ITS at a glance

Produced By The Department Of Transportation's Intelligent Transportation Systems, Joint Program Office

Covering: Advanced Travel Information Systems (ATIS) • Advanced Travel Management Systems (ATMS) • Advanced Public Transportation Systems (APTS) • Advanced Vehicle Control and Safety Systems (AVCSS) • Architecture • Automated Highway Systems (AHS) • Commercial Vehicle Operation (CVO) • ITS Issues

ITS Delivers Sizable Safety Benefits

ITS Can Prevent More Than a Million Accidents and Save in Excess of $20 Billion

Overview

The National Highway Traffic Safety Administration (NHTSA) estimates that 1.1 million crashes could be prevented annually if all vehicles were equipped with the three Intelligent Transportation System (ITS) crash-avoidance countermeasures described in this article. The three ITS systems are part of NHTSA's ongoing research estimating the benefits of avoiding crashes. By avoiding more than a million accidents-17% of the total 6.4 million crashes nationwide-$23 billion could be saved each year.

The Problem

Motor vehicle crashes in the U.S. cost about $137 billion annually. NHTSA's analysis of real-world crashes found that-of the country's 6.4 million annual crashes-intersection collisions (30%), rear-end collisions (25%), roadway departure crashes (20%), and lane change/merge crashes (4%) comprise nearly 80% of the total (Figure 1).

Causes

As shown in Figure 2, approximately 90% of all crashes result from driver-related factors, including 76% due to driving errors, such as not recognizing hazardous situations in time (inattention) or bad decisions (tailgating, excessive speed). About 14% involve drivers in a poor physiological state (drunk, asleep, ill).

Developing ITS Countermeasures

Given the magnitude and causes of the safety problem, NHTSA is establishing performance specifications for ITS collision avoidance systems. Projects are underway to develop coun-

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ITI TOOLBOX

Automated Highway System Research

Focusing Research on Driver Acceptance

Defining Operational Scenarios

The success of an AHS will depend on the attention paid during system design to driver acceptance and performance capabilities. Defining operational scenarios is the first step in defining driver roles and driver-system interface requirements.

> The Automated Highway System (AHS) will provide "hands-off, feet-off' operations and increase highway safety by reducing driver error. By controlling the speed and gaps between vehicles, the system will improve throughput and reduce congestion.
>
> The Human Factors Research Program at the Federal Highway Administration (FHWA) addresses how human performance considerations affect highway system design. Current research focuses on highway safety and Intelligent Transportation Systems (ITS) such as the AHS, with a special emphasis on the trend toward the increasing number **of** older drivers.

Seven operational AHS scenarios were defined with variations in the complexity of the automated and manual maneuvers required, the physical space allowed for maneuvers, and the nature of the resulting demands on drivers. FHWA selected three scenarios differentiated by three key dimensions:

- degree to which automated and manual traffic is separated

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Figure 1 – Total Crashes by Type

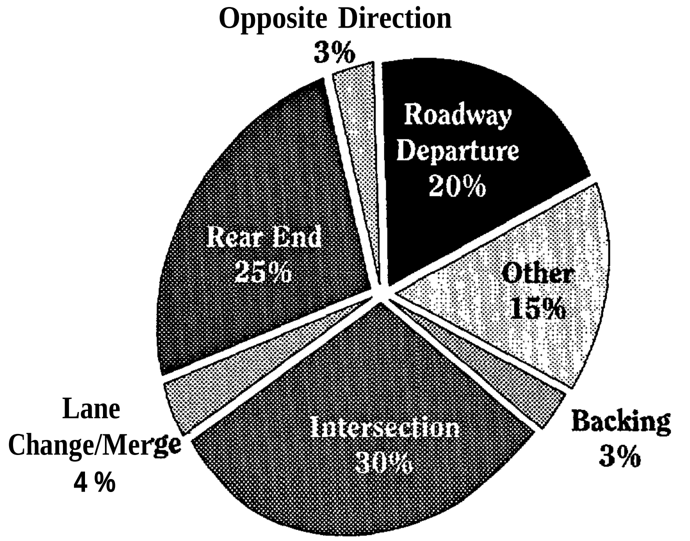
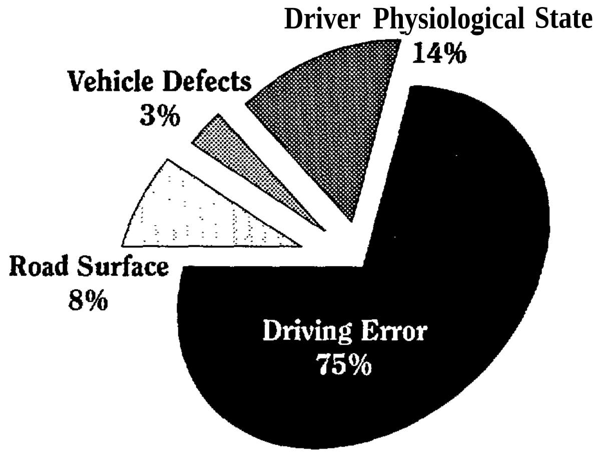


Figure 2 – Causal Factors



termeasures for various types of crashes including: intersection, rear-end, road departure, lane change/merge, and backing.

Importance of Estimating ITS Safety Benefits

Developing a methodology to estimate safety benefits is a critical component of NHTSA's program. These benefits, which demonstrate that taxpayer money is being well spent, are estimated in terms of collisions avoided and reductions in deaths, injuries, and property damage costs.

The estimates of benefits will help steer the direction of the Crash Avoidance Program and assist the ITS community with decisions on the most cost-effective allocation of R&D resources for collision countermeasures.

A report documenting NHSTA's efforts to estimate ITS safety benefits will be released for public comment and peer-review this summer. Comments will be used to develop improved methodologies, gather additional data, and refine the preliminary estimates of benefits presented in this article.

To date, NHTSA has developed estimates of crash reductions by ITS systems for three types of crash conditions-roadway departure, rear-end, and lane change/merge. As shown in Figure 3, these crash types account for 3.1 million of the 6.4 million annual crashes in the U.S.

Approach Used to Estimate Benefits

NHTSA determines benefits by comparing the number of crashes when driving without ITS collision avoidance systems to the estimated number of crashes when driving with such systems. The difference is the estimated benefit.

NHSTA's three-step approach consists of:

- determining relevant crashes
- developing effectiveness estimates for countermeasures
- calculating safety benefits, as the product of the sum of relevant crashes (x) countermeasure effectiveness

Each ITS countermeasure applies only to certain crash scenarios under each crash condition-i.e., to "relevant" crashes.

Effectiveness values-i.e., number of crashes reduced-for ITS countermeasures were estimated with mathematical models. These computer models describe the crash condition, analyze individual crash scenarios and their likelihood, and then estimate the number of crashes reduced-i.e., the effectiveness value. The analysis of effectiveness was based on basic data from driving simulators and test track experiments-and occasionally on expert judgments when simulator or experimental data were not available.

Crashes that could be avoided with a particular ITS system are calculated as the product of the number of relevant crashes and the effectiveness of countermeasure being considered.

ITS Systems and Their Effectiveness

As noted in Figure 3, about 1.1 million crashes could be prevented by the three countermeasures described below.

Rear-End Crash, Driver Warning System

ITS rear-end crash warning systems would monitor a vehicle's forward path and headway in relation to a lead vehicle in

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Figure 3 – Crashes Prevented by Selected Crash Avoidance Systems

Crash Condition (1)	Total # of Crashes (2)	Relevant Crashes Addressed by Countermeasures (3)	Effectiveness Estimates (4)	Number of Crashes Reduced (3) x (4)
Rear-End Crashes	1.7 million	1,547,000	0.49	759,000
Roadway Departure	1.2 million	458,000	0.65	296,000
Lane Change/Merge	0.2 million	192,000	0.20	39,000
Totals	**3.1 million**	2,197,000	-	1,094,000

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front, The system would alert drivers to dangerous situations with a graphical display and voice warning. The overall effectiveness reflects different effectiveness values for different crash scenarios/circumstance (e.g., lead vehicle moving v. stopped, dry v. wet/icy conditions).

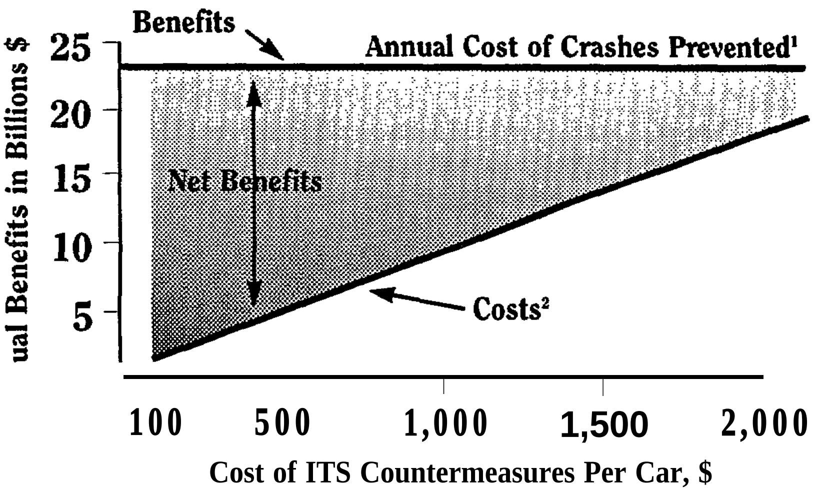
Results: ITS countermeasures are capable of addressing over 1.5 million of the 1.7 million rear-end crashes that occur annually. NHTSA estimates that ITS driver warning systems would be effective in 49% of the relevant crashes, which would prevent 759,000 crashes annually.

Roadway Departure Countermeasure System

The ITS roadway departure warning system detects a vehicle's potential to depart the road based on the position/speed of the vehicle and road geometry ahead. The system alerts drivers of the need for corrective actions through audio or other signals. The estimate of overall effectiveness, based on crash studies using a driving simulator, takes into account whether drivers are alert, inattentive, impaired (due to drinking), or drowsy.

Results: ITS countermeasures apply to about 458,000 of the 1.2 million roadway departure crashes that occur annually. With an overall effectiveness of 65%, the ITS roadway departure system would prevent 296,000 crashes.

Figure 4 – Benefits and Costs of Selected ITS Crash Countermeasures



1 Based on crashes prevented by roadway departure, rear-end, lane change/merge countermeasures.

2 Based on 10 million vehicles per year with ITS countermeasures installed in the entire motor vehicle fleet.

lane Change/Merge Crash Avoidance System

The ITS crash avoidance system measures the distance to, and speed of, vehicles in adjacent lanes along the full length and to the rear of the ITS-equipped vehicle. If no lane change is started, the system would simply provide a visual alert of any vehicles in an adjacent lane. Once a lane change starts, the system provides an audible or other signal to augment the visual alert.

The ITS system is designed to prevent the execution of an ill-advised maneuver by alerting drivers starting, or about to start, a lane change. Crash records show that lane change/merge crashes occur because drivers are largely unaware of vehicles in adjacent lanes.

Results: ITS countermeasures apply to 192,000 of the approximately 200,000 lane change/merge crashes per year. The estimated effectiveness of the crash avoidance system is about 20%, which would prevent about 39,000 accidents per year.

ITS System Costs and Net Economic Benefits

The country's 6.4 million crashes cost $137 billion annually. The three ITS systems evaluated by NHTSA so far could reduce the total number of crashes by 17%. The economic benefits would be (0.17)($137 billion) = $23 billion.

Net benefits would equal these economic benefits minus the cost of ITS countermeasures. However, since production costs are unknown at this time, a range of costs-from $100 to $2000 per vehicle-is used to calculate net benefit. The net economic benefits range from approximately $3 to $22 billion, depending on the cost of the countermeasures (Figure 4).

Reference

Based on remarks of NHTSA Deputy Administrator Philip R. Recht at the ITS America Annual Meeting, April 15, 1996. This benefits analysis is currently being updated, and results will be published in the summer of 1996..

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- degree to which automated lanes are separated from one another
- vehicle-following rules (e.g., groups versus individual vehicles)

These scenarios became the basis for a series of analytical studies and provided a framework to explore systematically the impacts on driver behavior. Many of the variables identified have become candidates for further experiments, such as the project (described next) dealing with methods of transferring control from the automated system to the driver.

Drivers Are Positive About AHS Experience

Experiments Address Driving Performance and Analyze Safety Problems

As AHS moves through concept/design phases, FHWA is assessing driver and system attributes to make the system usable and acceptable to all drivers. Driver capabilities and limi-

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tations must be considered to ensure successful implementation of an AHS.

Recent experiments that simulate the AHS experience for a mix of younger and older drivers focused on methods of transferring control from the automated system to drivers exiting the system. In the simulated three-lane highway, the left lane was automated and the center and right lanes were unautomated. Drivers began by operating the simulator vehicle in the middle of three automated vehicles before moving from the automated to unautomated lane and then exiting the highway.

Results

- Both younger and older drivers said in a questionnaire that they were generally positive about their experience driving the simulated AHS.
- Drivers preferred the automated over the unautomated lane, felt that an AHS would help reduce the stress of driving, and said they would use an AHS if available.
- Both groups could maneuver from an AHS to an unautomated lane.
- Drivers preferred greater gaps between automated vehicles.
- The number and percentage of incursions (crossing a lane line, but not completing a lane change) and collisions when exiting represented a very high level/rate of unsafe driving performance.

Analyzing AHS Throughput and Unsafe Driving Performance

For all drivers, the higher the AHS design velocity, the longer it took to complete the exit maneuver. Also, the carry-over effect of higher velocity in the automated lanes may impact driving performance in unautomated lanes, leading to faster driving and the high incursion and collision rates.

Furthermore, speed differentials greater than 10 m.p.h. between automated and unautomated lanes increased exit times and reduced AHS throughput. The reduced throughput was attributed to this particular simulated AHS configuration where no transition lane was available for drivers to slow to unautomated lane speeds.

Contacts/Reports

The complete report, *Automated Highway System: **Transferring Control to the Driver*** (FHWA-RD-94-114), is available from the FHWA R&D Report Center, 703/285-2144. Other human factor investigations are examining how drivers enter the AHS and the possible effects that using the AHS may have on regular driving.

Funding Intelligent Transportation Infrastructure Projects

Funding ITI Projects Under Updated CMAQ Guidance

On 3/7/96 USDOT issued updated guidance for the Congestion Mitigation and Air Quality (CMAQ) Improvement Program in response to CMAQ program changes made by the National Highway System Act. The CMAQ program's primary purpose is to fund projects "shown to improve air quality" that "will assist air quality nonattainment and maintenance areas reduce transportation emissions...."

In noting that Intelligent Transportation Infrastructure (ITI) traffic management and traveler information systems can be effective in improving air quality, the guidance references the nine ITI components identified as a framework for integrating and deploying ITI in metropolitan areas. Seven components with "the greatest potential for improving air quality" are singled out:

- regional multimodal traveler information systems
- traffic signal control systems
- freeway management systems
- transit management systems
- incident management programs
- electronic fare payment systems
- electronic toll collection systems

The guidance highlights the effectiveness of electronic fare/toll systems in reducing air quality "hot spots" and emphasizes linking components together in a system so their benefits are likely to be greater.

Operating/maintenance expenses of these ITI projects are eligible for CMAQ funding where air quality benefits are demonstrated (i.e., operating costs are necessary for the overall transportation system to contribute to standard attainment), the expenses are for new/additional services, and previous funding mechanisms (e.g., fees) are not displaced. This operating assistance can extend beyond "an initial three-year period of eligibility" if the federal agencies determine that the IT1 projects "will assist in the attainment of the air quality standard."

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ITS at a glance is a quarterly newsletter produced by the U.S. Department of Transportation's Intelligent Transportation Systems (ITS) Joint Program Office (JPO). This quarterly publication highlights and shares major ITS developments within USDOT.

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