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An Overview of the National Highway Traffic Safety Administration's Light Vehicle Antilock Brake Systems Research Program

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ABSTRACT

This paper presents an overview of currently ongoing research by the National Highway Traffic Safety Administration (NHTSA) in the area of light vehicle (passenger cars and light trucks) Antilock Brake Systems (ABS). This paper serves as a lead-in to other papers that will be presented during this session.

Several statistical crash data studies have found there to be little or no net safety benefit from the implementation of four-wheel ABS on passenger automobiles. Typically, these studies have found ABS to be associated with:

1. A statistically significant **decrease** in multi-vehicle crashes.
2. A statistically significant **decrease** in fatal pedestrian strikes.
3. A statistically significant **increase** in single-vehicle road departure crashes.

The safety disbenefit due to the third finding approximately cancels the safety benefits from the first two findings.

The third finding from the statistical crash data studies, the increase in fatal single-vehicle crashes associated with the implementation of ABS on passenger automobiles, is quite surprising. Prior to the widespread introduction of ABS, safety experts expected that adding ABS would decrease the frequency of single-vehicle crashes, not increase the frequency. Interestingly, such a decrease is exactly what was found by crash data studies that have looked at the effects of adding rear-wheel only ABS to light trucks.

NHTSA wants to find out why the addition of ABS has been associated with an increase in the frequency of single-vehicle crashes for passenger automobiles. NHTSA hopes that once the reasons for this increase are known, countermeasures can be developed so that ABS will produce its expected overall safety benefit for passenger automobiles.

A list of possible reasons why ABS is not producing its anticipated safety benefits is presented. The paper then gives a summary of the research tasks being performed to investigate each of these possible reasons.

INTRODUCTION

Antilock brake systems (ABS) first appeared in the U.S. during the late 1960's. By the late-80's four-wheel ABS had become standard equipment on a limited number of automobiles (mainly sport and luxury models) and light trucks. In recent years, ABS has become more common and is now standard equipment on many high production passenger cars and light trucks. Sixty-two percent of 1996 model year vehicles were equipped with four-wheel ABS [1].

Light vehicles include passenger cars and light trucks (pickup trucks, sport utility vehicles, and vans lighter than 10,000 pounds). The principle reason for equipping these vehicles with ABS is to increase safety. Years of watching the enhanced lateral stability and improved stopping performance of ABS-equipped vehicles on the test track has convinced brake experts that the widespread introduction of ABS should significantly reduce the number of crashes, and resulting injuries and fatalities, that occur on our nation's highways.

To check the experts' belief that the introduction of ABS will increase safety, several statistical analyses of crash databases have been performed in recent (1993 and later) years. Analyses of the effects of ABS for automobiles were published in 1994 by Kahane [2] and by Kullgren, Lie, and Tingvall [3], in 1995 by Evans[4], by Hertz, Hilton, and Johnson [5], and by Failure Analysis Associates [6], in 1996 by the Insurance Institute for Highway Safety [7], and in 1998 by Hertz, Hilton, and Johnson [8, 9]. Analyses of the effects of ABS for light trucks were published in 1993 by Kahane [10], in 1995 by Hertz, Hilton, and Johnson [11], and in 1998 by Hertz, Hilton, and Johnson [8,9].

The automobile studies fall into two groups. The first group consists of the six studies [2,3,4,5,6,7] that were published between 1994 and 1996. These studies were all

based on data from ABS-equipped vehicles with model years from 1989 through 1993. While the precise numbers varied from study to study, typically, these studies found that ABS was associated with the following:

1. A statistically significant **decrease** in multi-vehicle crashes on wet or unfavorable road surfaces.
2. A statistically significant **decrease** in fatal pedestrian strikes.
3. A statistically significant **increase** in single-vehicle road departure crashes.

The safety disbenefit due to the third finding approximately cancels the safety benefits from the first two findings. However, note that in [7], a net safety benefit associated with ABS was found. Table 1 shows the magnitude of these effects that were found by two studies, Kahane [3], and Hertz, Hilton, and Johnson [6].

The second group of automobile studies consists of the 1998 study by Hertz, Hilton, and Johnson [8,9]. This study is similar to [5] except that it is based on more recent (1995 - 96) crash data. Table 2 shows the effects found by this study. They are generally similar to the findings of the earlier studies except that ABS now appears to be decreasing one particular subtype of single-vehicle road departure crashes, frontal impacts with fixed objects, instead of increasing their numbers.

The light truck studies deal with two types of ABS. All three light truck studies cover vehicles equipped with rear-wheel only ABS (RWAL). The 1998 study by Hertz, Hilton, and Johnson [8,9] also covers light trucks equipped with four-wheel ABS (4WAL). Table 3 shows the magnitude of the effects for RWAL-equipped light trucks that were found by Hertz, Hilton, and Johnson [8,9]. Table 4 shows the magnitude of the effects for 4WAL-equipped light trucks that were found by Hertz, Hilton, and Johnson [8,9].

While the precise numbers varied from study to study, as shown in Table 3, the effects on safety of RWAL typically are:

1. No statistically significant change in multi-vehicle crashes or pedestrian strikes due to RWAL.
2. A statistically significant decrease in single-vehicle road departure crashes due to RWAL.

Therefore, RWAL demonstrates an overall safety benefit for light trucks.

For 4WAL, Hertz, Hilton, and Johnson [9] found an increase in fatal rollovers and side impacts ,which differed from the results of their earlier study [8] which found no change. 4WAL related non-fatal crashes on favorable surfaces, which had previously shown an increase, showed a decrease in the more recent study [9]. Run-off-road crashes with 4WAL showed a significant decrease in the more recent study [9] whereas the previous study [8] revealed no change.

Table 1: Typical Findings From 1994 - 1995 Studies of the Effects of ABS on Automobile Safety

Crash Type	From Kahane [2]		From Hertz, Hilton, and Johnson [5]	
	All Crashes	Fatal Crashes	All Crashes	Fatal Crashes
Multi-vehicle				
- Dry or Favorable Pavement	-5	+3	-9*	-1
- Wet or Unfavorable Pavement	-14*	-24*	-35*	-35*
Pedestrian Strikes	+3	-27*	Not Studied	
Road Departure				
- Primary Rollovers	+49*	+23	+24*	+60*
- Front Impacts with Fixed Objects	+15*	+19	+15*	+11
- Side Impacts with Fixed Objects	+22*	+57*	+36*	+91*

+Indicates an **increase** in that type of crash for ABS-equipped vehicles
- Indicates an **decrease** in that type of crash for ABS-equipped vehicles
* Indicates that result is statistically significant at the 95 percent confidence level

Table 2: Findings From 1998 Studies of the Effects of ABS on Automobile Safety

Crash Type	From Hertz, Hilton, and Johnson [8, 9]	
	All Crashes	Fatal Crashes
Multi-vehicle		
- Dry or Favorable Pavement	-18*	+5
- Wet or Unfavorable Pavement	–42*	-40*
Pedestrian Strikes		
- Dry or Favorable Pavement	-10*	+10
- Wet or Unfavorable Pavement	-30*	-38*
Road Departure		
- Primary Rollovers		+40*
-- Dry or Favorable Pavement	-17*	+51*
-- Wet or Unfavorable Pavement	+16	-14
- Front Impacts with Fixed Objects		-12
-- Dry or Favorable Pavement	-13*	-11
-- Wet or Unfavorable Pavement	+2	-16
- Side Impacts with Fixed Objects	+8*	+63*
-- Dry or Favorable Pavement	+7*	+61*
-- **Wet or Unfavorable Pavement**	+8	+69*

+Indicates an **increase** in that type of crash for ABS-equipped vehicles
- Indicates an **decrease** in that type of crash for ABS-equipped vehicles
* Indicates that result is statistically significant at the 95 percent confidence level

Table 3: Typical Findings From Studies of the Effects of RWAL on Light Truck Safety

Crash Type	From Hertz, Hilton, and Johnson [8, 9]	
	All Crashes	Fatal Crashes
Multi-vehicle		+20
- Dry or Favorable Pavement	+4	+20
- Wet or Unfavorable Pavement	-7	+21
Pedestrian Strikes	-3	-3
- Dry or Favorable Pavement	-5	-5
- Wet or Unfavorable Pavement	+4	+5
Road Departure:		
- Primary Rollovers	-41*	16
-- Dry or Favorable Pavement	-43*	+5
-- Wet or Unfavorable Pavement	-38*	+89
- Front Impacts with Fixed Objects	-11*	-23*
-- Dry or Favorable Pavement	-11*	-28*
-- Wet or Unfavorable Pavement	-10	+3
- Side Impacts with Fixed Objects	-20*	-6
-- Dry or Favorable Pavement	-15*	-10
-- Wet or Unfavorable Pavement	-29*	+2

+Indicates an **increase** in that type of crash for ABS-equipped vehicles
- Indicates an **decrease** in that type of crash for ABS-equipped vehicles
* Indicates that result is statistically significant at the 95 percent confidence level

Table 4: Findings From Study of the Effects of 4WAL on Light Truck Safety

Crash Type	From Hertz, Hilton, and Johnson [8, 9]	
	All Crashes	Fatal Crashes
Multi-vehicle		+19
- Dry or Favorable Pavement	-14*	+31
- Wet or Unfavorable Pavement	–38*	-14
Pedestrian Strikes	-5	
- Dry or Favorable Pavement	-1	+8
- Wet or Unfavorable Pavement	-19	-50
Road Departure:		
- Primary Rollovers	-39*	+103*
-- Dry or Favorable Pavement	-36*	+97*
-- **Wet or Unfavorable Pavement**	-43*	+125*
- Front Impacts with Fixed Objects	-26*	+6
-- Dry or Favorable Pavement	-24*	+16
-- Wet or Unfavorable Pavement	-33*	-25
- Side Impacts with Fixed Objects		+51
-- Dry or Favorable Pavement	+14	+111
-- Wet or Unfavorable Pavement	-33*	-26

+Indicates an **increase** in that type of crash for ABS-equipped vehicles
- Indicates an **decrease** in that type of crash for ABS-equipped vehicles
* Indicates that result is statistically significant at the 95 percent confidence level

LIGHT VEHICLE ABS RESEARCH PROGRAM OBJECTIVES

Numerous controlled, "test track" studies of ABS effectiveness have been performed by automobile manufacturers, ABS/brake manufacturers, and the Government. These test track studies have, in general, shown ABS to be a very promising safety device. Under many pavement conditions, ABS allows the driver to stop a vehicle more rapidly while maintaining steering control, even during extreme panic braking.

NHTSA wishes to, as rapidly as possible, determine why crash data analyses of actual vehicles, equipped with production ABS and operating under real world conditions, are not finding the anticipated positive ABS effectiveness that has been suggested under test track conditions. NHTSA hopes that once the reasons for the identified increases in crash rates are known, countermeasures can be developed so that ABS will produce a significant net safety benefit for passenger automobiles. Therefore, NHTSA, with the assistance of its Motor Vehicle Safety Research Advisory Committee's Light Vehicle ABS Working Group, developed NHTSA's Light Vehicle ABS Research Program. This program attempts, in a series of tasks, to examine all plausible reasons why the crash database studies do not show that ABS is improving automobile safety.

Many possible reasons as to why ABS appears not to be as effective on actual vehicles operating under real world conditions as is suggested by test track studies have been hypothesized. These reasons include:

1. The apparent increase in single-vehicle crashes involving ABS-equipped vehicles may be a statistical fluke. While the crash data studies have found, with a very high probability of significance, that single-vehicle crashes have increased for ABS-equipped vehicles, the make/models studied have, for technical reasons, been "sportier" or "more luxurious" than the common family sedan. Therefore, the possibility exists that the apparent increase in single-vehicle

crashes observed for these types of vehicles may be due to some characteristic(s) of those vehicle types and may not necessarily be present for some of the more common automobile models.

2. The apparent increase in single-vehicle crashes involving ABS-equipped vehicles may be due to one or more flaws in the hardware and/or algorithm of previous ABS models, i.e., an engineering problem. Newer, better performing ABS hardware and software may have already solved the problem. The ABS crash data studies that show the apparent increase in single-vehicle crashes for ABS-equipped vehicles involved systems that are now several years old. Newer light vehicle ABS hardware and software has since been introduced; this newer generation of ABS may have improved performance which will enable drivers to avoid single-vehicle, as well as multi-vehicle crashes.

3. The apparent increase in single-vehicle crashes involving ABS-equipped vehicles may be due to the fact that ABS hardware and software may not perform adequately in all driving situations. Situations (such as braking in a hard turn, grass, split mu, washboard roads, etc.) may arise in which the activation of the ABS in a panic stop produces a reduction in vehicle braking capability compared with a non-ABS-equipped vehicle. This loss of braking capability could result in an increase in single-vehicle crashes.

4. The apparent increase in single-vehicle crashes involving ABS-equipped vehicles may be due to a driver-related problem. In situations of extreme, panic braking, drivers may not be aware of the steering control that four-wheel ABS provides. Without four-wheel ABS, aggressive braking may lock the front wheels of the vehicle, eliminating directional control capability, rendering the driver's steering behavior irrelevant. With four-wheel ABS, the vehicle does not lose directional control capability during hard braking due to front wheel lockup, therefore allowing drivers to maintain steering control. It is possible that instead of making controlled steering movements, drivers perform extreme steering movements in panic situations. This could result in drivers avoiding multi-vehicle crashes by driving off the road, resulting in single-vehicle crashes instead.

5. The apparent increase in single-vehicle crashes involving ABS-equipped vehicles may be due to changes in driver behavior due (i.e., risk compensation) to their perceptions of the benefits provided by ABS. Drivers of ABS-equipped vehicles may operate their vehicles at higher speeds due to the perception that ABS increases the vehicle's handling and braking performance. This increased vehicle speed could result in more run-off-road, single-vehicle crashes, particularly on curved roads.

The overall objective of the current research program is to determine why the implementation of ABS has not resulted in a substantial net reduction in crashes. Crash studies show increased involvement of ABS-equipped vehicles in single-vehicle crashes and less involvement in multi-vehicle crashes. Identifying the cause(s) of the apparent lack of benefits provided by ABS will be accomplished through the following four specific goals:

1. Determine whether the apparent shift for ABS-equipped automobiles involving a decrease in multi-vehicle crashes and a corresponding increase in single-vehicle crashes continues to be seen in automobiles equipped with newer ABS hardware.

2. Determine the reasons why ABS-equipped automobiles appear to be more involved in single-vehicle crashes than in multi-vehicle crashes.

3. Determine whether the shift from multi-vehicle crashes to single-vehicle crashes will also occur for other types of light vehicles (pickup trucks, sport utility vehicles, and vans) as their brake systems shift from RWAL to 4WAL.

4. Develop consensus between/within NHTSA, the auto industry, and other stakeholders as to the research findings and conclusions.

PROGRAM TASKS

TASK 1: Update Statistical Studies to Determine the Effects of ABS on Single- and Multi-Vehicle Crashes

This task involves the analysis of crash data to determine the effects of equipping vehicles with ABS on single- and multi-vehicle crashes. This study differs from previous ABS crash data studies in several ways. First, high volume make/models, such as the Ford Taurus and Honda Accord, will be studied as compared to the "sportier" and "more luxurious" models used in previous studies. Earlier studies only used make/models that changed from standard conventional brakes one model year to ABS as standard for the next model year. This study will obtain assistance from the automobile manufacturers to fully decode Vehicle Identification Numbers (VIN), thereby determining the presence or absence of ABS on vehicles.

Also, in previous studies, crash data from one model year for a make/model was compared with crash data for another model year without taking into account generational differences that may have existed in different make/models (e.g., different engine size, different body style, etc). Since data from make/models with optional ABS are being used here, this study will endeavor to compare crash data for vehicles equipped with ABS versus those with conventional brakes for the same

make/model vehicle for the same model year in order to minimize potentially confounding factors.

Finally, this study will focus on make/models equipped with newer generation ABS designs. Unfortunately, due to the difficulties which exist in attempting to characterize ABS versions or iterations into "generations", a convenient method for examining the effects of crash rates due to ABS installed on vehicles when ABS was first introduced to that installed on present day vehicles has not been identified. However, comparing results of this new study to results obtained in previous studies [2,3,4,5,6,7,8,9,10,11] will provide some insight into this matter.

A meeting was held in which industry stakeholders were given the opportunity to review plans for the statistical analysis method for this task. This briefing allowed NHTSA to gain their input regarding the comprehensiveness and relevance of the factors being assessed and the method in which they are being examined.

Note that even though the 1998 Hertz, Hilton, and Johnson study [8,9] was performed by NHTSA personnel, it was not performed as part of this research program but as part of the National Center for Statistics and Analysis's ongoing research into the effects of new technologies on automotive safety. The planned Task 1 study differs from the 1998 Hertz, Hilton, and Johnson study [8,9] in several important ways (such as VIN decoding).

TASK 2: Conduct a Representative National Survey of Driver Experiences and Expectations Regarding Conventional Brakes versus ABS.

A telephone survey concerning driver experiences and expectations regarding conventional brakes versus ABS will be designed and nationally administered. The survey data will be analyzed to determine differences in drivers' expectations of brake performance between ABS-equipped and non-ABS-equipped vehicles. From these findings, the public's knowledge about ABS and the need for an educational campaign for specific demographic groups will be assessed.

TASK 3: Study NASS Hardcopy Crash Files to Determine Typical Single-Vehicle Crashes for ABS-Equipped Vehicles

Task 3 consists of an examination of National Automotive Sampling System (NASS) hardcopy files to further investigate the circumstances surrounding crashes involving ABS-equipped and non-ABS-equipped vehicles. This analysis will attempt to determine whether crashes of vehicles were due to some aspect of brake performance or whether they were due to some other operational factor, such as road departure as a result of falling asleep while driving. Crashes that are determined to be brake performance related will be used to assist in the development of test plans for other tasks.

TASK 4: Test Track Study of the Performance of Production ABS Over a Broad Range of Real World Situations

This task endeavors to measure the braking performance of an assortment of ABS-equipped vehicles over a broad range of driving conditions. The goal of this task is to attempt to find situations and/or conditions in which many vehicles equipped with ABS do not perform as expected due to shortcomings in either the ABS hardware, algorithm, or other software. This effort involves in-depth examinations of one system from each major ABS manufacturer resulting in a total of approximately 8 systems being examined. Each system was tested on a separate vehicle.

The antilock brake system evaluation spans a broad and comprehensive range of driving maneuvers with respect to vehicle speeds, vehicle loading conditions, road surfaces (adhesion and texture), steer angles, split mu's, transition surfaces, etc. This evaluation scheme involves testing many maneuvers for each ABS design. The focus of testing is to find situations in which there are gross differences in vehicle performance due to the presence/absence of ABS. For example, ABS-equipped vehicles are known to exhibit poorer stopping performance on loose gravel and snow. The goal of this task is to find if there are other situations where the performance of all ABS-equipped vehicles is grossly worse in comparison to non-ABS-equipped vehicles and in comparison to the population.

TASK 5: Conduct Tests to Assess the Prevalence of Driver "Oversteering" in Panic Braking Situations

This task involves the examination of driver behavior in panic, crash-imminent situations involving passenger car conventional brake systems and ABS. Crash data suggest that drivers may be using ABS inappropriately or otherwise exhibiting incorrect or extreme behaviors with ABS which lead to increased crashes. For example, drivers may use the same strategies, in terms of pedal application, in panic braking situations involving ABS-equipped vehicles as they do in non-ABS-equipped vehicles. Aspects of driver behavior to be focused on in an effort to address this issue also include steering and other types of crash avoidance reactions.

A previous study of driver behavior in an intersection incursion scenario for non-ABS-equipped vehicles which was conducted on the Iowa Driving Simulator found that drivers tend to first apply the brakes aggressively, locking all four wheels, and then steer. The observed steering amplitudes were generally very large. In the case of conventional brakes, large amplitude steering has no effect on the vehicle's direction of travel since vehicles with all four wheels locked travel in basically a straight line. A hypothesized reason for the increase in single-vehicle crashes and decrease in multi-vehicle off-road crashes with ABS is that driver's use the same braking and steering strategy for ABS-equipped vehicles. Since with

ABS (four-wheel ABS, in particular) all of the vehicle's wheels may not lock, the vehicle's steering remains fully effective. Large amplitudes of steering motion (such as are frequently seen for vehicles not equipped with ABS) have the potential to cause the vehicle to run off of the road. This may be a plausible explanation of why four-wheel ABS-equipped vehicles tend to be involved in more rollover incidents or off-road crashes with fixed objects.

The main goal of this task is to determine whether drivers exhibit instinctive crash avoidance responses (i.e., braking, steering, "over-steering", etc.) in an effort to avoid hitting another vehicle. A second goal of this task is to determine, if drivers do, in fact, exhibit an instinctive behavior pattern involving heavy braking and steering, and whether drivers exhibit this behavior with vehicles equipped with both conventional and antilock brakes. This task will involve both simulator and test track studies (using instrumented vehicles) which examine driver behavior in a variety of different conflict situations (e.g., intersection incursion, brake-in-curve leading to run-off-road, and other obstacle avoidance).

Task 5.1: Driving Simulator Study
Driver behavior in an intersection incursion scenario with a four-wheel ABS-equipped vehicle will be examined on the Iowa Driving Simulator (IDS). A previous study examined driver steering and braking reactions in a vehicle equipped with conventional brakes. This study will expand upon the previous between-subjects study in order to determine the effects of four-wheel ABS on driver behavior and their ability to avoid a collision in this scenario. Specifically, this study will investigate driver crash avoidance behavior as a function of speed limit and how ABS instruction and posted speed limit affect drivers' ability to avoid crashes with ABS versus conventional brakes.

Task 5.2: Dry Test Track Study
Driver behavior will be examined in crash-imminent situations on a test track with actual vehicles equipped with both conventional and antilock brakes on dry pavement. The scenario to be used will involve an intersection incursion similar to that used in the Task 5.1 study described above. This study will endeavor to determine the effect of four-wheel ABS, ABS instruction, and braking practice on drivers' behavior and ability to avoid a collision in a crash-imminent situation.

Task 5.3: Wet Test Track Study
This study also involves the examination of driver behavior in a crash-imminent situation on a test track with actual vehicles as a function of conventional versus antilock brakes. However, this study will involve examination of driver behavior in a crash-imminent situation on wet pavement. This study will also address the effect of four-wheel ABS on drivers' behavior and ability to avoid a collision in a crash-imminent situation and the effects of providing ABS instruction to drivers.

TASK 6: Test the Effects of ABS When Performing a Two-Wheel Road Recovery Maneuver

The task will address the problem of driver recovery of vehicle control after having allowed two wheels to stray from the road surface onto a surface having a different frictional coefficient (e.g., gravel) and surface height change or road edge drop-off. This vehicle control recovery scenario is a common one which frequently occurs at curves wherein drivers enter a curved portion of roadway at a speed which is too high for them to maintain adequate control resulting in their inability to maintain the vehicle in the lane. The scenario in which two wheels leave the roadway also may occur when a driver falls asleep at the wheel or during an evasive maneuver. ABS could prevent optimal braking performance on gravel or other non-paved surfaces. Thus ABS may complicate the drivers ability to return their vehicle fully onto the roadway. This task will assess issues relating to the effects of ABS on drivers' ability to recover vehicle control and lane position in this type of situation.

TASK 7: Study Driver Risk Compensation in Relation to ABS-Equipped Vehicles

This task endeavors to assess passenger car ABS-related driver risk compensation. This task will examine the behavior of drivers to determine whether they tend to drive more aggressively (e.g., drive faster, brake harder, make more abrupt maneuvers) with ABS-equipped vehicles. Aggressive driving behavior is likely to contribute to increased incidence of rollover crashes. Aspects of driver behavior to be focused on in an effort to address this issue include steering, braking, and following distance. Observations will also be made to determine whether drivers tend to operate ABS-equipped vehicles at higher speeds than non-ABS-equipped vehicles. Studies will be conducted to collect data on driver behavior during normal driving maneuvers and activities such as speed maintenance and braking aggressivity.

Task 7.1: License Plate Study
Changes in vehicle speeds due to the presence of ABS will be examined by unobtrusively observing drivers on public roadways in various weather conditions. The speed at which vehicles are traveling will be measured and license plate numbers will be recorded from an inconspicuous off-road location. From the license plate numbers, VINs will be obtained. These VINs will then be decoded to determine whether the vehicle has ABS.

Task 7.2: On-Road MicroDAS Study
Driver aggressivity with and without ABS will be examined using vehicles equipped with the NHTSA-developed MicroDAS [12] instrumentation package. MicroDAS is an unobtrusive system for measuring and recording driver and vehicle behavior. Six identical, instrumented vehicles will be driven by 12 to 18 subjects. Each subject will drive a vehicle in their normal, everyday driving for a period of two months, one month with ABS enabled and one month with ABS disabled. Subject groups will be representative of the general driving population. Data will be collected

to assess drivers' steering, braking, and following distance behavior during this period.

TASK 8: Assess the Overall Effect of Passenger Car ABS on Drivers' Ability to Avoid Crashes

This task will involve the examination of ABS performance and the ability of drivers to accurately make use of ABS to avoid crashes. ABS performance data and ABS-related driver behavior data will be compiled to form conclusions regarding the underlying cause(s) of the shift in crash statistics with ABS. Forming this conclusion will facilitate the development of a general consensus among the ABS research community and ABS manufacturers as to why past studies of ABS effectiveness in real world operation have found mixed results. Research results will be shared with ABS stakeholders and meetings will be held to discuss research and test program results and determine appropriate future activities to increase the effectiveness of ABS for passenger vehicles.

TASK 9: Status Briefings

NHTSA will conduct status briefings as necessary for the purpose of sharing knowledge and new-found facts regarding ABS performance and driver interaction with ABS with interested parties within NHTSA and the public at large. Summaries of current research efforts and results-to-date will be presented for discussion. Status briefings will be conducted approximately twice per year to keep stakeholders abreast of task progress and acquire their input.

NHTSA's Light Vehicle ABS Research Program is only a first step in obtaining the anticipated safety benefits from ABS. This program deals solely with trying to learn why the crash database studies did not find the anticipated increase in safety for ABS-equipped automobiles. The development of countermeasures to resolve any problems discovered is left to future research.

PROGRAM PROGRESS TO DATE

Work on NHTSA's Light Vehicle ABS Research Program began in December 1996. The planned completion date for the entire program is September, 1999.

Research during Federal Fiscal Years 1997 and 1998 focused on Tasks 1 through 5 and 9. While substantial progress has been made on all of these tasks, only Tasks 4 and 5 have been completed. Findings from Tasks 4 and 5 are reported upon in a set of three companion papers. The paper "A Comprehensive Light Vehicle Antilock Brake System Test Track Performance Evaluation," [13], presents the Task 4 work. The paper "Driver Crash Avoidance Behavior in Light Vehicles Equipped with ABS," [14], presents the results of the Task 5 Wet and Dry Test Track studies. Finally, the paper "Driver Crash Avoidance Behavior in Light Vehicles Equipped with ABS on the Iowa Driving Simulator," [15], presents the results of Task 5.1.

Work on Tasks 6 through 8 began in September, 1998. As of December, 1998, the status of each task in NHTSA's Light Vehicle ABS Research program is as follows:

Table 5: Summary of NHTSA Light Vehicle ABS Research Program Task Status

TASK	STATUS
1	VIN number decoding to be completed by January, 1999. Task should be completed by April, 1999.
2	Questionnaire design completed. Survey administration underway. Task should be completed by August, 1999
3	Task should be completed by January, 1999.
4	Completed
5	Completed
6	Task should be completed by August, 1999.
7	Task should be completed by August, 1999.
8	Task should be completed by September, 1999.
9	Ongoing

NHTSA's research to date has not succeeded in determining the reasons for the apparent increase in single-vehicle, road departure crashes for automobiles equipped with ABS. It is hoped that completion of the remaining tasks in NHTSA's Light Vehicle ABS Research Program will make the reasons for this unexpected statistical finding clear.

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