAPPED		

Restraint Factors

Restrain	Lap and shoulder
AOPS	YES-RES DET
Airbag Deployment	NONDEPLOYED
Airbag Deployment - 1st Seat	NONDEPLOYED
Airbag Deployment - Oth Seat	BAG DEPLOYED

Injuries

Occupant	2001-12-164-1-1
MAIS	2=Moderate
Seat Position	Front left side

AIS Level	Injury Description	Contacts
2=Moderate	751900	Left A pillar
1=Minor	Scalp avulsion, NFS	Roof left rail

Figure 7: Details on the vehicle & occupant injuries

Use of NASS Data to Study Rollovers

Now, I would like to show you what can come from a major study of the crash data that we have. I have been seriously interested in rollover crashes for nearly a decade. Fully one third of all serious to fatal casualties in light motor vehicles in the U.S. are in rollovers. However, until I personally looked at every rollover of a vehicle less than ten years old in which there was an AIS 3 injury, I did not fully understand what was happening in these crashes [Figure 8].

It became obvious as I looked at these crashes that the traditional ways of classifying rollovers – the number of quarter turns or the manner in which the rollover was initiated – was of little practical use. Rather, I found that rollovers fell fairly neatly into five classes [Figure 9]:

- Rollovers where an unbelted occupant is completely ejected.
- Rollovers where a belted occupant receives a head or neck injury from roof crush.
- All other pure rollovers (i.e. without a significant collision).
- Rollovers that follow a major collision that is the most harmful event.
- Rollovers in which there is a major collision or change in elevation during the rollover where that is the most harmful event.

I used a sophisticated version of the Harm concept developed initially by the late Dr. Sakis Malliaris at NHTSA, to assess the consequences of the rollovers I found in NASS. That methodology computes the product of the economic cost of an injury and the frequency of occurrence of that injury to get an economic measure of its consequence [Figure 10].

Since each crash in NASS has an estimate of the number of similar crashes in the U.S., I could make a reasonable estimate of the economic consequence of each of the rollover crashes I found in NASS that involved a serious to fatal injury.

A Study of NASS Rollover Cases

- Studied all rollovers of vehicles 10 years old or less with AIS 3+ injuries in years 2002 -2004
- Determined type of rollover and cause of injury
- Calculated economic consequence of injury (HARM = Cost x Frequency of Occurrence)
- Estimated the effectiveness in each crash of:
  - a strong roof
  - laminated side windows with edge containment
  - a strong safety belt use reminder
- Calculated value of countermeasures

Figure 8

Classes of Rollovers

1. An unbelted occupant is completely ejected.
2. A belted occupant receives a head or neck injury as a consequence of roof crush.
3. All other pure rollovers (i.e. without a significant collision)
4. Rollovers that follow a major collision where the collision is the most harmful event.
5. Rollovers in which there is a major collision or change in elevation during the rollover where that is the most harmful event.

Figure 9

AIS	Body Part	Cost	AIS	Body Part	Cost
3	SCI	$ 1,506,961	5	SCI	$10,210,387
	Brain	$ 1,306,647		Brain	$ 6,826,032
	Lower Extremity	$ 530,725		Lower Extremity	$ 2,056,783
	Upper Extremity	$ 235,160		Upper Extremity	N.A.
	Trunk, Abdomen	$ 266,856		Trunk, Abdomen	$ 860,798
	Face, Head, Neck	$ 325,650		Face, Head, Neck	$ 1,805,288
4	SCI	$ 7,296,260	6	All	$ 3,623,787
	Brain	$ 2,939,047			
	Lower Extremity	$ 1,161,530			
	Upper Extremity	N.A.			
	Trunk, Abdomen	$ 480,459			
	Face, Head, Neck	$ 869,853			

Figure 10: Cost of AIS 3+ Injuries by Body Part and Severity of Injury from NHTSA's "Economic Inpact of Motor Vehicle Crashes"

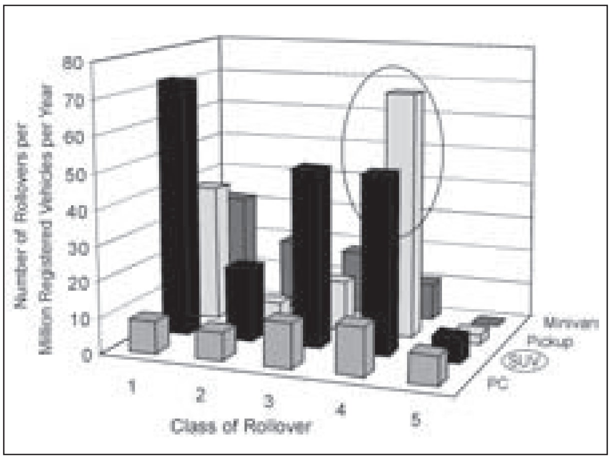


Figure 11 Rollovers per Million Registered Vehicles per Year

What is most striking about what I found is the substantial overrepresentation of SUVs where an unbelted occupant is ejected [Figure 11]. I was also somewhat surprised by the fact that roughly one-third of all rollovers have a collision before or during the rollover as the most harmful event. The differences in these two figures are that the first shows only the estimated counts of rollover injuries while the second shows the harm, in economic terms [Figure 12].

Looked at this way, we can immediately see how to substantially reduce rollover casualties. I picked three basic countermeasures: a strong roof, belt use (i.e. effective belt use reminders), and side windows that do not break out as a consequence of roof contacts with the ground. I then made an estimate of the effect of these countermeasures on the casualties that occurred in the rollover: how much the harm would be reduced by the countermeasure [Figure 13].

Using this technique, I made an educated prediction of the effectiveness of these simple countermeasures. Now, I realize that the sexy technologies for rollovers are electronic stability systems and rollover-triggered window curtain air bags. Yet even in full production, each of these would add $ 250 or € 200 to the cost of a new car. By comparison, the combination of a strong roof, an effective safety belt use reminder, and laminated side glazing would add a total of less than $ 200 or € 160 to the price of a typical car or light truck. Yet these three together would be substantially more effective overall in reducing casualties than the fancy new technologies [Figure 14].

I also learned by looking in detail at the NASS rollovers that you would get a substantial part of the total benefit by applying these countermeasures only to SUVs. It is interesting that either an effective safety belt use reminder or laminated side glazing could deal with the problem of complete ejections in rollovers. However, laminated side glazing will not contain occupants if the roof distorts substantially during a rollover. Thus, for this to be a successful countermeasure requires a strong roof as well [Figure 15].

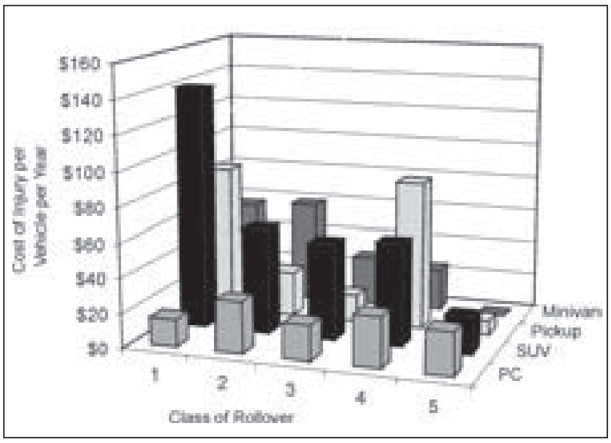


Figure 12: Cost of Injury in Rollovers per Vehicle per Year

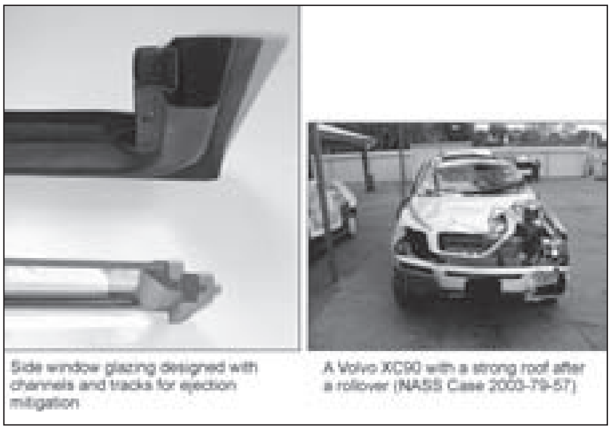


Figure 13

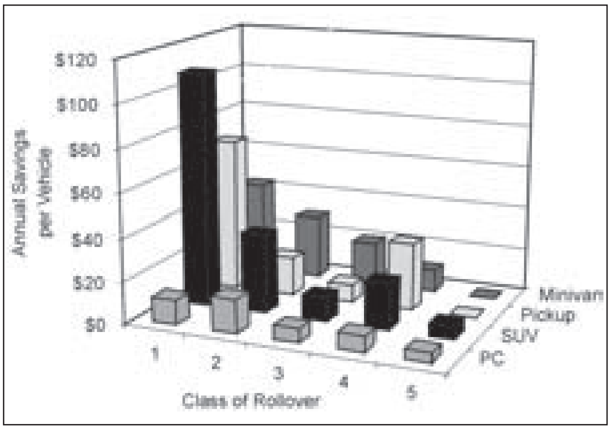


Figure 14: Savings from Common, Low Cost Countermeasures per Vehicle per Year

Class of Rollover	Passenger Car	SUV	Pickup	Minivan
Unbelted Occupant Fully Ejected	$ 2,177	$ 3,658	$ 3,359	$ 1,004
Belted Occupant w/Head or Spinal Column Injury	$ 4,061	$ 1,600	$ 1,016	$ 1,062
Other Primary Rollovers	$ 2,768	$ 1,461	$ 612	$ 511
Collision Before Rollover	$ 3,925	$ 1,546	$ 3,340	$ 439
Collision During Rollover	$ 3,399	$ 561	$ 311	$ 0
Total	$16,330	$ 8,826	$ 8,638	$ 3,016
Number of Vehicles in Use (In millions)	127	17	37	18
Annual Cost per Vehicle in Use	$ 130	$ 520	$ 230	$ 165

Figure 15 Annual economic consequences of rollovers per vehicle by type of vehicle and class of rollover (in millions). The sum for all light vehicles is $ 36.8 billion per year

It is clear from reviewing the pictures in the NASS files that most cars on the road in the U.S. – and that includes some German and Swedish cars – do not have adequately strong roofs. It is also clear that a typical vehicle's pitch angle during a rollover is at least 10º as shown by damage to the front fenders of vehicles, and that the windshield always breaks when there is damage to the front of the roof. These types of observations show the importance of reviewing cases in detail to get ideas about both countermeasures and about designing useful performance tests for safety performance. To rely simply on the electronic files of systems like FARS and NASS can not only deprive one of the richness contained in the complete file; it may mislead an analyst.

No Cause for Optimism

When thinking about data, we must remind ourselves that highway crashes are fundamentally a public health challenge: little different from cancer, bird flu and AIDS in either their impact on society or in how we should approach them. The lack of sufficient crash data in the U.S. meant that we were unable to see problems with the first generation air bags, and with automatic belts, until these systems had killed a significant number of people. We also did not see the problem with Firestone tires on Ford Explorers until they had killed hundreds of people.

Although I don't want to cast a pall over this meeting, I am increasingly feeling that despite our air bags, electronic controls and advanced materials, we have progressed only modestly in the 40 years since Ralph Nader published "Unsafe at Any Speed" [Figure 16].

Why is the Glass Only Half Full?

- A lack of complete commitment to safety by the auto industry (it will not even lobby for a comprehensive U.S. crash data program).
- The public still thinks "the nut behind the wheel" causes crashes, and that "I'm a good driver: it can't happen to me."
- Belt use among people who are most likely to be in a serous crash is depressingly low.
- NHTSA has lost its drive and support.

Figure 16

The U.S. auto industry still lacks a comprehensive commitment to safety that involves strong support of research and the application of all known, practicable safety advances in a timely manner to its products. The industry has not even supported a strong, well funded crash data system in the U.S. that would help it make cost-effective safety improvements in its products. There is little public concern over the massive loss of life on our roads. There is a pervasive public attitude that the problem is still mostly "the nut behind the wheel," and that "it can't happen to me". Safety belt use among those most likely to be in a serious crash remains depressingly low.

Our National Highway Traffic Safety Administration has become a toothless shadow of its former self: drastically under-funded, politically hamstrung, and focused on programs and initiatives that have only modest payoff but are inoffensive to industry. Although NHTSA has collected a substantial body of crash data, it does little to diagnose current auto safety challenges or to evaluate designs and technologies that would reduce casualties.

A Trauma-Based Crash Data System

In attempts to improve the understanding of crashes in the U.S., ten years ago NHTSA initiated the Crash Injury Research and Engineering Network (CIREN) based at eight trauma centers around the country. Some of the centers are sponsored by auto makers. CIREN produces a small number of detailed investigations of crashes that have very severe outcomes. CIREN cases include particular detail on the medical aspects of crash injuries and treatment. The investigations are triggered by the admission of an individual to the trauma center for severe crash injuries.

While the CIREN cases are interesting and useful, they lack a basis in statistical sampling, so that it is difficult to determine the importance or breadth of problems identified in them. NHTSA has several other crash data programs, mostly in cooperation with the states, and I leave it to you to learn of them from the NHTSA web site.

A Future U.S. Crash Data System

As a result of my work, I have given further thought to how we could improve the crash data systems in the U.S. [Figure 17]. We spend roughly $ 25 million

U.S. Data Collection in the Future?

- Continue the existing FARS program
- Expand the NASS program to its originally designed size of 75 teams investigating a sample of more than 18,000 cases per year.
- Conduct full NASS investigations of a sample 5,000 fatal crashes
- Crash Causation: install a GPS, video camera (~1 frame/second), sensors (brake pressure, steering angle, and throttle position), and data recorders in a fleet of 1000+ vehicles to monitor emergency conditions (whether there is a crash or not)
- Increase funding to at least $75 million per year

Figure 17

on Federal crash investigation and data programs. This is less than $ 1 for every $ 10,000 in economic loss from crashes. While I suppose we should be thankful that we have at least that amount of information, it is a travesty that a rich, advanced country like the U.S. collects so little data on this critical problem.

I think that a reasonable crash investigation program would have the following:

- Continuation of the existing FARS program.
- Expansion of the NASS program to its originally designed size of 75 teams investigating a sample of more than 18,000 cases per year, and closing of the General Estimate System.
- A new program that will sample roughly 5,000 fatal crashes in the U.S. with NASS personnel conducting detailed investigations of them.
- A new project on crash causation where Global Positioning Systems, video cameras (taking only about one frame/second), sensors (brake pressure, steering angle, and throttle position), and data recorders are put in a fleet of at least 1,000 vehicles to monitor emergency conditions (whether there is a crash or not). This project would give critical, real time information on the conditions that immediately precede an actual crash or a near crash.

We would need at least $ 75 million per year for what I would consider a reasonable crash investigation program in the U.S. NHTSA also needs to have a much more comprehensive program to analyze the data it already has to identify problems, set priorities, and justify a more dynamic vehicle safety program.

It might be useful to develop cooperative international programs in crash investigation. Such programs have not occurred in the past because of major institutional impediments, not to mention budgetary, language and philosophical constraints. Further problems are the significant differences in the vehicles and fleets in the major areas of the world as well as in their differing traffic conditions. Even without greater formal cooperation, we can clearly learn much from each others programs and experiences.

Frankly, I think that the area that could provide the highest payoff in international cooperation, it is the New Car Assessment Program. Although this concept was first developed in the United States in the late 1970s, Europe and Australia have taken it considerably further than we have. NCAP can have major payoff in improving vehicle safety without resorting to more regulation.

That is the beginning of my dream for safe motor vehicle transportation.