EVALUATION PLAN FOR FEDERAL MOTOR VEHICLE SAFETY STANDARD 208 OCCUPANT CRASH PROTECTION

OCTOBER 1979

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EXECUTIVE SUMMARY

Federal Motor Vehicle Safety Standard 208 will require automatic crash protection for front seat occupants in full-sized automobiles beginning in model year 1982. Automatic crash protection will be required for intermediate and compact passenger automobiles in model year 1983, and for subcompacts in 1984. Automatic restraints have been available as optional equipment on a few makes and models since 1974. There were over 150,000 such automobiles on the highway by mid-1979 and more are expected to be sold prior to the Standard's effective date. Standard 208 is one of the National Highway Traffic Safety Administration's (NHTSA) most significant regulations.

This is NHTSA's proposed plan for evaluating automatic restraint systems and Standard 208 during the period 1980-86. The plan covers passenger automobiles equipped with automatic crash protection both prior to and after the Standard's effective dates. The development of an evaluation plan prior to the effective date of a major regulation is a requirement based on the President's Executive Order 12044 and the Department of Transportation's "Statement of Regulatory Policies and Procedures." The Department stated that it would evaluate the Standard in the preamble of the Standard issued in June 1977.

The National Transportation Safety Board (NTSB) and the General
Accounting Office (GAO) both reviewed Standard 208 and, in view of the
exceptional significance of the regulation, they also recommended that
NHTSA prepare a complete evaluation plan. The NTSB further recommended
that the plan be published for public comment by October 1979.

The evaluation plan, as can be seen below, addresses an extensive list
of specific questions. Most of the questions are not new: NHTSA has
developed, to date, answers to most of them as a result of an extensive
program of testing, data collection and analysis of automatic
restraints. NHTSA has, for example, published estimates of the
effectiveness of restraints, their cost, and the likely usage rates of
automatic belts and has refined the estimates as additional information
became available. Since 1978, and throughout the period of the
implementation of Standard 208, NHTSA will publish Occupant Protection
Program Progress Reports.

The purpose of this evaluation plan is to make further refinements in
the assessment of the actual, on-the-road experience of automobiles with
automatic restraints as the Standard takes effect. Also, should
unexpected problems occur with particular cars equipped with automatic
restraints, the evaluation plan will enable NHTSA and the auto makers to
become aware of them promptly and to take remedial action. This could
also encourage foreign car manufacturers to increase the variety of
automatic restraint system designs available to the American public. If
consumers have a choice of restraint systems, and have the information
developed in the evaluation available, they are more likely to make a
choice of systems that will give them the best protection.
The primary objectives of this evaluation are:

o   To measure the actual overall effectiveness of automatic
    restraints in reducing fatalities and injuries in highway
    crashes.

o   To observe the operational characteristics of restraint systems
    on the road and their effectiveness in specific crash situations.

o   To assess the public acceptance and utilization of automatic
    restraints.

o   To assess the industrial consequences of the Standard.

o   To perform a cost analysis of the Standard, including
    manufacturing, repair, and replacement, and to analyze insurance
    savings, etc.

These 5 general objectives subsume a larger number of specific
questions. NHTSA formulated 30 individual evaluation questions and
ranked them by priority. The questions that have the highest priority
are:

o   What is the fatality reducing effectiveness of the various
    production automatic restraint systems?

o   What is the injury reducing effectiveness of the various
    production automatic restraint systems?

o   What are the attitudes of the general public and of new car
    buyers toward the Standard?

o   What injuries do people in crashes receive with automatic
    restraints? How do they compare with injuries that would have
    occurred if the occupants had been unrestrained?

o   Are there any instances of automatic restraint malfunctions in
    crashes?

o   Are there any instances of automatic restraint malfunctions
    during normal vehicle operations?

o What other automatic restraint system malfunctions occur? How frequent are the malfunctions and what are their causes?

o What is the sales mix of air bags and automatic belts?

o What is the automatic belt usage rate?

o How effective are automatic restraints as a function of automobile size?

The questions next in priority are the following:

o What is the frequency of air bag deployment in crashes? What types of crashes cause deployments?

o What is the casualty reducing effectiveness of automatic restraints at various levels of crash severity? At various directions of crash force?

o How effective are restraints in exceptional crash situations, such as with occupants of unusual size, with occupants who are not in the normal seating position, or under extreme operating conditions?

o How are undeployed air bags disposed of when vehicles are scrapped? Do vehicle disposal techniques pose any health or environmental hazards?

o How comfortable and convenient are various production automatic belt systems relative to one another?

o What is the cost of automatic restraints?

o What is the cost of replacing automatic belts or air bags deployed in crashes? To what extent is it paid by insurance companies?

o What is the effect of the Standard on insurance costs?

o What product liability claims are made relating to automatic restraints? Are product liability claims generally reduced as a result of automatic restraints?

The remaining questions are lower in priority, but should be addressed to the extent that resources permit:

o What crash injuries do users of the various automatic restraint systems experience?

o Is there a difference in the effectiveness of automatic restraints by seating position (i.e., driver, right front, center front)?

o How are various production automatic belts disconnected or otherwise not used? What are the reasons for disconnecting or not using them?

o How often are deployed air bags not replaced in cars that are crashed and later repaired?

o How often are malfunctioning restraint systems left unrepaired?

o How does the standard affect consumers' car buying habits?

o How does the Standard affect manufacturers' decisions on automotive design, production and marketing?

o What is the effect of NHTSA public information programs on restraint purchase and usage?

o What, if any, is the cost of routine maintenance of restraints?

o What is the cost of repairing malfunctioning restraint systems?

o What is the economic impact of the Standard on restraint system suppliers?

The NHTSA evaluation plan consists of 14 projects that will be scheduled
to provide timely and reliable results on each of the evaluation
questions, especially on the high-priority questions. The projects
involve such disciplines as accident investigation and analysis,
economic analysis and consumer surveys. NHTSA considers the plan to be
feasible and consistent with potentially available resources. The
specific projects are:

o National Accident Sampling System data collection and analysis

o Fatal Accident Reporting System data analysis

o State accident data analysis

o In-depth accident investigation and clinical analysis

o Analysis of reports to NHTSA's "Auto Safety Hotline"

o Analysis of information from auto manufacturers and restraint
   system suppliers

o Analysis of new car registration data

o Analysis of on-the-road belt usage observations

o New car owner survey

o Public survey

o Controlled tests of automatic belt comfort and convenience

o Cost and weight study based on component teardown of production
   restraint systems

o Analysis of auto repair manual data to determine the number of
   restraint system replacements, and repair jobs.

o Analysis of insurance cost data

In addition to these specific evaluation projects, NHTSA has six ongoing programs that pertain to Standard 208:

o   Industry monitoring activities

o   Research, development and testing of occupant crash protection

o   Safety belt usage stimulation

o   Automobile crashworthiness ratings

o   Defects investigation

o   Standards enforcement

While these programs are not part of the evaluation plan per se, they will contribute useful data to the evaluation effort. In turn, the evaluation findings will play a role in shaping the future course of these programs.

The anticipated completion milestones - the dates when interim or summary reports dealing with an evaluation question can be prepared - are sensitive, to some extent, to factors outside of NHTSA's control, such as the auto makers' production plans and the sales mix of air bags and automatic belts. These factors could advance or delay the completion of some of the analyses by as much as a year. The following, however, is a year-by-year list of likely evaluation accomplishments during the period from calendar year 1980 through calendar year 1986:

1980

o Initial estimates of automatic belt fatality and injury reduction

o Continuing in-depth investigation of selected accidents involving cars with automatic restraints

o Collection of production and sales information

1981

o Initial estimate of manufacturing cost of automatic restraint systems

o Collection of initial insurance cost information

1982

o Initial estimates of air bag fatality and injury reduction

o Initial public survey on consumer attitudes towards the Standard

o First study of on-the-road usage of automatic belts in post-Standard cars

o Refinement of estimates of the manufacturing cost of automatic restraints

o First report on product liability claims experience

1983

o Refined estimates of injury and fatality reduction

o Report on restraint-malfunctions and types of injuries with automatic restraints.

o Estimate of air bag deployment rate

NHTSA'S CALL TO EVALUATE STANDARD 208

Introduction

The National Highway Traffic Safety Administration (NHTSA) was
established in 1966, at a time when traffic fatalities had increased by
40 percent in 5 years. During NHTSA's first 10 years, as a result of
the Agency's safety programs and other factors, fatalities decreased by
18 percent. The fatality rate per 100 million vehicle miles dropped a
dramatic 40 percent.

But in 1976 fatalities began to edge upwards. The fatality rate per 100
million vehicle miles resumed climbing in 1977. The rising number of
small cars, which must share the road network with a rapidly increasing
fleet of light and heavy trucks, suggests that the fatalities would
continue to rise unless safety programs are upgraded.

The Federal Motor Vehicle Safety Standards (FMVSS) are one of NHTSA's
principal safety programs. Each standard requires certain types of
motor vehicles or motor vehicle equipment sold in the United States to
meet specified safety performance levels. Standard 208, which took
effect in 1968, required that occupant restraint systems (safety belts)
be installed in passenger cars. Unfortunately, the Standard has failed
to achieve its life-saving potential because the seat belts are not

effective unless manually fastened by the occupants. Most occupants (*currently 86 percent*) *do not choose to fasten their belts.*

Therefore, NHTSA has revised Standard 208 to require automatic occupant protection systems at each front seating positon in passenger cars. Automatic restraints require no fastening action by the occupants, thereby eliminating the principal shortcoming of current manual safety belts. The revised Standard specifies performance tests that can be objectively carried out under controlled conditions. Any restraint system that meets the test requirements could be installed in response to the Standard. Practically speaking, however, one of two alternative systems - the air bag or the automatic belt - will probably be used in most if not all cars. These restraints have already proven feasible, producible and capable of meeting the test requirements.

The revised version of Standard 208 (hereinafter referred to, simply, as "the Standard" or "Standard 208") takes effect on September 1, 1981 for cars whose wheelbase is greater than or equal to 114 inches. In other words, it takes effect for full-size cars in the 1982 model year. Cars with wheelbases of 100 - 113.9 inches (compacts and intermediates) must meet the Standard in model year 1983. Cars with a wheelbase under 100 inches (subcompacts) will have automatic restraints in model year 1984.

Standard 208 is somewhat unique in that substantial on-the-road exposure of automatic restraint vehicles will take place before the effective date. There are over 150,000 automatic restraint vehicles now on the

road (12,000 with air bags and the remainder with automatic belts).
There will be even more by September 1981. The experience with these
cars has already demonstrated the workability of automatic restraints;
these vehicles and their on-the-road exposure, both before and after
September 1981, needs to be considered in any plan for evaluating
Standard 208.

Since front-seat occupants of passenger cars account for 50-60 percent
of all traffic fatalities (about 500 persons killed each week) and since
automatic occupant restraint systems have great life-saving potential,
Standard 208 is clearly a significant safety program to reverse the
recent upward trend in the fatality rate.

NHTSA's Evaluation Mission

On March 23, 1978, the President issued Executive Order 12044, titled
"Improving Government Regulations." It called for a Government-wide
analysis of proposed major regulations and review of existing regulations.
The Secretary of Transportation responded to Executive Order 12044 with
a "Statement of Regulatory Policies and Procedures" dated February 26,
1979. His statement seconds the President's initiative and further
requires that prior to the effective date of any significant regulation,
the responsible agency will develop a plan for evaluating the regulation
after its issuance.

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The National Transportation Safety Board (NTSB) and the General Accounting Office (GAO) both reviewed Standard 208 and, in view of the exceptional significance of the regulation, they recommended that NHTSA prepare a complete evaluation plan. The NTSB further recommended that the plan be published for public comment by October 1979. The GAO recommended that the plan be developed by "a task force comprised of representatives from the Safety Administration, the insurance industry, the automobile industry, and independent highway safety researchers." The agency responded that it would have its plan reviewed by the National Accident Sampling System Advisory Committee, which is made up of an even broader spectrum of parties.

This report contains NHTSA's plan for a complete evaluation of Standard 208 over a period of approximately 7 years, beginning in 1980. The evaluation covers the period before as well as after the Standard's September 1981 effective date. Automatic restraint vehicles sold prior to the effective date will be included in the evaluation.

The evaluation plan attempts to cover all aspects of Standard 208. Its primary objectives are

o To measure the overall effectiveness of automatic restraints in reducing fatalities and injuries in highway crashes.

o To observe the operational characteristics of restraint systems on the road and their effectiveness in specific crash situations.

o To assess the public acceptance and utilization of automatic
  restraints .

o To assess the industrial consequences of the Standard.

o To perform a cost analysis of the Standard, including
  manufacturing, repair, and replacement, and to analyze insurance
  savings, etc.

With its broad scope, the evaluation plan satisfies the requirements
of Executive Order 12044 that the review examine whether a regulation
achieves its goals, imposes unnecessary burdens, causes serious public
dissatisfaction or fuels inflation.

Standard 208 is also somewhat special in that a number of detailed
evaluation plans already exist. Since the plan draws heavily on several
previous ideas, it is appropriate to briefly review them here.

Earlier Automatic Restraint Evaluation Plans

The NHTSA has for many years devoted attention to evaluation of
automatic restraints in use. A complete evaluation plan was developed
in the Fall of 1973. The plan addressed evaluation of air bag
effectiveness, operational characteristics and public acceptance. It
was based on the assumption that General Motors would sell 150,000 air
bag equipped cars in 1974-75. The plan could not be carried out because
only about 10,300 air bag equipped cars were produced for sale to the
public.

Two contracts for evaluation methods of Standard 208 were completed in
1976 (DOT HS-802 348 and DOT HS-802 341). They primarily addressed the
effectiveness and cost of restraint systems but did not give a detailed
time table for evaluation because the final ruling on Standard 208 was
pending at the time.

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A plan was prepared for evaluating air bag equipped cars in conjunction with the field test proposed by the Secretary Coleman in his 1976 ruling. An analagous plan was developed for automatic belt equipped passenger cars. Both plans dealt mainly with the measurement of effectiveness. Neither was published, because the field test decision was changed shortly thereafter.

The Period before September 1981

Highway operation of automatic restraint vehicles began in 1972 with two manufacturers' air bag test fleets totalling just under 2000 vehicles. General Motors offered air bags to the general public as an option on certain cars during 1974-76 and sold a total of 10,000 such cars. Volkswagen introduced automatic belts as an option in 1975 and sold a total of about 180,000 such cars during model years 1975-79. General Motors produced about 10,000 automatic belt cars in 1978. The automatic restraint vehicles sold to date (Fall 1979) will have accumulated approximately 850,000 vehicle years of on-the-road experience by September 1981; 85,000 of the vehicle years will be in air bag equipped cars.

Increased sales of automatic restraint vehicles in model years 1980 and 1981 are anticipated. The selection of cars with automatic belts will be expanded. NHTSA estimates sales of approximately 75,000 automatic belt cars in model year 1980 and 150,000 in model year 1981. It is possible that over 50,000 air bag equipped autos will be sold in model year 1981 depending on final plans by manufacturers.

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The exposure of these optionally equipped vehicles could be substantial. Moreover, the optionally equipped cars will continue accumulating on-the-road experience after September 1981. Finally, NHTSA anticipates that an additional 150,000 smaller cars with optional automatic belts will be purchased in both the 1982 and 1983 model years.

The on-the-road experience of the optionally equipped vehicles will make a substantial contribution to the evaluation of Standard 208.

There may be, however, certain differences between the experience with optionally equipped vehicles and the subsequent experience with mandatory automatic restraints. Persons who voluntarily purchase cars with automatic belts are more likely to use them (80% usage has been observed in the Volkswagens [15]) than those required to purchase an automatic restraint vehicle. The restraint hardware used before 1982 may differ from subsequent equipment. It is also possible that the make/model mix of the optionally equipped cars may be somewhat different from the nation's vehicle fleet. These differences will be identified and taken account of during the evaluation of experience with optional and mandatory automatic restraints.

Automatic restraints made before the standard takes effect have to meet the performance requirements of the standard. It must be recognized that there is no one kind of air bag or automatic belt but rather a variety of each with different costs, performance, effectivenss and other features. The evaluation, while differentiating among major automatic restraint systems (typically air bags and automatic belts) will reflect an "average" of systems that are in the field as a result of manufacturer choice.

The Period after September 1981

The duration of the evaluation effort and the choice of evaluation methods is highly dependent on what will be happening, in terms of sales and usage of alternative automatic restraint systems, after September 1981.

Prior to developing a plan, it is necessary to discuss factors that affect sales and usage for the 5-year period following September 1981. This involves 3 principal questions:

(1) What will be the distribution of passenger car sales, by wheelbase size, in 1982?

This question is important because the effective date of the Standard depends on the wheelbase size, i.e., model year 1982 for cars with wheelbase $\geq$ 114 inches, 1983 for cars $\geq$ 100 inches and < 114 inches,

1984 for cars < 100 inches. The more cars there are that fall into the first category, the sooner there will be a fleet large enough to produce accident sample sizes needed for statistically significant results.

Information supplied by the manufacturers suggests that full-size and luxury cars are most likely to have wheelbases ≥ 114 inches in model year 1982. The 100-113.9 inch category will most likely include the domestic compacts and intermediates as well as Mustang, Capri and a small percentage of the imports. The remaining domestic subcompacts and imports will have wheelbases under 100 inches.

The distribution of motor vehicle sales in January-May 1979 was as follows:

TABLE 1-1

AUTO SALES BY SIZE CATEGORY

Wheelbase Size Range (inches)	1979 auto sales January - May
≥ 114	20%
100 - 113.9	47%
< 100	33%

This distribution is expected to stay about the same between now and 1982. There is currently a trend toward smaller fuel-efficient cars. But since a substantial amount of weight will be trimmed from many

models between now and 1982, the trend toward smaller cars can be maintained without appreciably changing the market mix by wheelbase.

(2) What percentage of vehicles will have air bags after 1982?

This question is important because the higher the percentage of cars with bags, the sooner there will be an adequate sample size for measuring the effectiveness and operational characteristics of air bags.

In general, cars with 3 designated front-seating positions will probably have air bags, because there does not appear to be an interest in developing an automatic belt that can be used by a center-front occupant. These are primarily larger cars with bench seats. Cars with 2 designated front-seating positions (subcompacts, many compacts and larger cars with bucket seats or permanent center armrests) are more likely to have the less costly automatic belts, although there may be substantial demand for the convenience of air bags.

A summary of public attitudes toward automatic crash protection in new cars showed that of the 62 percent who knew what an air bag was, 35 percent would pay more than $100 or more for one (Yankelovich, 1976). A 1977 Gallup survey found that the public favors requiring air bags 46 percent to 37 percent. A survey by Hart (1978) showed that there are nearly equal public preferences for air bags and automatic belts.

Three alternative air bag sales levels (called A, B and C) are assumed to cover the likely range of possibilities:

TABLE 1-2

PERCENT OF CARS WITH

AIR BAGS

(Alternative Assumptions)

Air Bag Sales Level	Wheelbase Range		
	$\geq$ 114"	100-113.9"	$\leq$ 100"
A	50	40	25
B	30	25	10
C	10	10	Trace

For sales Level A, it is assumed that air bags will be standard on bench seat cars and that manufacturers will not substantially reduce production of bench seat cars. Levels B and C assume an increasing diversion of production to vehicles with only 2 designated front seating positions.

(3) What will be the belt usage rate by occupants of automatic belt vehicles? (What percentage of belts will not be disconnected by owners nor disabled by a malfunction?)

This question is critical because the higher the belt usage, the sooner there will be an adequate sample of belt users for measuring effectiveness.

Belt usage will probably not be constant over the life of the car but could decline gradually as the car gets older, with most of the decline taking place in the first 2 years [5].

Three alternative belt usage levels (called A, B, and C) were assumed to cover the likely range of possibilities:

TABLE 1-3

AUTOMATIC BELT USAGE RATES
(Alternative Assumptions)

Belt Usage Level	After 1 year	After 2 years
A	80%	60%
B	60%	30%
C	30%	20%

Usage Level A approximately reflects the experience with automatic belt vehicles currently on the road (in which purchase of automatic restraints was voluntary). Usage Level C more or less reflects what happened with the manual belt-starter interlock combination that was mandated in 1974. Levels A and C reflect the bounds for post-Standard automatic belt usage.

About 1/3 of the evaluation projects included in the recommended NHTSA evaluation plan are sensitive to air bag sales and automatic belt usage - i.e., the work can be completed sooner if sales and usage are higher. In the listing of completion milestones (Chapter 5), a range of

potential completion dates, rather than a single date, has been estimated for these projects. In general, the beginning of the range applies to the scenario wherein both air bag sales and automatic belt usage achieve Level A; the end of the range corresponds to sales and usage both Level C. Other combinations of sales usage (e.g., sales Level A and usage Level C) would tend to result in intermediate completion dates.

It will not be necessary to drop any project or substantially change the evaluation approach presented in this plan, even if sales and usage fall as low as Level C.

Summary of Projected On-the-Road Experience Before and After 1981
Table 1-4 shows the combined on-the-road experience of optional and mandatory automatic restraint vehicles during 1979-83. Separate projections were made for air bags and automatic belts. NHTSA's projections of sales of optional automatic restraints were discussed above; mandatory restraint sales are projected according to Level B. Table 1-4 shows, for each year from 1979 to 1983, the total number of vehicles that will be on the road on October 1 of that year and the cumulative exposure, in vehicle years, from the time the cars were produced until October 1 of that year. The table shows the number of towaway accidents likely to have occurred as a consequence of this exposure and the number of front-seat occupants involved. Finally it projects the number of severe injuries and fatalities likely to occur, assuming current NHTSA estimates of restraint effectiveness (see Appendix A).

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TABLE 1-4

PROJECTIONS OF CUMULATIVE ON-THE-ROAD
EXPERIENCE WITH AUTOMATIC RESTRAINT VEHICLES

		Vehicles On the Road (000) [1]	Cumulative Vehicle Years (000)	Cumulative Towaway Accidents [2]	Cumulative Occupants Involved [2]	Cumulative Expected [3] Injuries AIS ≥ 3	Cumulative Expected [3] Fatalities
AIR BAGS							
(Thru Oct. 1)	1979	12 [4]	63 [4]	750 [5]	1,000 [5]	30 [5]	6 [4]
	1980	12	75	1,000	1,300	35	7
	1981	112	137	2,200	2,900	62	15
	1982	770	580	11,000	15,000	270	70
	1983	2,700	2,300	45,000	60,000	1,000	280
AUTOMATIC BELTS							
(Thru Oct. 1)	1979	190 [5]	380 [5]	7,600 [5]	10,000 [5]	180 [5]	50 [5]
	1980	265	610	12,000	16,000	290	80
	1981	315	950	19,000	25,000	450	120
	1982	2,000	2,100	42,000	56,000	1,100	290
	1983	7,600	6,900	140,000	180,000	3,800	1,000

1/ Projections assume sales level B.
2/ Projections based on towaway and occupancy assumptions in Appendix A.
3/ Projections based on belt usage level B, 15% lap belt usage with air bags, 80% belt usage in optional automatic belt cars, and injury rate and restraint effectiveness in Appendix A.
4/ Actual.
5/ Estimated actual.

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A significant feature of Table 1-4 is the contrast between the projected air bag and automatic belt exposure. There will not be enough air bag cars on the road to provide a substantial body of accident data until calendar year 1982. The automatic belt cars, on the other hand, have already been involved in a large number of towaway accidents and are expected to experience more before the standard's effective date.

Organization of this Report

The specific objectives and projects that constitute the NHTSA evaluation plan for Standard 208 are discussed in Chapters 3-5. Preceding this detailed discussion, Chapter 2 provides background information on the range of NHTSA activities related to the implementation and enforcement of Standard 208 and development of occupant protection systems. These concurrent activities, while not part of the evaluation plan per se, will supply information that contributes to NHTSA's overall evaluation program for the Standard.

The 4 principal objectives of this evaluation (effectiveness, operational characteristics, public acceptance and cost) encompass 30 specific evaluation questions, which are examined in detail in Chapter 3.

Chapter 4 contains a description of each evaluation project recommended for inclusion in the NHTSA evaluation plan.

Chapter 5 groups the evaluation questions according to their relative priorities. It shows, for each question, the evaluation projects that will provide the necessary data and the expected completion milestones. Finally, a summary plan schedule and a preliminary projection of resource requirements for the evaluation projects are presented.

Appendix A explains the computations of casualty-reducing effectiveness and its variability.

CHAPTER 2

BACKGROUND: OTHER NHTSA PROGRAMS THAT PERTAIN TO FMVSS NO. 208

The NHTSA has six major programs pertaining to the implementation
and enforcement of FMVSS No. 208 and the development of occupant
crash protection. They are briefly described below. While these
are ongoing activities and not part of the evaluation plan per se,
they have important ties to the FMVSS No. 208 evaluation program.
They provide additional field, laboratory and test data that will
assist the overall evaluation effort. They will aid in the early
identification of possible operational or consumer acceptance
problems with automatic restraints. They may help provide
engineering explanations of some phenomena that could be observed in
the evaluation projects. At the same time, the findings from the
evaluation projects will help shape the future activities under
these programs.

Industry Monitoring Activities

When Secretary of Transportation Brock Adams issued the automatic
restraint mandate June 30, 1977, he committed the Department to an
intensive monitoring program to oversee the implementation plans of
both vehicle manufacturers and their suppliers. The purpose of this
monitoring program, which has been ongoing since the fall of 1977,

is not only to confirm that adequate levels of reliability and quality are being achieved in implementing designs to comply with the standard, but also to provide assurance to the public that the issues that have been raised on automatic restraint reliability have been resolved.

The Agency has and will continue to be in direct contact with the vehicle manufacturers and their suppliers to monitor the progress of engineering and test programs, and programs to train and prepare vehicle dealers to sell and service automatic restraint equipped vehicles. This fosters a high level of government/industry communication, cooperation and coordination to help ensure successful achievement of the NHTSA's overall automatic restraint systems objective.

Research, Development, and Testing

This activity is a continuation of the independent research, development, and test work that NHTSA has sponsored for several years. Areas of activity include (1) technical assessments of automatic restraint systems and their application to passenger cars of various types, (2) the conduct of tests of such systems and vehicles to determine their performance characteristics in conventional and non-conventional crash modes and with various surrogate occupant situations, (3) the preparation of engineering assessments of particular restraint systems including the development of pertinent information on the production feasibility,

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quality, and reliability of automatic restraint systems and (4) research and development on advanced concepts in automatic occupant protection that will prepare the Agency for future advances in the occupant restraint standards.

Safety Belt Usage Stimulation

It is well documented that manual safety belt usage is very low. Current usage, nationwide, is about 14 percent, leaving more than five out of six motorists unprotected from serious crash injuries. Increasing manual belt usage has been and still is a very important NHTSA objective, notwithstanding the forthcoming introduction of automatic restraints. There are over 120 million passenger cars, light trucks, and vans on the road today equipped with manual belts. Moreover, an additional 40 to 50 million such vehicles still with manual belts will enter the fleet between now and 1984 when FMVSS No. 208 will be fully effective. Even then, some cars equipped with automatic systems will continue to offer manual lap belts for additional protection, and trucks and vans may have manual belts for several more years.

Since 1970, the NHTSA has spent approximately $2 million on research and evaluation studies concerning safety belt use, and close to one million dollars for production, printing and distribution of educational materials for specific groups and for mass media.

The motor vehicle manufacturing industry and insurance industry along with several private safety organizations such as the National Safety Council and American Automobile Association also have been active in promoting the use of restraint systems. Most of these have conducted public information programs, often consisting of the distribution of brochures or radio or TV public service announcements. However, most of these groups have acted independently and without knowledge of what others were doing in this area.

In response to this, an informal confederation of organizations that are directly interested in promoting occupant restraint usage was formed in late 1978. The confederation consists of NHTSA, the National Safety Council, the motor vehicle manufacturing industry, the insurance industry, and a number of additional organizations.

The goals of the confederation are (1) to achieve maximum coordination among the various organizations in the implementation of ongoing or planned programs to increase the availability or use of occupant restraint systems, and (2) to provide a means to identify, develop, and implement cooperative programs in any or all of the following specific areas: manual safety belts, child restraint systems, automatic restraints. The activities of the confederation will address all restraint systems, while member organizations will be free to pursue their own individual goals and objectives to increase usage of restraint systems.

Because of the importance of restraint usage, the NHTSA has and will continue to work in cooperation with States, local traffic safety officials, private organizations, and consumer groups, to identify programs, informational materials, and other means for stimulating both manual and automatic belt usage.

Automobile Crashworthiness Ratings

One of the requirements of Title II of the Motor Vehicle Information and Cost Savings Act of 1972 is that the NHTSA establish and publish comparative automobile crashworthiness ratings. As a part of this effort, the NHTSA has initiated an ongoing program to develop crashworthiness ratings using experimental data generated from high speed crashes. The program entails frontal crash testing of a representative sample of cars of various sizes into a fixed solid barrier at speeds from 35 to 40 mph. Each test vehicle includes two fully instrumented 50th percentile test dummies in the front seats.

Automatic restraint equipped cars will be used in this ongoing program, as they become available, to evaluate the extent to which such vehicles exceed the minimum 30 mph crash speed requirement of the standard.

Defects Investigation

Congress recognized when passing the National Traffic and Motor
Vehicle Safety Act of 1966 that it would be impractical to issue
standards that address all conceivable aspects of performance for
all vehicle systems that could cause accidents, injuries, or deaths.
Therefore, defect investigations were authorized for the primary
purpose of influencing manufacturers to build products free of
safety-ralated defects and to assure that, when safety defects are
discovered, the manufacturers take appropriate action to correct
such defects.

As a part of its ongoing motor vehicle safety program activities,
the NHTSA monitors and analyzes information from vehicle owners,
accident reports, consumer group reports, manufacturer service
bulletins, and research reports to identify possible safety defects
that are unknown to or overlooked by the manufacturer. When safety
defect problems are discovered, appropriate action is taken to
assure that the manufacturer corrects the problem in a timely
manner. Particular emphasis will be placed on automatic restraint
systems as they enter the market place to provide early detection of
any reliability, quality, or design defects.

CHAPTER 3

EVALUATION OBJECTIVES

The evaluation objectives largely determine the content of the
evaluation plan. What are the objectives in the case of Standard 208 -
what are the facts, rates or quantities that must be determined to
measure the impact of the Standard?

The questions addressed in this evaluation fall into four basic
categories. First, there are questions relating to the overall
effectiveness of automatic restraints - the numbers of deaths and
injuries prevented - the bottom line benefits of the Standard. Second,
there is a need for information on the operational characteristics of
the restraint systems and, their effectiveness in specific crash
situations. The information is needed to identify potential areas for
improving the systems or the Standard itself. Third, there are
questions relating to public acceptance of the restraint systems.
Finally, it is necessary to know all major sources of expense (or
savings) to consumers as a result of the Standard.

A total of 30 questions or objectives have been identified for this
evaluation. They will now be discussed one-by-one, within the four
basic categories.

1. EFFECTIVENESS

1.1 <u>Fatality Reduction.</u> The number of lives that will be saved on the highway by Standard 208 is probably the single most important quantity sought in this evaluation effort. It is also crucial to measure the fatality reducing effect of specific restraint systems: the air bag, the air bag plus lap belt, the air bag system (including lap belt users and nonusers), the automatic belt when used, and the automatic belt system (including belt users and nonusers).

Fatality reduction may be expressed as a number or a percentage: e.g., "the Standard saves 9000 lives per year" or "air bags reduce the fatality risk by 40 percent." The latter is computed as follows:

$$\left[\left(1 - \frac{\text{Fatality rate of air-bag protected occupants}}{\text{Fatality rate of unrestrained occupants}} \right) \times 100\right]\%$$

The fatality rates could be fatalities per 100 crash-involved occupants or per 1,000,000 car years. The rates should be adjusted to control for differences in the populations using alternative restraint systems and their exposure. Appendix A provides details on the calculation of effectiveness and its statistical variability.

1.2 <u>Injury reduction.</u> The number of injuries that will be prevented annually by Standard 208 is a quantity of obvious interest.

Furthermore, it is desirable to categorize the injury reduction by severity level, because there are wide discrepancies in the severity of injuries. Injury reduction should be measured for Standard 208 as a whole and for each of the specific restraint systems, separately.

Injury reduction may be expressed as a number or as a percentage (see 1.1 Fatality Reduction). Injury reduction should be calculated for injuries of AIS $\geq$ 3 and AIS $\geq$ 2 or (less satisfactory) for police-rated fatal or "A" level injuries. "AIS" stands for the Abbreviated Injury Scale [1]. The computational procedures for calculating injury reduction are discussed in Appendix A.

2. OPERATIONAL CHARACTERISTICS

2.1 Frequency and characteristics of air bag deployment in crashes. Each air bag system on the market will contain sensors that are designed to signal for a deployment in response to crash pulses above a threshold level of severity. The threshold "level" will vary from system to system. It cannot be expressed by any single parameter (e.g., longitudinal velocity change during the crash) but it is related to the crash deceleration history in a way that is difficult to quantify.

What can be done is to determine the likelihood of deployment as a function of crash velocity change and other observable parameters (e.g., type of object struck or width of contact).

The purpose of gathering this information is three fold: (1) To determine the overall frequency of deployment of the various air bag systems. This must be known for calculating the total cost of replacement and for calculating the percent of vehicles with functional air bags. (2) To determine if there are high-risk situations in which certain air bag systems do not normally deploy - thereby providing information for improving these systems. (3) In those cases where manufacturers have suggested a velocity change at or above which the bag is most likely to deploy, the actual deployment experience can be compared to the manufacturer's specifications.

2.2 <u>Injury-contact point patterns of alternative restraint system users.</u> Classify the restrained occupants with non-minor injury by type of injury and by contact area that caused the injury (e.g., dashboard, windshield, etc.). Obtain, for each restraint system, the frequencies of the more common injury-contact point couples. Also determine the frequency of those injury-contacts, if any, that suggest a restraint system, although functioning as designed, did not provide adequate protection: e.g., steering-wheel caused injuries despite air bag deployment and windshield caused injuries despite use of automatic belt.

The frequencies are expressed as proportions of the total number of crash-involved occupants (injured plus uninjured) who suffered a particular injury from a particular contact point (e.g., 2 percent of the crash-involved occupants suffered non-minor head injury due to windshield contacts). The contact-injury frequencies for occupants using a specific restraint system are compared to the corresponding frequencies for unrestrained occupants in order to determine the effectiveness of the restraint system in preventing specific contact-injury combinations.

The purpose of collecting this information is to determine for which injury mechanisms restraint systems provide sufficient protection and for which ones there is room for improvement. It is especially important to determine if a restraint system is successfully preventing those types of injuries it was specifically designed to prevent (e.g., air bags and steering-wheel contact injuries).

2.3 <u>Types of injuries with automatic restraint systems.</u> Injuries that are a consequence of occupant contact with restraint system hardware or otherwise result from restraint system deployment are of special interest. The frequency and severity of such injuries, if any, need to be determined as well as the associated crash conditions. The information can readily be used to show areas of potential improvement of restraint systems.

Restraint-caused injury frequency can be expressed as a proportion of crash-involved occupants or as a proportion of injured occupants.

2.4 <u>Restraint system effectiveness by car size</u>. Smaller cars are relatively less crashworthy because they are less resistant to velocity change and because there is less space in which the occupants can be safely brought to a stop. Restraint systems are likely to be less effective in small cars than in large cars [12].

The effectiveness of restraint systems should be measured separately in cars of different sizes in order to:

o identify whether certain systems provide adequate protection to small car occupants.

o permit projections of the overall effectiveness of systems as more small cars enter the fleet.

The effectiveness of a restraint system for cars of a particular size category is expressed in the same terms as the effectiveness in cars of all sizes (see questions 1.1 and 1.2).

2.5 <u>Restraint system effectiveness by seating position</u>. Drivers, right front occupants and center front occupants are exposed

to different crash conditions and contact different parts of the vehicle interior. Also, in the case of air bags, the driver's and passengers' restraint systems are not identical.

For each type of restraint system, effectiveness should be measured separately by seat position in order to investigate the possibility that it does not provide adequate protection in one of the positions.

2.6 Restraint system effectiveness by crash severity and direction of force. The crash environment can be partitioned into cells by crash severity (Delta V) and direction of force. The effectiveness of automatic restraints should be determined in each cell. Inadequate performance in some of the cells may point out the need for relatively straightforward improvements in a restraint system (e.g. lowering the deployment threshold, putting a force-limiting device in belts). A secondary use of this information is to project the effect of changing driving conditions (e.g., a change in the speed limit) on the number of casualties prevented by the Standard.

2.7 Automatic restraint effectiveness in exceptional situations. Automatic restraints are designed to be effective for a wide range of occupant types (5th percentile female to 95th percentile male)

and crash situations. It is important to know how effective they are outside their design range to determine their limits in providing protection. In particular,

o can any system restrain very tall occupants from injurious contact with the windshield, pillars, etc.?

o Can air bags restrain very heavy occupants from contacting the steering wheel, etc. in severe crashes?

o Are otherwise unrestrained children and other small occupants well restrained by automatic belts and bags?

o Do the systems effectively restrain occupants who are out-of-position because of pre-braking or unusual seating?

o Does system performance deteriorate at extreme temperatures, altitude or after exposure to water?

o Are automatic restraints functioning in a manner compatible with child restraints?

The purpose of collecting the information is to identify areas of improvement for restraint systems.

2.8 <u>Automatic restraint malfunctions during normal vehicle operation.</u>
The rate of these malfunctions is of interest because:

o replacement of automatic restraints adds to the cost of the system

o malfunctions may reduce public confidence in the system.

o a deployment while the car is moving may cause a safety hazard.

The rate of non-crash deployments per 1000 vehicle years should be determined for each of the air bag systems on the market. The causes of non-crash deployments should also be determined (defective hardware, defective installation, electromagnetic interference, off-road vehicle use, vandalism, etc.). The information can readily be used to improve the systems.

2.9 Automatic restraint system malfunctions in crashes. Air bags are designed to deploy and provide crash protection when the sensors detect a signal that exceeds the threshold set by the manufacturer. Since the threshold cannot be easily described by parameters such as the change in vehicle velocity during the crash, one cannot readily decide after a malfunction in a crash whether the bag "should have deployed." Evidence of failure to deploy exists when

o the crash was so severe that it obviously exceeded the threshold, or

o only one of the bags deployed (or a similar hardware misadventure), or

o subsequent analysis of the system showed it was inoperable at the time of the crash.

The frequency and causes of various air bag systems' failure to deploy should be discovered in order that the faults in those systems can be quickly corrected.

2.10 Disabling malfunctions of restraint systems. There are two types of disabling malfunction: the more common sort is when the

restraint system cannot be used at all due to physical deterioration - the inoperability of the system is obvious even without a crash taking place. The other type is when the owner seems to be using the system properly, but when involved in a crash, the system fails to perform. Restraint systems, especially automatic belts, that were deliberately disabled or disconnected are not included here.

The adverse effects of disabling malfunctions are

o Higher cost (when systems are repaired)

o Reduced protection (when systems are not repaired and the vehicles' occupants become, essentially, unrestrained).

The percent of inoperable restraint systems should be determined by type of restraint system, cause of malfunction and vehicle age. (The percent of systems inoperable presumably increases as the cars get older). The primary purpose of gathering the information is to identify causes of malfunction so that the deficiencies can be remedied. Secondary objectives are to assist calculation of the percentage of systems that are operational and overall repair expenditures.

2.11 Disposal of undeployed air bag systems. When cars with undeployed air bags are retired, the gas generating subsystems must be properly disposed of. Two research firms, Batelle Laboratories and Arthur D. Little, have developed acceptable disposal procedures. The objective here is to determine if there are any air bag car retirements in which the actual disposal is not made under the approved procedures.

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3. PUBLIC/INDUSTRY ACCEPTANCE

3.1 <u>Production and sales of vehicles with alternative restraint</u>
<u>systems</u>. The actual production of air bag and automatic belt
vehicles, by make and model, will be tracked on a month-to-month
basis. The sales of these vehicles will also be tracked, as well
as the average days of inventory for air bag and automatic belt
vehicles. For those makes and models in which automatic belts are
standard and air bags are optional, the incremental price of the
optional air bags will be obtained.

The actual production and sales of alternative restraint systems
provide the basic exposure data needed for answering many of the
other questions. It is crucial that these data be obtained
promptly. Production and sales of air bag versus automatic belt
cars within makes and models also shed light on the industry's and
public preferences among restraint systems, especially when
analyzed in conjunction with inventory and price figures: the days
of inventory figures for air bag versus automatic belt cars
indicate public demand vis a vis industry's willingness and ability
to produce.

A microeconomic analysis, by make and model, of the price of
optional air bags versus the percentage of cars purchased with an
air bag will indicate the price elasticity of the public demand for
air bags.

3.2 <u>Automatic belt usage on the road</u>. The number of casualties prevented by automatic belt systems depends heavily on the extent to which they are used by the public. Automatic belts can be temporarily or permanently disconnected or they may become inoperable. If past experience with manual belts equipped with interlocks is used as a guide, some owners may disconnect automatic belts, but is not now possible to accurately predict the extent of this practice.

Accurate and timely information on automatic belt usage is needed.

o the usage information can be combined with preliminary estimate of effectiveness when used to obtain early estimates of overall casualties prevented by automatic belts
o Usage recorded by make and model may identify belt systems thats the public finds especially acceptable.

Since usage may deteriorate for several years as the vehicle ages before finally levelling off, it will be necessary to track usage on a continuing basis for older cars as well as new ones.

3.3 <u>Automatic belt disconnect rate</u>. The previous question (3.2) assessed belt non-use, without specific attention to whether the belt was deliberately disconnected or had malfunctioned. This question deals specifically with cases of deliberate disconnection. For each type of automatic belt on the market, the frequency of disconnection, the reasons given for disconnecting and

the techniques for disabling the belts will be determined.
Special attention will be given to the status of ignition inter-
lock systems in those cases where manufacturers have installed
them in combination with the belts.

The purpose of finding out the reasons for disconnecting belts is
to identify and remedy sources of consumer dissatifaction with
specific belt systems. The information on techniques for disabl-
ing belts can be used to redesign belts in a more tamper-proof
manner.

3.4   Deployed air bag replacement rate. After a deployment, there are
3 possibilities regarding the status of the air bag system
o the air bag is replaced
o the air bag is not replaced and the occupants are, essentially,
   deprived of automatic protection
o the car is retired (it was totalled in a crash).
The rates of deployment per 1000 vehicle years were already
addressed by questions 2.1 (crash) and 2.8 (non-crash). This
question addresses the likelihood of the 3 above alternatives
given that a bag has deployed. The percent of air bags replaced
must be known in order to calculate the overall replacement cost.
The percent of air bags not replaced must be known for calculating
the overall casualty-reducing effectiveness of the air bag
system.

3.5　Inoperable restraint system repair rate. When restraint systems

have become inoperable due to physical deterioration, vandalism or

other reasons (except deliberate disconnection by the owner) it is

possible that the owner will have them repaired or replaced. This

adds to the overall cost of restraint systems. Alternatively, if

the owner allows them to remain nonfunctional, the occupants of

the vehicle will, essentially, be deprived of automatic protection

and the effectiveness of the Standard will be reduced. Thus, it

is necessary to determine the likelihood of repair or replacement

given that a system has become inoperable. The rate at which

systems become inoperable was already addressed in question 2.10.

Deployed air bags are included among the disabling malfunctions

addressed here, but have also been treated as a separate question

(3.4) because of their exceptional interest.

3.6　Effect of restraint systems price and availability on car

purchase. Persons who have recently purchased an automobile will

be asked to what extent their choice was influenced by automatic

restraints. Some potential influences of restraints are

o A specific model was not purchased because the restraint system

　　preferred by the consumer was not available.

o One model was chosen over another because the restraint system

　　preferred by the consumer was available at a lower price in the

　　former than in the latter.

o   A model was not purchased because the specific restraint system
    in that car was perceived as inferior to restraint systems of
    the same general type in competing models.

o   The consumer compensated for the added cost of automatic
    restraints by purchasing a less expensive model or forgoing
    desired optional equipment.

o   The information about restraint systems that the consumer
    received at the point of sale influenced his choice of restraint
    system and/or automobile.

The purpose of collecting the data is to provide a basis for NHTSA
public information programs on automatic restraints.

3.7 Influence of Standard 208 on car design, production and marketing.
     Manufacturers may find it desirable or necessary to adjust their
     production and marketing strategy in response to the Standard. For
     example, they might

o   Produce more cars with bucket seats, fixed center armrests or
     reduced hip room, thereby avoiding the need for air bags to
     comply with Standard 208.

o   Accelerate phase-out of models whose design is not suited for
     installation of automatic belts.

Timely information on developments such as these is desired because manufacturers' capital costs would be affected. Also consumers might become dissatisfied if their range of available models and options were reduced. Finally, if manufacturers install a large number of fixed center armrests and a sizable portion of these are removed by consumers, it would lead to a vehicle fleet in which many center front occupants do not have restraints available.

3.8 Comfort and convenience of automatic belts. One of the most frequent reasons given for nonuse of manual belts is the discomfort of wearing a belt. This complaint would not necessarily be remedied by merely making the belts automatic. NHTSA is considering rulemaking that would set performance standards for automatic belts in areas related to comfort and convenience. If the rule is promulgated, controlled tests of comfort and convenience using human volunteers would supplement the basic compliance test in evaluating whether the rule has achieved its goal. If the rule is not promulgated, the controlled tests would help identify the less satisfactory restraint systems on the market and the areas in which they need to be improved.

3.9 Evaluate NHTSA public information programs on automatic restraints. The immediate objective of public information programs is to make the public more aware of the life-saving potential and operational characteristics of automatic restraints. The longer-term objectives are to

o Achieve high usage of automatic belts in vehicles equipped with them

o Encourage purchase of air bag cars by persons who do not like to use a belt restraint

o Encourage consumers to maintain, repair or replace their restraint systems when necessary.

A number of alternative messages and media may be used. Before engaging in a costly large-scale program, NHTSA would pilot test various alternatives and choose the most effective ones. Subsequently, NHTSA would periodically evaluate its program to see if the message is still appropriate and well received by the public.

3.10 Evaluate public satisfaction with the Standard. NHTSA should keep informed about the current public view on automatic restraints, especially in the years following the effective date. NHTSA should know how the public perceives

o the effectiveness and availability of alternative systems

o the cost of automatic restraints

o the effect of restraints on safety and insurance costs

o the reliability of alternative systems

o the comfort and convenience of alternative systems

o the manufacturers' reaction to the Standard

o the appropriate role of the government in specifying crash protection

o the need for modifying, amending or upgrading the regulation

The information is needed to provide rulemaking and the public information programs that are responsive to the public need.

4. COST TO CONSUMER

4.1 Cost and weight of original equipment. The two most important cost items for the consumer are undoubtedly the increase in the purchase price of a car to cover the cost of the restraint and the increased fuel consumption during the lifetime of the car as a result of weight added by the restraint system.

The direct manufacturing cost and weight added by the Standard can be calculated by a comparison of the restraint hardware of vehicles produced immediately before and after the effective date. The consumer cost (increase in the purchase price) can be estimated for restraints that are standard equipment by adding markups and taxes to the manufacturers' cost and taking market factors into account. The cost of increased fuel consumption during the lifetime of the car is a function of the weight added by the Standard and the cost of fuel.

4.2 Cost of replacing deployed air bags. While a relatively small percentage of vehicles will have the bags replaced before retirement, the cost per replacement is fairly high. When this cost is spread over the entire air bag fleet, it is likely to add measurably (i.e., more than $1) to the lifetime average cost of

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owning an air bag car. The prices paid by consumers for bag replacement will be determined from actual case histories.

It will be desirable to know the variation of replacement cost by make, model and servicing organization and to analyze in greater detail the cases where costs are exceptionally high or low. This information should be gathered for dissemination as consumer advisories.

4.3 Cost of routine maintenance of restraint systems. At this time it cannot be predicted whether any of the restraint systems that will appear on the market will require routine, periodic maintenance (other than a simple inspection). Where maintenance is required, it will increase the lifetime consumer cost of a restraint system.

It will be desirable to learn both the maintenance intervals, activities and costs recommended by manufacturers and the actual maintenance activities undertaken by consumers. The former will be available rather quickly and can be used for a preliminary estimate of lifetime maintenance cost. The latter will be used to refine the estimate. Also, discrepancies between the former and the latter may point to the need for a consumer advisory to reduce

unnecessary maintenance or, conversely, to increase maintenance to the manufacturers' recommended levels.

4.4 Cost of repairing malfunctioning restraint systems. Non-routine repairs are part of the lifetime cost of restraint systems. It is necessary to determine what types of repair are performed, how frequently and at what cost. The total cost of repairs for each type of restraint system will be divided by the number of vehicles equipped with that system to obtain average lifetime cost per vehicle.

Also, it will be desirable to study the variation of prices paid for certain repairs and the effect of vehicle age on repair costs. The information may reveal the need for issuing a consumer advisory. Restraint systems that are difficult to maintain or repair should be identified.

4.5 Effect of Standard 208 on auto insurance costs. One of the major benefits of the Standard should be a significant reduction of auto insurance costs because there will be fewer deaths and injuries on the highway.

A reduction in liability premiums will not be realized immediately, but only gradually, as the post-Standard vehicles approach 100 percent of the nation's vehicle fleet. The reduction may be masked by the year-to-year inflationary trend of insurance costs. Different premiums will be affected in different ways. Medical

expense coverage may decrease immediately while collision coverage may increase slightly because of the added expense of repairing automatic restraints.

It will be desirable to analyze the trends of insurance costs for a sample of hypothetical drivers and vehicles to determine the effect of the Standard on costs.

4.6 Product liability claims. There has been some concern about the possibility that the Standard could lead to an increase of product liability suits against manufacturers (the cause for the concern is that compliance with the Standard could be interpreted by some consumers as a "guarantee" of no injury in certain types of crashes).

Since a major increase in product liability claims could affect the public acceptance and cost of the Standard, it is necessary to monitor the situation closely. The number of claims, the reasons given for the claim, the disposition and the cost to the manufacturer should be determined.

Some specific potential causes for product liability suits are
o significant injury in a crash of moderate severity
o alleged failure to deploy
o failure of belt webbing, latch, retractor, or anchorage
o injury to out-of-position occupants.
o certain types of non-crash deployments.

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4.7 Economic impact of Standard 208 on restraint system suppliers.

Most restraint system components are purchased by the auto
manufacturers from suppliers. Since there is still considerable
uncertainty about the quantities of various types of restraint
systems that will be needed and since the suppliers must make their
decisions on production levels in the face of this uncertainty,
there are possibilities of shortages of some systems and wasteful
over-capitalization to produce quantities of other systems that far
exceed demand. The net result could be economic disruption of the
supplier industry as well as public dissatification and excessive
prices for the systems whose demand exceeds production. If the
economic disruption is severe, there could be a question as to
whether the Standard "falls within the financial capabilities of
suppliers and manufacturers."

Before and during the Standard's implementation period, NHTSA should
monitor the production capability, actual production, inventories
and prices charged by suppliers. NHTSA would then be in a position
to react promptly if serious economic problems arise.

CHAPTER 4

EVALUATION PROJECTS

Chapter 3 presented 30 questions that the NHTSA has identified as
important for its evaluation of Standard 208. For each of the
questions, there is at least one evaluation project that will provide
data to help answer the question. In some cases additional projects can
provide further information on the question.

This chapter describes 14 information-gathering projects related to
Standard 208. Each study addresses one or more of the 30 evaluation
questions. Conversely, each of the 30 questions is fully addressed by
at least one of the studies and, in most cases, there will be backup
information from several of the other projects.

The discussion of each project includes a description of what data are
collected and how; a listing of the questions for which the study prov-
ides primary or backup information; and a schedule for project implemen-
tation including dates of major results.

The first 3 projects, the National Accident Sampling System (NASS), the
Fatal Accident Reporting System (FARS) and State accident systems all
serve the purpose of estimating casualty-reducing effectiveness of
automatic restraints based on statistical analysis of highway accident
data. The NASS would provide the most authoritative results (i.e.,

accurate and unbiased, with measurable sampling error, and permitting detailed characterization of injury severity and other factors). But NASS data can only be collected in a limited number of areas, so it will take several years to produce a sample sufficient for precise results - i.e., until 1983-85 for various measurements of injury reduction and even later for fatality reduction. The other two systems, which involve much wider data collection areas, will provide fairly authoritative results in a much shorter time.

1. National Accident Sampling System (NASS)

The NASS permits investigation of a probability (random) sample of the nation's traffic accidents and provides detailed information such as occupant restraint system usage, occupant injury severity (using the Abbreviated Injury Scale and other measures), crash severity (Delta V) and crash configuration. NASS can be relied upon to produce injury and fatality rates for restrained and unrestrained occupants.

o NASS is one of the primary data sources for measuring injury reduction (Question 1.2) due to restraints.

The NASS data can, for example, be used to calculate effectiveness as follows: Suppose there were 2200 towaway crashes involving air bag equipped cars on the file, and there were a total of 3000 front-seat occupants in these cars. And let us assume 150 of these persons had injuries of AIS $\geqslant$ 2. This would be an injury rate of 5 percent (i.e., 150/3000). At that time, the NASS file might also

contain 7500 cases of comparable pre-Standard cars involved in towaway crashes (e.g., model years 1980 and 1981 cars of the same size categories as the air bag cars). If there were 10,000 front-seat occupants in these cars and 1000 of them had injuries of AIS $\geq$ 2, this would give an injury rate of 10 percent. Since the injury rate in the air bag equipped cars is 50 percent lower (5% versus 10%), the estimated effectiveness of the air bag system is 50 percent. (The estimate would be refined by standardizing the injury rates in the pre-Standard and post-Standard cars, using control variables such as ΔV.)

NASS will be organized to investigate accidents in 75 geographical areas (Primary Sampling Units), which produce about 6 percent of the nation's accidents. NASS will not routinely investigate each accident in these areas, but only a sample of these accidents (Continous Sampling Subsystem). In order to produce an adequate sample size of automatic restraint cases, it will be necessary to supplement the basic NASS sample by oversampling towaway crashes in the 75 areas that involve a post-Standard vehicle. Fortunately, NASS has been organized to allow for the investigation of a supplementary sample of accidents, such as the one above (Special Studies Subsystem). Furthermore, NASS allows for the supplementation of the regular data collection forms with additional data elements relating to the special study topic (i.e., automatic restraints). The possibility of collecting additional data elements makes NASS a primary data source on operational characteristics of automatic restraints:

o   NASS is the primary data source for the frequency and
    characteristics of air bag deployments (2.1)

o   It is the primary source on injury-contact point patterns (2.2)
    of alternative restraint systems.

o   NASS will be used to estimate and compare restraint system effec-
    tiveness by car size (2.4), by seating position (2.5), and by
    crash severity and direction of force (2.6).

NASS also provides backup information for several other questions,
viz.

o   Type of injuries with automatic restraints (2.3) and restraint
    effectiveness in exceptional situations (2.7) - when NASS
    investigators suspect problems in these areas they could trigger
    NHTSA to send an in-depth investigation team.

o   Automatic belt usage by crash-involved persons (3.2), automatic
    belt disconnect rate (3.3) - NASS would eventually supply reli-
    able estimates of these rates. Other projects, however, will
    supply precise estimates more promptly.

The estimation of injury reduction requires thousands of accident
cases. The NASS system will take until 1984 to accumulate the
necessary sample, assuming NASS is fully operational by September
1981 and assuming sales/usage Level B for automatic restraints (see
Chapter 1). Appendix A gives a more detailed discussion on the
computation of effectiveness and its variability.

The two reasons that NASS data collection is prolonged are

(1) The relatively small number of automatic restraint vehicles on the road before 1983.

(2) The areas in which NASS data are collected comprise only 6 percent of the nation's accidents.

The first factor is outside NHTSA's control. An increase in the number of NASS teams could alleviate the second factor but is not considered likely at this time.

2. Fatal Accident Reporting System (FARS).

The FARS is a census of the nation's fatal traffic accidents, based on Traffic Records System (primarily police) data. FARS will provide counts of front-seat occupant fatalities in air bag, automatic belt, and control group cars. The fatality counts are divided by the number of exposure years for each type of vehicle (derived from sales data) to yield fatality rates per 1,000,000 car years. The fatality rates for air bag and automatic belt vehicles are compared to those of the control group in order to obtain the fatality reduction due to the these systems.

The FARS data can, for example, be used to calculate effectiveness as follows: Suppose there are 100 front-seat occupant fatalities on file for cars equipped with optional automatic belts. And if this optional automatic belt fleet had accumulated 500,000 vehicle years of exposure at that time, the fatality rate is 200 per million

vehicle years. At that time, the FARS might also contain records of 700 front-seat occupant fatalities in manual belt cars of the same makes, models and model years as the automatic belt fleet. These manual belt equipped cars, let us say have accumulated 2,000,000 vehicle years of exposure. Their fatality rate is 350 per million vehicle years. Since the fatality rate in the automatic belt cars is 43 percent lower (200 versus 350), the estimated effectiveness of the optionally installed automatic belt system is 43 percent. Appendix A contains further discussion on the computation of effectiveness and its variability.

This approach is feasible because FARS records the vehicle make, model, model year and Vehicle Identification Number (VIN). After September 1980, FMVSS 115 will require that the type of restraint system installed in the vehicle be recognizable from the VIN. For automatic restraint vehicles produced before that time, manufacturer-supplied VIN lists will be required.

o FARS will contain a sufficient number of cases to measure the fatality reducing effectiveness of the air bag system with a fair degree of reliability by Fall 1982 and with high reliability by mid 1983 and the effectiveness of the automatic belt system with a high degree of reliability by Fall 1982 (assuming sales/usage Level B).

o FARS already contains a census of fatalities in automatic
restraint vehicles. It can be used to make estimates of
effectiveness, especially for automatic belts, in 1980 and 1981.
The reliability of the estimates will increase as the on-the-road
experience with automatic restraints accumulates.

o FARS will also provide estimates of fatality reduction by car
size (2.4) and occupant seating position (2.5).

FARS is obviously much more timely than NASS in providing reliable
estimates of fatality reduction (See Table 3-1 for the NASS dates).
On the other hand, the FARS estimates may be somewhat less defen-
sible than NASS. FARS provides fatality rates per 1,000,000 car
years, rather than per 100 accidents. The fatality rate for one
restraint system might be higher than for another because the cars
are driven more miles per year or have more accidents per 1,000,000
miles, rather than because the restraints are less effective. In
other words, there may be confounding by effects other than the
restraint systems. There are analytic techniques for eliminating
some of the confounding effects but they are not foolproof.

Another shortcoming of FARS is that there will be no direct,
reliable way for comparing the fatality rates of automatic belt
users versus non-users, or air bag plus lap belt versus air bag
alone. The primary purpose and capability of FARS is to provide
fatality rates for air bag equipped vehicle occupants (regardless of
lap belt use) and automatic belt equipped vehicle occupants (whether
they use belts or not).

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The FARS has been fully operational since 1975. No modification or supplementation of the basic FARS will be required to perform this project.

3. Analysis of State Accident Data

Each State maintains a census of its reported traffic accidents, based on police reports. The data files will provide counts of front-seat occupant injuries in post-Standard and pre-Standard cars. "Injuries" would include police-reported fatalities and "A" level injuries. The "A" level is the most severe one on the three-level police-reported "ABC" non-fatal injury scale. If the data file contains restraint system information or the Vehicle Identification Number (from which "type of restraint system" can be decoded), it will be possible to obtain separate counts for air bag and automatic belt vehicles.

There are several alternative procedures for making effectiveness estimates based on State accident data files: (Appendix A contains additional discussion on the computational procedures):

(a) If, for example, the State maintains information on the files about all towaway-involved vehicle occupants, both injured and uninjured, it would be possible to calculate fatal and serious (K+A) injury rates per 100 towaway-involved front-seat occupants. The effectiveness calculation would be quite similar to the one used with NASS data (See Project No. 1).

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(b) Some States do not generally record information on uninjured occupants, but they do maintain records on all towaway-involved vehicles and all injured occupants. Let us assume, for example, that data were acquired from several of these States and that we find 2000 towaway crashes involving air bag equipped cars in the files. Suppose that 100 front seat occupants of those cars were Killed or had "A" injury. This would be a K+A injury rate of 5 per 100 towaway-involved vehicles. At the same time, the files might also contain 6000 cases of comparable pre-Standard cars involved in towaway crashes and these have 600 front seat occupants who were killed or had "A" injury. This would be an injury rate of 10 per 100 towaway-involved vehicles. Since K+A injury rate in the air bag cars is 50 percent lower (5 versus 10) the estimated effectiveness of the air bag system is 50 percent.

(c) Some States do not generally record information on property-damage towaway accidents, but they do maintain records on all injured occupants of vehicles involved in fatal or injury towaway accidents. In these States, it would be possible to calculate K+A injury rates per million vehicle years and to compute effectiveness by the same technique used with FARS data (See Project No.2) State-by-State vehicle sales data would also be needed to calculate the vehicle years exposure of a fleet in a State.

o The State data files would be used to measure injury reduction (1.2) using the K+A injury criterion. If 5 or more large State files are usable (e.g., contain the Vehicle Identification

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Number), the State files would generate a sufficiently large
sample of air bag accidents by mid 1982 and optionally equipped
automatic belt accidents in 1981.

o State data would be used to measure injury reduction by car size
(2.4) and occupant seating position (2.5)

The utility of State files for this evaluation depends on the number of
States that will be collecting the necessary data elements by 1982 and
the amount of time required to encode, automate and retrieve the data.
(If this exceeds a year, it would essentially make the State data
analysis no timelier than NASS.) The need to use the K+A injury
criterion and, possibly, injury rates per 1,000,000 car years are the
principal shortcomings of State files.

NHTSA will analyze State accident files for the calendar years 1980 and
1981 in order to monitor the accident experience of automatic restraint
cars sold before the Standard's effective date, and for calendar years
1982 through 1984 in order to monitor accidents involving optional and
mandatory automatic resraints.

If the analysis of State accident files for the calendar years 1980 and
1981 should prove unsatisfactory due to data quality problems, NHTSA
would implement an extension of FARS (Project No. 2) to selected classes
of non-fatal accidents, the Limited Accident Reporting System (LARS).

The groundwork for LARS implementation will have been laid in 1980-81, simultaneously with analyses of State accident data tapes. LARS would provide information that is on State accident records supplemented by information drawn from other existing State record systems. The effort would involve approximately 5 large States. The LARS accident population would include crashes involving automatic restraint vehicles plus a suitable control group. LARS could be further improved if States add questions on air bag deployment and automatic belt use to police accident reports. This would make possible the calculation of deployment frequency (2.1) as well as more detailed analyses of restraint effectiveness.

If LARS is implemented, data would be collected during 1982-84.

4. In-Depth Accident Investigation.

NHTSA has 6 multidisplinary in-depth accident investigation teams under contract. They can be dispatched promptly to perform clinical investigations of selected individual accidents anywhere in the United States. In depth investigators can perform more detailed, expert investigations than NASS teams and, unlike NASS members, they are empowered to follow up, in an open-ended fashion, those aspects of an accident that they consider of particular interest or importance. Their ability to go to accidents anywhere in the United States gives them an opportunity to cover rare events (such as failures to deploy). These types of events would occur so infrequently at the NASS sites (which contain only 6 percent of the

nation's accidents) that national rates could not reliably be calculated from NASS data.

o NHTSA currently plans to investigate in depth every fatality in automatic restraint vehicles during 1980-84 for which timely notification is received.

o In-depth investigation is the primary data source on the type of injuries with automatic restraint systems (2.3), restraint effectiveness in exceptional situations (2.7), and automatic restraint malfunctions in crashes (2.9).

o In-depth data are a secondary information source on automatic malfunctions during normal vehicle operation (2.8). In-depth investigations will not be routinely required for such malfunctions, but only in those cases where the cause is not immediately evident.

o In-depth investigation is the primary data source on accidents involving air bag equipped cars currently on the road.

The notification systems that will trigger the in-depth investigations include NASS (Project No. 1), the NHTSA Hotline (5), communications from the manufacturers (6), and owner surveys (9). The events that could trigger in-depth investigation include

o Fatal crashes (especially during 1980-84)

o Other exceptionally severe crashes

o Non-deployment crashes with high injury or accident severity

o Non-crash deployments with no obvious explanation

NHTSA's tentative projections for the likely volume of in-depth investigation during fiscal years 1982-84 are the following:

	FY 82	FY 83	FY 84
Fatal crashes	55	130	130
Severe injury crashes	130	250	250
Other events (such as restraint malfunctions)	115	120	120
Total	300	500	500

5. **Use of NHTSA's "Auto Safety Hotline" and Analysis of Consumer Letters**

In 1976, NHTSA established the Hotline, a nationwide toll-free number which consumers can call if they have any safety-related troubles with their vehicles. Consumers receive expert advice over the phone or their problems are referred for possible corrective action to the appropriate NHTSA office - usually the Office of Defects Investigation. Consumers also report safety-related problems, request information or express opinions by writing to the NHTSA Administrator or the Secretary of Transportation.

The Auto Safety Hotline (including the consumer letters) will play a vital role after Standard 208 becomes effective. Consumers can receive information about what to expect from automatic restraints. NHTSA, in return, will promptly become aware of any problems that may be occuring with automatic restraints - problems concerning operating performance, consumer acceptance and purchase or repair prices.

The primary advantage of the Hotline, relative to other notification systems, is that it can bring problems to NHTSA's attention very quickly. On the other hand, the Hotline is by no means a complete reporting system and cannot be used for statistical purposes such as tallying the number of non-crash deployments.

The usefulness of the Hotline will be enhanced by a public information program advising consumers of its availability, at about the same time the Standard takes effect.

o The Hotline will promptly provide information about malfunctions of restraint systems during normal vehicle operation (2.8), and in crashes (2.9), other operational malfunctions (2.10), malfunctions in extreme operating environments (2.7), exceptional discomfort or inconvenience (3.8).

o The Hotline will provide information about price-related problems, such as inability to obtain a car with the desired restraint system at a reasonable price (3.6), excessive charges

for replacing deployed bags (4.2) and complaints about the quality or cost of restraint system repairs (4.4).

o The Hotline would provide early indications if there were substantial public dissatifaction with the Standard (3.10) and information about product liability suits (4.6).

o The Hotline may occasionally be the notification source for high-interest events such as the types of injuries with automatic restraint systems (2.3), extremely severe accidents involving post-Standard cars, or accidents involving exceptional situations (2.7). It will serve as a trigger for in-depth investigation of these events (Project No.4).

6. <u>Inquiries to New Car Manufacturers and Restraint System Suppliers</u>
Information about the production and delivery of automatic restraint vehicles is best obtained directly from the new car manufacturers and importers. NHTSA will make arrangements with the manufacturers that production and delivery data be sent to NHTSA on a periodic basis. NHTSA looks forward to a continuation of the current cooperative efforts with manufacturers for notification and investigation of fatal and severe injury crashes, instances of restraint system malfunctioning and other information of common concern. When NHTSA learns through one of its information sources that a vehicle has been involved in one of these events it will promptly notify the manufacturer. When manufacturers learn through their channels of an event, we would expect them to notify NHTSA. Also, NHTSA and the manufacturers would share in the in-depth investigation effort by sending joint teams or by taking turns performing the investigations.

o Inquiries to manufacturers are the primary source of vehicle production data (3.1), liability claims (4.6); impact on suppliers (4.7) and production/marketing strategies (3.7)

o They are a source of information on possible restraint systems malfunctions to support objectives 2.3, 2.8 and 2.9.

o They are a source of information on the prices of air bag replacement (4.2), as well as the recommended procedure for disposing of undeployed air bags (2.11).

This project would be part of an ongoing NHTSA activity during 1980-86.

7. Acquisition of New Car Registration Data

NHTSA will periodically obtain new car registration data from the manufacturers, a commercial firm, or the States. The data should be decodable to determine the type of restraint system installed in the vehicle. They should also provide names and addresses of new car owners so they can be used for drawing samples of the owners.

o The registration data are the primary source of vehicle sales information (3.1)

o The registration data will be used for drawing a sample of new car owners, which will be used for the owner survey (Project No. 9).

The files can be used to determine the exposure, in vehicle years, of cars with alternative restraint system. Nationwide exposure data may be needed to measure fatality reduction in conjunction with the Fatal Accident Reporting System (Project No. 2). Statewide data may be needed in conjunction with the State accident files (Project No. 3).

o   Sales information based on registration data will support
    analyses of the impact of the Standard on manufacturers (3.7) and
    suppliers (4.7).

The level of detail of the registration data required for evaluation
of Standard 208 will be established during 1980.

8. On-the-Road Belt Usage Survey

NHTSA has tracked on-the-road usage rates of manual and automatic
belts by vehicle make and model since 1974 and will continue doing
so during 1980-86. The tracking procedure involves observation of
belt usage in vehicles stopped for traffic signals. The survey is
currently conducted at urban, suburban and rural locations within 19
areas of the United States. The observers also record the license
plate number of the vehicle and check it against State registration
files in order to confirm that the vehicle make, model, model year
and restraint system installation were correctly recorded.

o   On-the-road belt usage surveys are the primary source for
    estimating automatic belt usage rates (3.2) as well as lap belt
    usage in air bag cars.
o   The survey will support analyses of belt disconnection (3.3) in
    that it will provide gross statistics on modes of belt non-use
    (e.g. belts worn behind back, emergency release used, etc.) and
    misuse (e.g. belts worn under the arm).

Since there will be relatively few automatic restraint cars on the road in 1982, there will be some difficulty in securing a sufficiently large sample of observations. It will be necessary to double the current number of observers during 1982 in order to obtain statistically reliable estimates of restraint use, by manufacturer, in post-Standard cars that year.

9. New Car Owner Survey

A probability sample of the nation's recent purchasers of post-Standard cars would be surveyed, possibly using a combination of telephone interviewing and mailback questionnaires. The survey will cover three main topics: (1) public opinion on automatic restraints (2) disconnection of restraint systems (3) malfunctions of restraint systems.

o The owner survey will be a primary data source for evaluating public satisfaction with the .Standard (3.10), the effect of restraint system price and availability and point-of-sale information about restraint systems on car purchase (3.6) and the impact of NHTSA public information programs on automatic restraints (3.9).

o It will be the primary data source for estimating the disconnect rate for automatic restraints (3.3), the frequency of various disconnect techniques and the reasons for disconnection.

o It will be a primary source on the frequency and type of restraint system malfunctions (2.10), the extent to which these

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are repaired (3.5), and the prices consumers actually paid for routine maintenance (4.3) and non-routine repairs (4.4).

o The owner survey will provide supporting data on the comfort and convenience of alternative belt system (3.8) and the frequency of malfunctions during normal vehicle operation (2.8).

Since the project will be a new activity for NHTSA (although a somewhat similar survey of current automatic belt car owners is now underway), a relatively long lead time is needed. The project will be initiated in Summer 1980.

Some of the problems under consideration here - especially restraint system disconnection and malfunction - may be related to the age of the car. Thus, in order to obtain unbiased statistics for the whole post-Standard car population, it is inadequate to perform the survey as a one time effort using only new cars. The survey will be repeated annually, beginning in 1982, and the sample will contain older post-Standard cars as well as new cars in subsequent years. The survey may occasionally act as trigger for in-depth accident or defect investigations (e.g., upon report of a restraint system malfunction whose cause cannot be explained).

10. Public Survey

In 1978, NHTSA conducted a public survey [11] to determine consumers' attitudes towards safety and their familiarity with and opinions about automatic and manual restraint systems. Similar

surveys would be conducted in 1982 and 1983, after the Standard takes effect.

o The public survey will be a primary data source for evaluating public satisfaction with the Standard (3.10) and the impact of NHTSA public information programs on automatic restraints (3.9)

The general public's familiarity with and attitudes towards automatic restraints would also be compared to those of new car owners (Project No. 9).

Since the survey would largely be an update of an earlier NHTSA effort, a long lead time would not be needed.

11. <u>Controlled Tests of Comfort and Convenience</u>

In 1978, NHTSA began assesssing the comfort and convenience of belt systems in new cars. This involves evaluating belt systems in a representative sample of cars of the latest model year. A representative sample of volunteers takes turns sitting in each of the cars and trying out the restraint systems. For each car, they are asked a series of questions pertaining to the comfort and convenience of the restraints. The responses are scaled and averaged to provide a numerical rating for the belt system in each car. In addition, the feasibility and convenience of using child restraint systems in the front seats of the various cars will be assessed.

o The Controlled Tests are the primary data source for studying

   comfort and convenience of automatic belts (3.8)

NHTSA is already performing this study annually, using cars of

latest model year (i.e., with manual belts). The transition from

pre-Standard to post-Standard vehicles will only require minor

changes in the approach.

12. Cost and Weight Study Based on Component Teardown

Complete restraint system assemblies, for each of the major systems

available on the market, are acquired. They are torn down to their

subassemblies and components to the greatest level of detail practi-

cable. The components are analyzed with the objective of identify-

ing the material types, general processing methods, weights, cost

per pound, tooling cost and all other manufacturers' costs. Weight

and consumer's cost are estimated by individual make and model as

well as averaged over all the cars produced in a model year.

o Studies based on component teardown are the primary data source

   for estimating the cost and weight added to cars by the Standard

   (4.1).

NHTSA has conducted studies of this type since 1977 as part of its

program to evaluate the cost of existing safety standards. Automa-

tic restraints will readily fit within the program. It will be

necessary to analyze automatic restraints from model year 1982

(large cars only), model year 1983 (medium sized cars) and model

year 1984 (small cars). Only than will it be possible to calculate

unbiased averages for the entire fleet. It will also be necessary

to cost manual restraints in comparable pre-Standard cars, since the

objective is to determine the incremental cost due to the Standard.

Finally, it will be desirable to repeat the cost analysis using cars

of later model years (1985 and beyond) to check if the cost of

complying with the Standard has changed.

13. Analysis of Automatic Restraint Replacement and Repair Data

Important information on restraint systems repair and maintenance

can be obtained from a number of repair industry publications. For

example, Hunter's Service Job Analysis [13] provides estimates of

the numbers of repair and maintenance jobs of various types that are

performed nationwide. The estimates are broken down by type of

repair facility (dealer, service station, etc.). Chilton's Labor

Guide and Parts Manual [4] , among others, lists the recommended

labor charges and parts prices for repair and maintenance work. The

manufacturers' repair and owners' manuals will list the recommended

maintenance intervals, if any, for restraint systems as well as

instructions for performing maintenance and repair.

The Hunter manual can be used to calculate the actual number of

restraint system maintenance and repair jobs performed. The Chilton

manual can be used to calculate the suggested prices for these jobs.

It is not certain at this time that publications such as Hunter's and Chilton's will have detailed listings (or any listings) for repairs of automatic restraints. A special effort on the part of NHTSA may be needed to assure their inclusion.

o Job manuals will be a primary data source for determining the number of deployed bags that are replaced (3.4) and the number of other repair and maintenance jobs (3.5).

o Job manuals will provide supporting data on the normative prices of air bag replacement (4.2) and other maintenance (4.3) and repair (4.4) of automatic restraints.

This project will require considerable leadtime because new job categories will have to be added to the job manuals. Also, methods for the economic analysis of job manual data, in particular, and repair cost data, generally, must be developed in advance. The project will be initiated in Summer 1980. After the Standard takes effect, the analyses should be updated periodically.

14. Analyses of Insurance Cost Data

The economic analysis of the effect of Standard 208 on auto insurance costs (4.5) will be based on 3 types of data which can be obtained from the insurance industry:

(1) Discounts or price adjustments offered by certain insurance companies or required by certain State insurance commissioners for purchasers of vehicles with specific types of restraint systems.

(2) Gross data on the total premiums received and claims paid on various types of coverage (liability, medical, etc.) will be statistically analyzed.

(3) Data on the frequency and amount of personal injury protection and medical insurance claim payments to owners of vehicles with specific types of restraint systems (air bags, automatic belts, manual restraints).

The first of the three studies measures the immediate effect of the Standard on insurance costs. NHTSA should be ready to collect data as soon as the Standard takes effect and should continue collecting information throughout the evaluation. The leadtime and subsequent level of effort required for this study are rather small.

The second study measures the long term effect of the Standard - i.e., as the nation's vehicle fleet becomes predominantly equipped with automatic restraints. Several years may pass before there is a noticeable effect on liability premiums, for example. This study need not be ready for implementation in September 1981. The final results may not be apparent within the timeframe of this evaluation effort.

The third study will provide a surrogate measure of the casualty reducing effectiveness of alternative restraint systems. The Highway Loss Data Institute has performed an analysis of this type on the 1975-77 Volkswagen Rabbits.

CHAPTER 5

PROPOSED NHTSA EVALUATION PLAN

The proposed NHTSA evalution plan is based on considerations of the relative priorities of the objectives, the feasibility of alternative projects to meet these objectives, available resources, and the projected scenario for automatic restraint systems sales and usage during the evaluation period (1980-86).

This chapter is a four-section presentation of the NHTSA plan. First, each of the 30 objectives are assigned to priority groups. Next, the projects that contribute to each objective are listed, including completion milestones.

The third section is a summary plan schedule for the 14 evaluation projects. Finally, NHTSA's preliminary projection of resource requirements is presented.

NHTSA proposes to issue evaluation progress reports on an approximately semi-annual basis during 1980-86. The reports will summarize the results of the evaluation projects and present additional pertinent statistical, engineering and economic analyses.

Priorities of the Objectives

The 30 objectives discussed in Chapter 3 were assigned to three priority groups. The highest priority group, listed in numerical order, but not necessarily by order of importance, was as follows:

1.1 Fatality reduction

1.2 Injury reduction

2.3 Types of injuries with automatic restraint systems

2.4 Effectiveness by car size

2.8 Automatic restraint malfunction during normal vehicle operation

2.9 Automatic restraint malfunctions in crashes

2.10 Other disabling malfunctions

3.1 Production/sales mix of alternative restraint systems

3.2 Automatic belt usage on the road

3.10 Public satisfaction with the Standard

Since the main purpose of Standard 208 is to prevent deaths and injuries, the highest evaluation priority is to find restraint system effectiveness. Restraint component contact injury, nondeployment in crashes, non-crash deployment and other malfunctions are serious potential side-effects of the Standard and need to be monitored closely. The proportion of small cars in the nation's vehicle fleet is likely to increase in the 1980's, so it is especially important to evaluate automatic restraint effectiveness in small cars. The belt/bag sales mix, belt usage and public acceptance of automatic restraints play a major role in determining the ultimate benefits of Standard 208.

The second priority group of objectives, listed in numerical order rather than order of importance, was the following:

2.1 Air bag deployment frequency and characteristics

2.6 Restraint effectiveness by crash velocity change and direction of force

2.7 Effectiveness in exceptional situations

2.11 Disposal of undeployed air bags

3.8 Comfort and convenience of automatic belts

4.1 Manufacturing cost and weight of restraints

4.2 Cost of replacing air bags

4.5 Effect on insurance costs

4.6 Product liability claims

The remaining objectives were of lower priority, but should be addressed if resources permit:

2.2 Injury-contact point patterns

2.5 Effectiveness by seat position

3.3 Automatic belt disconnect modes

3.4 Air bag replacement rate

3.5 Inoperable restraint repair rate

3.6 Effect of Standard on car purchase

3.7 Effect on car design, production and marketing

3.9 Effect of NHTSA information programs

4.3 Cost of routine maintenance

4.4 Cost of repairs

4.7 Economic impact on suppliers

Project and Completion Milestones for Each Objective

Figure 5-1 shows a complete listing of the milestones for each objective. It is organized to show what data system or source will be used; the type of result that will be obtained, whether initial, final or an update and when this result will be available. The objectives are ·listed in the order used above - i.e., in the three priority groups.

The Fatal Accident Reporting System will be the basis for the analyses of fatality reduction during the period 1980-85, as shown in Figure 5-1. FARS data have already been used for preliminary analyses of the automatic restraint vehicles now on the road [10]. If sales of automatic belt vehicles during 1975-81 continue as anticipated, it will be possible to estimate the effectiveness of automatic belts by 1980 or 1981. An estimate of air bag effectiveness will be available in 1982. Estimates of injury reduction will, at first, be based on State accident data. Estimates of automatic belt effectiveness may be available in 1980 or 1981 and air bag effectiveness in 1982. Finally, the National Accident Sampling System will be used to produce effectiveness estimates after 1983.

In-depth accident investigation will be the primary means of studying the problems of restraint component contact injury, nondeployment in crashes and non-crash deployment. NHTSA expects to conduct this effort cooperatively with the motor vehicle manufacturers. The owner survey will be the main information source on other malfunctions of restraint systems.

Estimates of restraint effectiveness by car size can be made from FARS and State data in late 1984. The reason for these late completion dates is that automatic restraints will not be required in small cars until model year 1984.

Production and sales figures for air bag and automatic belt cars will be obtained both before and after the effective date of the Standard.

On-the-road belt usage surveys will be conducted annually during 1980-86. They will provide information on automatic belt usage and, starting in 1982, on manual belt usage in air bag cars.

Public and owner surveys will provide information on consumer attitudes toward the Standard.

The plan schedule for the other objectives, as well as additional details on the above objectives, may be found in Figure 5-1.

FIGURE 5-1

COMPLETION MILESTONES FOR EACH OBJECTIVE

Group A--Highest Priority Objectives

Objective	Project	Type of Results	Completion Date
1.1 Fatality reduction	2. FARS data	Initial-belts Initial-bags Final Updates	1980, 1981 Late 198? Early-mid 1983 Annual
1.2 Injury reduction	3. State data	Initial-belts Initial-bags Final (K + A) Update	1980, 1981 1982 Late 1982-early 1983 1984
	1. NASS data	Final (AIS) Update	Late 1983-late 1984 1985
2.3 Type of injury with restraint system	6. Inquiries to mfgrs. and 4. In-depth investigat'n	Case histories Summary rep't Updates	Throughout 1980-86 1983 Annual
2.4 Effectiveness by vehicle size	2. FARS data	Final (fatals)	Late 1984
	3. State data	Final (K + A)	Late 1984
2.8 Auto restraint malfunctions during vehicle operation	5. NHTSA Hotline	Notification	Throughout 1981-86
	6. Inquiries to mfgrs. and 4. In-depth investigat'n	Case histories Summary rep't Updates	Throughout 1980-86 1983 Annual
	9. Owner survey	Auxiliary	1983-85
2.9 Auto restraint malfunctions in crashes	5. NHTSA Hotline	Notification	Throughout 1981-86
	6. Inquiries to mfgrs. and 4. In-depth investigat'n	Case histories Summary rep't Updates	Throughout 1980-86 1983 Annual
2.10 Disabling malfunctions	5. NHTSA Hotline	Case histories	Throughout 1981-86
	9. Owner survey	Initial Final Updates	1983 1984 Annual

Objective	Project	Type of Results	Completion Date
3.1 Production and sales of bags and belts	6. Inquiries to manufacturers	Quarterly	1980-86
	7. New car registration data	Semi-annual	1982-86
3.2 Automatic belt usage on the road	8. On-the-road survey	Annual	1980-86
	1. NASS data	Auxiliary (annual)	1983-86
3.10 Evaluate public satisfaction with the Standard	10. Public survey	Initial Final	1982 1983
	9. Owner survey	Initial Final Updates	1983 1984 Annual
	5. NHTSA Hotline and consumer letters	Case histories Initial rep't	Throughout 1980-86 1982

Group B--Second Priority Objectives

Objective	Project	Type of Results	Completion Date
2.1 Air bag deployments	1. NASS data	Initial Final	1983 1984
2.6 Effectiveness by ΔV and PDOF	1. NASS data	Initial Final	1984 1985
2.7 Effectiveness in exceptional situations	4. In-depth investigation	Case histories Summary rep't Updates	Throughout 1980-86 1983 Annual
2.11 Disposal of undeployed air bags	6. Inquiries to manufacturers	Initial Updates	1981 1983-86
3.8 Comfort and convenience of automatic belts	11. Controlled tests	Annual	1982-84
	9. Owner survey	Auxiliary (annual)	1983-86
	5. NHTSA Hotline	Case histories	Throughout 1981-86

Objective	Project	Type of Results	Completion Date
4.1 Cost and weight of original equipment	12. Component teardown studies	Final-large cars Medium size cars Small cars Updates	Early 1982 Early 1983 Early 1984 Annual
	6. Inquiries to manufacturers	Initial Updates (as needed)	1981 1982-85
4.2 Cost of replacing deployed air bags	14. Insurance cost data	Initial Updates	1982 Annual
	6. Inquiries to manufacturers	Initial Updates (as needed)	1981 1982-85
	5. NHTSA Hotline	Case histories	Throughout 1981-86
4.5 Effect of Standard on auto insurance costs	14. Insurance cost data	Initial Updates (annual) Final	1981 1982-85 1986
4.6 Product liability claims	6. Inquiries to manufacturers	Initial Update Final	Late 1982 Late 1983 Late 1984
	5. NHTSA Hotline	Case histories	Throughout 1981-86

Group C--Third Priority Objectives

Objective	Project	Type of Results	Completion Date
2.2 Injury contact-point patterns	1. NASS data	Initial Final	1984 1985
2.5 Effectiveness by seating position	2. FARS data	Initial (fatals) Final (fatals)	1983 1985
	3. State data	Final (K + A)	1983
	1. NASS data	Final (AIS) Update	1984 1985

Objective	Project	Type of Results	Completion Date
3.3 Automatic belt disconnect rates	8. On-the-road survey	Auxiliary (annual)	1980-86
	9. Owner survey	Initial Final Updates	1983 1984 Annual
	1. NASS data	Auxiliary	1983, 1984, 1985
3.4 Deployed air bag replacement rate	6. Inquiries to manufacturers	Auxiliary (annual)	1982-86
	13. Analysis of job manuals	Initial Final Updates	1983 1984 Annual
3.6 Effect of restraint systems price and availability on car purchase	9. Owner survey	Initial Final Updates	1983 1984 Annual
	5. NHTSA Hotline	Case histories	Throughout 1981-86
3.7 Influence of Standard on auto design, production and marketing	6. Inquiries to manufacturers	Annual	1981-85
	7. New car registration data	Auxiliary (as needed)	1982-85
3.9 Evaluate NHTSA public information programs on automatic restraints	10. Public survey	Initial Final	1982 1983
	9. Owner survey	Initial Final Updates	1983 1984 Annual
4.3 Cost of routine maintenance of restraint systems	9. Owner survey	Initial Final Updates	1983 1984 Annual
	13. Analysis of job manuals	Auxiliary (annual)	1982-86

Objective	Project	Type of Results	Completion Date
4.4 Cost of repairing disabled restraint systems	6. Inquiries to manufacturers	Initial	1981
	9. Owner survey	Initial Final Updates	1983 1984 Annual
	13. Analysis of job manuals	Auxiliary (annual)	1982-86
	5. NHTSA Hotline	Case histories	Throughout 1981-86
4.7 Economic impact of Standard 208 on restraint system suppliers	6. Inquiries to manufacturers and suppliers	Initial Update Final	Late 1981 Late 1982 Late 1984

Summary Plan Schedule

A proposed schedule for each project is shown in Figure 5-2. It specifies starting and completion times and, where appropriate, the periods of preparatory or analytic work that precede or follow full project operation. Figure 5-2 was obtained by condensing the information in Figure 5-1, the detailed schedule of milestones and projects by objective.

To help relate which projects address each objective, a cross reference chart, Figure 5-3, has also been included. It shows the projects which are primary, auxiliary or early-response methods to be used to address the objectives. It also shows the projects that play a supporting role and provide basic information to facilitate the conduct of other projects.

CALENDAR YEAR

PROJECT	1980	1981	1982	1983	1984	1985	1986
1. NATIONAL ACCIDENT SAMPLING SYSTEM			▦━━━━━━━━━━━━━━━━━━━━━▦				
2. FATAL ACCIDENT REPORTING SYSTEM Projects for initial results and annual updates	▢	▭	▢	▢	▢	▢	▢
3. ANALYSIS OF STATE ACCIDENT DATA	▭	▭	▭	▭	▭	without LARS / with LARS	
4. IN-DEPTH ACCIDENT INVESTIGATION							
5. USE OF NHTSA "AUTO SAFETY HOTLINE"			▦━━━━ Ongoing Activity ━━━━				
6. INQUIRIES TO MANUFACTURERS AND SUPPLIERS							
7. AQUISITION OF NEW CAR REGISTRATION DATA	▦▦▦▦━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━						
8. ON-THE-ROAD BELT USAGE SURVEY	▭ Manual and optional restraints	▭ automatic	▭ Large Cars	▭ Medium	▭ Small	▭ Update	▭ Update
9. NEW CAR OWNER SURVEY		▦▦▦▦▦	▦ Large Cars	▢▦ Medium	▢▦ Small	▢▦ Update	
10. PUBLIC SURVEY		▦	▦	▦			
11. CONTROLLED TESTS OF COMFORT AND CONVENIENCE	▢▦ Optional auto. Restraints	▢▦ Large Cars	▢▦ Medium	▢▦ Small			
12. COST AND WEIGHT STUDY BASED ON COMPONENT TEARDOWN			▢ Large Cars	▢ Medium	▢ Small	▢ Update	▢ Update
13. ANALYSIS OF REPAIR DATA FOR AUTOMATIC RESTRAINTS — No. of Repair Jobs	▦▦▦▦▦▦▦▦▦▦▦▦▦			▦ Large Cars	▢▦ Medium	▢▦ Small	▢▦ Update
13. (Repair Costs)	▦▦▦▦ Large Cars	▦ Medium	▢▦ Small	▢▦ Update	▢▦ Update	▦	▢▦
14. ANALYSIS OF INSURANCE COST DATA — Short Term Effects (Discounts)		▦ Large Cars	▢ Medium	▢ Small	▢ Update	▢ Update	
14. (Long Term Effects)		▦▦▦▦▦▦▦▦	▦▦▦▦▦				
14. (Claims Analysis)			▦				

FIGURE 5-2 PROJECT SCHEDULES
PROPOSED NHTSA PLAN
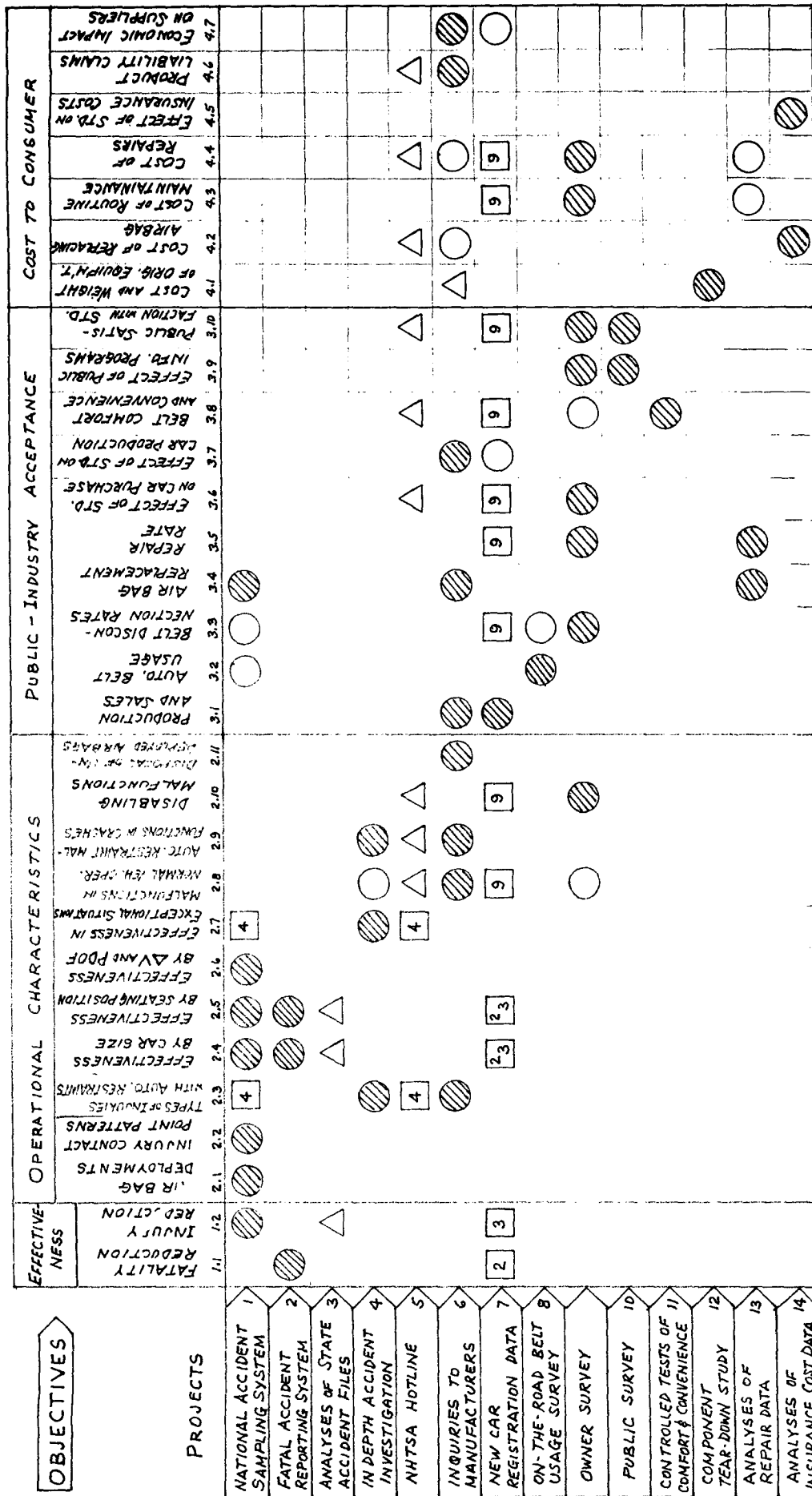
82

▦ START UP
▦ ANALYSIS

FIGURE 5-3 RELATIONSHIP OF PROJECTS
TO OBJECTIVES

PROPOSED NHTSA PLAN

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Preliminary Projection of Resource Requirements

NHTSA's preliminary assessment of resources needed to accomplish the evaluation of Standard 208 were made for planning purposes. They have not been submitted for inclusion in any Federal budget, nor have they been reviewed outside NHTSA. They are presented in this report primarily to show the relative magnitudes of the projects.

Projections were made for funds (Figure 5-4) and person years (Figure 5-5). They are classified by project and fiscal years.

Some of the requirments for funds are shown in brackets. These are projections of ongoing NHTSA programs for future years, as these would directly relate to Standard 208 evaluation. The bracketed amounts are not included in the totals.

There are considerable uncertainties associated with the resource requirements for some of the projects. The requirements for Project No. 3, State Data Analysis, are the least certain at this time: it is unknown whether the Limited Accident Reporting System will be needed. Therefore, two values are shown for this project - one without LARS and the other with LARS. The levels of effort for In-Depth Investigation and New Car Registration Data are also difficult to predict. The remaining projects generally involve collection of a data sample of known size with relatively well known costs per case, so the projections should be fairly accurate.

FIGURE 5-4

PROJECTED RESOURCE REQUIREMENTS FOR NHTSA EVALUATION PLAN
FUNDS IN $(000)

Project	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986	Total
1. National Accident Sampling System		[355]	[1895]				
2. Fatal Accident Reporting System		[10]	[10]	[10]	[10]	[10]	
3. State data analysis	450	100-2000	100-2000	100-2000			750-6450
4. In-depth accident investigation	[300]	1500	2500	2500	500	500	7500
5. NHTSA Hotline	10	20	20	20	10	10	90
6. Inquiries to manufacturers							
7. New car registration data	200	100	100	100	100	50	650
8. On-the-road belt usage survey	[250]	[250]+200	[250]	[250]	[250]	[250]	200
9. Owner survey	[100]	150	175	200	200	175	900
10. Public survey		100	100				200
11. Tests of comfort and convenience		150	150	150			450
12. Cost and weight study		[150]	[150]	[150]	[100]	[50]	250
13. Analysis of repair data		50	50	50	50	50	
14. Analysis of insurance data	[100]	[100]	[50]	[50]	[50]	[50]	
TOTAL	660	2370-4270	3195-5095	3120-5020	860	785	10990-16690

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FIGURE 5-5

PROJECTED RESOURCE REQUIREMENTS FOR NHTSA EVALUATION PLAN
PERSONNEL YEARS

Project	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986	Total
1. National Accident Sampling System	1	1	2				4
2. Fatal Accident Reporting System	1/2	1/2	1/2	1/2	1/2	1/2	3
3. State data analysis	2	2	2	2			8
4. In-depth accident investigation		1/2	1/2	1/2	1/2	1/2	2 1/2
5. NHTSA Hotline		1	2	2	1		6
6. Inquiries to manufacturers							
7. New car registration data	1	1/2	1/2	1/2	1/2	1/2	3 1/2
8. On-the-road belt usage survey							
9. Owner survey		1/2	1/2	1/2	1/2	1/2	2 1/2
10. Public survey		1/4	1/4				1/2
11. Tests of comfort and convenience	1/4	1/4	1/4	1/4			1
12. Cost and weight study		1/4	1/4	1/4			3/4
13. Analysis of repair data	1/2	1/2	1/2	1/2	1/2	1/4	2 3/4
14. Analysis of insurance data	1/2	1/2	1/2	1/2	1/2	1/2	3
Program management, analysis & reporting	2	2	2	2	2	1 1/2	11 1/2
TOTAL	7 3/4	9 3/4	11 3/4	9 1/2	6	4 1/4	49

NHTSA projects that the evaluation will cost between $11 million (without LARS) and $17 million (with LARS) and will require 49 person years of in-house effort. The LARS and In-Depth Investigation are by far the costliest projects.

The projections do not include the normal funding requirements of NHTSA's three general-purpose data collection systems, the National Accident Sampling System, the Fatal Accident Reporting System, and State Data Analysis, all of which contribute control group and baseline data for Standard 208 evaluation. The annual funding requirements for these programs will be $19 million, $3 million and $1 million, respectively. The personnel projections exclude NHTSA staff positions already assigned to these programs or to general program evaluation and rulemaking analysis.

REFERENCES

[1]   "The Abbreviated Injury Scale (AIS)." American Association for
       Automotive Medicine, Morton Grove, Illinois, 1976.

[2]   R.L. Braun et al. Evaluation Methodology for Federal Motor Vehicle
       Safety Standards, Vol. 2. DOT HS 802 341, National Technical Infor-
       mation Service, Springfield, Virginia, 1977.

[3]   B.J. Campbell, W. Rouse & F. Gendre. "The Traffic Accident Data
       Project Scale," Proceedings of the Collision Investigation Metho-
       dology Symposium. DOT HS 800 329, National Technical Information
       Service, Springfield, Virginia, 1969.

[4]   Chilton's Labor Guide and Parts Manual. Chilton, Co., Philadelphia,
       annual publication.

[5]   C. Cooke, "Usage of Occupant Crash Protection Systems," NHTSA, 1976.

[6]   Docket 74-14; Notice 10 (Final Rule on Standard 208). Federal
       Register, Vol. 42, No. 128, pp. 34289 - 34299, Washington, 1977.

[7]   "Final Design and Implementation Plan for Evaluating the Effec-
       tiveness of FMVSS 208: Occupant Crash Protection." DOT HS 802 348,
       National Technical Information Service, Springfield, Virginia, 1977.

[8]   R.G. Hall. Fact Book: A Summary of Information about Towaway
       Accidents Involving 1973-75 Model Cars. DOT HS 802 036, National
       Technical Information Service, Springfield, Virginia, 1976.

[9]   D.F. Mela. "NHTSA's Evaluation of Air Cushion Restraint Systems
       Effectiveness (ACRS)." Report on the Fifth International Technical
       Conference on Experimental Safety Vehicles, U.S. Government Printing
       Office, Stock No. 050-003-00210, Washington, 1975, pp. 395-403.

[10]   "Occupant Protection Program Progress Report No. 2." NHTSA,
       Washington, 1979.

[11]   "Public Attitudes Toward Passive Restraint Systems." NHTSA,
       Washington, 1978.

[12]   D.W. Reinfurt, C.Z. Silva & A.F. Seila. A Statistical Analysis of
       Seat Belt Effectiveness in 1973-75 Model Cars Involved in Towaway
       Accidents. DOT HS 802 035, National Technical Information Service,
       Springfield, Virginia, 1976.

[13]   Service Job Analysis. Hunter Publishing Co., Chicago, annual publication.

[14] R.A. Smith, J.C. Fell & C.J. Kahane. "FY 1977 Implementation of
the National Accident Sampling System." DOT HS 802 260, National
Technical Information Service, Springfield, Virginia, 1977.

[15] C. Stowell & J. Bryant. "Safety Belt Usage: Survey of the Traffic
Population." DOT HS 803 354, National Technical Information Service,
Springfield, Virginia, 1978.

APPENDIX A
STATISTICAL METHODS

In preparing the evaluation plan for automatic restraint systems - Standard 208 - it was necessary to develop a series of estimates for time periods by which various accident data sets would provide results on the effectiveness of restraints. This Appendix describes methods particularly the determination of sample sizes, together with the analytical limitations, given the data systems envisioned.

There are five sections:

o Methods used for calculating completion dates. General procedures and criteria are presented which are then tailored to individual requirements of each of the subsequent data systems.

o Assumptions about the production mix by car size, automatic restraint type offered, projection of automatic restraint equipped cars involved in accidents, and estimates of injury rates for unrestrained car occupants, etc.

o The Fatal Accident Reporting System (FARS) as used for estimating the effectiveness of automatic restraint systems, and how sample sizes are calculated for this data base.

o Sample size requirements using the National Accident Sampling System (NASS).

o The use of State Accident Data and sample size requirements for estimating the injury reducing effectiveness of automatic restraint systems.

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METHODS FOR CALCULATING COMPLETION DATES

Definition of Effectiveness

The last 3 sections cover the calculation of the sample sizes for FARS, NASS, and State accident data necessary to provide stable estimates of restraint system effectiveness. Effectiveness is defined to be the percentage reduction in fatalities and/or injuries of occupants utilizing an automatic restraint system over a comparable group of unrestrained occupants. Effectiveness "e" is:

$$e = 1 - T/C$$

Where T is the percentage of deaths and injuries in the population of crash-involved front-seat occupants of automatic restraint equipped vehicles. C is the corresponding percentage for unrestrained crash-involved front-seat occupants in similar vehicles. "Similar" vehicles are vehicles of roughly the same size (weight and wheelbase) and age, but not equipped with automatic restraints.

Criteria for Stability of Effectiveness Estimates

For each of the three data sources we will be using, we will define two criteria for adequate stability of results.

With FARS and State accident data, we will say that stability is adequate for <u>initial</u> results if the standard deviation of observed effectiveness "e" is .075. The stability is adequate for <u>refined</u> results if the standard deviation of observed "e" is .05.

With NASS data, a higher level of sampling error can be tolerated than
with FARS or State data, because there is less risk of non-sampling
error: NASS would be more nationally representative than a selection of
5 or 6 States, it has a far more detailed system of quality control, and
NASS data can be adjusted on variables such as ΔV to remove possible
confounding biases. We will say that stability is adequate for initial
NASS results if the standard deviation of observed "e" is .10. The
stability is adequate for refined results if the standard deviation is
.075.

General Procedure for Calculating Sample Size

The general procedure is to calculate the number of casualties that must
occur in an automatic restraint system equipped population to assure that
the observed effectiveness meets the stability criterion. We solve an
equation whose unknown "x" is the number of casualties in the automatic
restraint equipped cars. Using the Taylor series approximation the
equation is:

$$V(e) \cong (1-e)^2 \left[CV^2(T(x)) + CV^2(C) \right] \qquad (1)$$

where:

$V(e)$ is the variance of observed effectiveness which
for FARS and State data is set at $(.075)^2$ for initial
results, and $(.05)^2$ for refined results. For NASS it is
$(.1)^2$ for initial results and $(.075)^2$ for refined
results.

e	is the effectiveness. Specific values are given in the "Assumptions" section.
CV(T(x))	is the coefficient of variation of observed T and is a function of x.
CV(C)	is the coefficient of variation of C. Since C will be calculated from existing data files, CV(C) will have a fixed value.

The equation will be solved for initial and refined V(e) and for each of the alternative automatic restraint systems.

Generalized Procedure for Calculating Completion Dates

A projection is made of the number of casualties that will occur in future time periods. Cumulating these will give us the number that have occurred by various dates. When that number equals the "x" just calculated, it will identify the approximate date when a stable estimate of effectiveness "e" can be made. The time lag between the occurrence of an accident and its accessibility on the data file must be added to the above date.

The projections of expected casualties are based on the assumptions that follow.

ASSUMPTIONS

Sales and Usage

Passenger automobile sales of 11 million units annually are assumed to prevail over the evaluation time frame. This sales level is further assumed to break down as follows:

Full size cars with wheelbase of

$\geq$ 114 inches   2.2 million units

Intermediate and Compact sizes with

a wheelbase range of 100 to 113.9 inches   5.2 million units

Subcompact sizes with wheelbase of

less than 100 inches   3.6 million units

As the reader will recall, in Chapter 1 of this plan, 3 sales/usage levels were presented. These were combinations of assumed air bag sales and automatic belt usage rates that could occur as the fleet of automatic restraint equipped cars is introduced and used. The 3 levels were designated A, B and C in order of descending air bag sales by car size, and descending automatic belt usage rates after introduction. To provide the numerical reference, the assumption levels are repeated in Table 1.

TABLE 1

ASSUMPTION ALTERNATIVES FOR AUTOMATIC RESTRAINT
SALES AND USAGE RATES

Percent of Cars Equipped with Air Bags
(by wheelbase range)

Air Bag Sales Level	> 114 in.	100-113.9 in.	<100"
A	50	40	25
B	30	25	10
C	10	10	trace

Automatic Belt Usage Rates (percent)

Automatic Belt Usage Level	After 1 year	After 2 years
A	80	60
B	60	30
C	30	20

Throughout this Appendix the "B" level is used as an example for the calculations. Table 2 shows the expected sales of air bag and automatic belt restraint equipped passenger cars for the model years '82 through '86 with the "B" level sales/usage assumptions. This, and all other subsequent calculations will not include vehicles optionally equipped with automatic restraints.

TABLE 2

AUTOMATIC RESTRAINT SYSTEM SALES

o Air Bag Sales (000)

	Car Size		
Model Year	Large	Medium	Small
82	660	0	0
83	660	1300	0
84	660	1300	360
85	660	1300	360
86	660	1300	360

o Automatic Belt Sales (000)

Model Year	Large	Medium	Small
82	1540	0	0
83	1540	3900	0
84	1540	3900	3240
85	1540	3900	3240
86	1540	3900	3240

Expected Accidents

Based on historical trends about 2 percent of the passenger car
population is involved in a towaway collision each year[1]. With this
value assumed, the following accident projections were calculated.

TABLE 3

PROJECTED TOTAL NUMBER OF TOWAWAY ACCIDENTS IN THE U.S. -
BY TYPE OF AUTOMATIC RESTRAINT SYSTEM
(000)

Fiscal Year	Air Bag	Automatic Belts
82	6.6	15.4
83	32.8	85.2
84	75.6	226.4
85	122.0	400.0
86	168.4	573.6

[1] H. Joksch, "Design of Field Passive Restraint Evaluation," Center
for the Environment and Man, Report No. 4250-641.

A similar projection was prepared to calculate the number of towaway accidents that are expected to occur within the National Accident Sampling System (NASS) sites. The projection is based on the assumption that there will be 75 NASS primary sampling units operational by September 1981, or shortly thereafter.

TABLE 4

PROJECTED NUMBER OF TOWAWAY ACCIDENTS AT
NASS SITES - BY TYPE OF AUTOMATIC RESTRAINT SYSTEMS

FY	Air Bag	Automatic Belts
82	396	924
83	1968	5112
84	4536	13584
85	7320	24000
86	10104	34416

Additional Assumptions

Several assumptions underlie the estimates made from the data systems in the remaining sections of this Appendix. These are briefly listed below, together with relevant reference material.

1. The front seat occupancy in towaway crashes averages 1.33. The reference for this factor is "Restraint System Evaluation Project Codebook" by Mungenast and Kahane, DOT HS 802 285, NHTSA, 1977.

2. The probability of a fatality involving an unrestrained occupant in a towaway crash is .008. This is based on "A Statistical Analysis of Seat Belt Effectiveness in 1973-1975 Model Cars Involved in Towaway Crashes, DOT HS 802 035, NTIS 1976.

3. Effectiveness estimates (fatality reduction), by type of automatic restraint are:

   (a) Air bag alone   40 percent

   (b) Air bag and lap belt: 66 percent

   (c) Automatic belt when used: 50 percent

   These estimates are based on Docket 74-14, Notice 10 (Final Rule of Standard 208). Federal Register, Vol. 42, No. 128,P. 34299, Washington, 1977. By taking the composite of these effectiveness assumptions, and projected belt usage (given elsewhere), we further obtain

   (d) Air bag system   43 percent

   (e) Automatic belt system   varies with time as belt usage varies.

4. The K+A Injury reducing effectiveness and the AIS $\geq$ 2 injury reducing effectiveness of automatic restraints are about the same as the effectiveness in reducing fatalities.

5. Manual belt usage in air bag equipped cars is 14 percent. NHTSA estimates that only 14 percent of the nation's drivers use their manual safety belts (Safety Belt Usage: Survey of Cars in the Traffic Population, Pub. No. DOT HS 803 354, NTIS, 1978). There is no reason to believe this will change substantially.

6. Automatic belt usage in cars with mandatory automatic restraints will be 60 percent after the first year and 30 percent after two years, as shown on Table 1 of this Appendix, usage level 3.

7. The probability of K+A injury to an unrestrained front seat occupant involved in a towaway crash is .087. This is based on a tabulation from the National Crash Severity Study, Pre April '78 Batch which contained 6627 unweighted cases.

8. The probability of an AIS $\geq$ 2 or greater injury to an unrestrained front seat occupant involved in a towaway crash is .08. This is based on the source quoted above (Assumption 7).

9. The probability of an AIS $\geq$ 2 injury to a front-seat occupant of a vehicle in which at least one occupant suffered a K+A injury is .577; and the probability of an AIS $\geq$ 2 injury to an unrestrained front seat occupant of a towed vehicle in which no occupant suffered K or A injury is .034. These values are based on data in the tabulations referred to in item 7 above. These conditional probabilities will be used in connection with the NASS sampling plan discussed further on.

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SAMPLE SIZE REQUIREMENTS FOR
FARS ESTIMATES

Approach

The Fatal Accident Reporting System (FARS) is a virtual census of police reported data on all fatal accidents occurring in the fifty States and the District of Columbia. Because it is a census there is no variability in the data attributable to sampling. All variability in estimating the underlying population parameters is attributable to the model used to estimate the parameters and possible non-sampling error. The model that will be used for estimating fatality reducing effectiveness is the following. The fatality rate "T" for automatic restraints is the number of front seat occupant fatalities divided by the number of vehicle years of on-the-road exposure. The number of fatalities is found from FARS and the exposure is calculated from sales or new car registration data.

The probability of a fatality in a vehicle year is approximately binomial. Both the observed fatality and exposure are viewed as a sample of a hypothetical infinite population. Therefore, the observed "x" fatalities in "n" vehicle years is a sample from an infinite binomial population with $p \cong x/n$. Using this model, we can find the coefficient of variation, CV(T) as a function of "x":

$$CV^2(T) \cong \frac{p(1-p)}{n} / p^2 = \frac{(1-p)}{np} = \frac{(1-p)}{x} \cong \frac{1}{x}$$

As can be seen the Poisson approximation to the binomial distribution is used.

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The same model and data sources are used to calculate "C", the fatality rate for the control group of unrestrained occupants. The control group will consist of manual belt equipped model year 1981 cars of the same size categories as the automatic restraint equipped cars. Since the control group includes some manual restraint users, the observed fatality rate must be adjusted upwards to give the unrestrained fatality rate.

The coefficient of variation of the control group is:

$$CV(C) = .04$$

Calculation of Required Sample Size

Using the equation for the variance of observed effectiveness [Equation (1)]:

$$V(e) \cong (1-e)^2 \left[CV^2(T(x)) + CV^2 (C) \right]$$

We solve for "x", using the binomial model discussed above, i.e. $CV^2(T)$ = $1/x$; $CV^2(C)$ = $(.04)^2$.

Substituting into Equation (1), for initial results for the air bag system:

$$(.075)^2 = (1 - .43)^2 \left[\frac{1}{x} + (.04)^2 \right]$$

Therfore: x = 63 fatalities.

In other words, initially stable results on air bag effectiveness will be available after 63 fatalities have occurred.

For refined results on the air bag system, and making similar substitutions into Equation (1), x = 164.

On the assumption that the effectiveness of the <u>automatic belt system</u> will be an average of 40 percent during 1982, and again substituting into Equation (1), x = 70 fatalities for initial results, and x = 186 fatalities for refined results.

To calculate the effectiveness of the air bag alone, the air bag plus lap belt, and the automatic belt when used, we cannot use FARS data because the belt use reporting is inadequate and incomplete.

Calculation of Expected Completion Dates

Table 5 recapitulates the required numbers of fatalities just calculated.

TABLE 5

FATALITIES REQUIRED FOR STABLE RESULTS

	Air Bag System	Automatic Belt System
Initial	63	70
Refined	164	186

The number of anticipated front seat occupant fatalities, by type of restraint system, are shown in Table 6.

TABLE 6

CUMULATIVE EXPECTED FATALITIES

Expected by	Air Bag System	Automatic Belt System
1-1-82	3	6
4-1-82	10	25
7-1-82	23	55
10-1-82	40	98
1-1-83	67	169
4-1-83	110	283
7-1-83	167	441
10-1-83	239	642

Allowing a 3 month time lag from the occurrence of the fatalities shown in Table 6 to their availability from FARS, we obtain the expected completion dates in Table 7.

TABLE 7

EXPECTED COMPLETION DATES FOR ANALYSIS OF EFFECTIVENESS
(based on FARS data)

	Air Bag System	Automatic Belt System
Initial Results	2nd Quarter 1983	4th Quarter 1982
Refined Results	4th Quarter 1983	2nd Quarter 1983

SAMPLE SIZE REQUIREMENTS FOR
NASS ESTIMATES

Approach

The National Accident Sampling System (NASS) is a probability sample of
the nation's accidents. It will be possible to make national estimates
of the AIS $\geq$ 2 reducing effectiveness of the air bag system, the air bag
alone, the automatic belt system and the automatic belts when used. It
will, moreover, be possible to measure directly the sampling error of a
NASS estimate - i.e., its likely variability from the results of a
national accident census.

The NASS is a stratified cluster sample. First, 75 geographical areas
(primary sampling units, PSU, or clusters) were selected from the United
States. Each PSU had some known probability of selection F_1. Within
the PSU's a stratified sample of persons involved in towaway crashes is
selected. Each person has some known probability of selection F_2
within the PSU. Thus, the probability that NASS will select a particular
person from among the nation's crash involved occupants is F_1F_2.
Consersely, one observation on NASS corresponds to $1/F_1F_2$ crash
involved persons in the United States. That number, $1/F_1F_2$, can be
called the weight of a NASS datum.

The injury rate "T" for automatic restraints is the number of weighted towaway-involved front-seat occupants with AIS $\geq$ 2 injury divided by the total number of weighted towaway-involved front-seat occupants. (The "number of weighted occupants" is the sum of the weights of the NASS observations).

The specific stratified sample that has been considered for use within the PSU's for automatic restraints will consist of two strata:

(1) We will sample 100 percent of the vehicles containing K or A injured front-seat occupants

(2) We will sample 50 percent of the other towed vehicles.

We will now develop a formula that approximates the coefficient of variation CV(T), as a function of X, the number of AIS $\geq$ 2 injuries that have occurred in the United States. The formula contains a number of simplifications and has not been tested with actual NASS data. It is expected, however, to give a conservative approximation, i.e., to overstate the true CV(T).

Since NASS is a cluster sample,

$$CV^2(T) = CV^2_B (T) + CV^2_W (T).$$

where CV_B is the contribution to the CV from between-PSU variation and CV_W is the within-PSU contribution.

An approximate, empirical formula for CV_B as a function of x has been developed for NHTSA in Contract DOT-HS-7-01706:

$$CV_B^2 (T) \cong (.000597 + \frac{16.38}{x}) \frac{125}{m}$$

where m is the number of NASS PSU's. The Contractor developed this formula for accident and vehicle statistics. We have conjectured that it is also appropriate for occupant statistics - i.e., injury rates. Since there will be 75 PSU's during the 1982-84,

$$CV_B^2 (T) \cong .001 + 27.3/x$$

The formula for the CV of a stratified simple random sample allows an approximation of CV_W. (It is only an approximation because the PSU's have different probabilities of selection and because NASS estimates will probably be standardized by ΔV or other variables.)

$$CV_w^2(T) \cong \frac{1}{T^2} \sum_{h=1}^{\ell} (1-f_h)(w_h)^2 \frac{p_h(1-p_h)}{n_h}$$

where f_h is the sampling fraction for stratum h,

   n_h is the number of NASS sample cases in stratum h

   p_h is the AIS $\geq$ 2 injury rate in stratum h

   w_h is the relative weight of stratum h, that is,

$$w_h = \frac{n_h/f_h}{\sum n_j/f_j} = \frac{n_h/f_h}{n}$$

where n is the total number of involved occupants at the NASS PSU's using the automatic restraint system in question.

Since our stratified sampling scheme involves two strata with $f_1 = 1$, $f_2 = .5$

$$CV_W^2(T) = \frac{1}{T^2} (.5)(w_2)^2 \frac{p_2(1-p_2)}{n_2}$$

Since $w_2 = \frac{n_2/f_2}{n} = \frac{n_2}{.5n}$,

$$CV_W^2(T) = \frac{1}{T^2} w_2 \frac{p_2(1-p_2)}{n}$$

Since a total of 6 percent of the nation's accidents occur at the NASS PSU's,

$$n = .06 \, X/T.$$

$$CV_W^2(T) = \frac{1}{T} w_2 \frac{p_2(1-p_2)}{.06X}$$

The next step is to determine w_2 and p_2 as a function of e, the effectivness of the restraint system in question. Because the 2nd stratum consists of the occupants who did not have K or A injury,

$w_2 = 1 - w_1 = 1 - (0.87 \, (1-e)) = .913 - .087e$,

where .087 was assumed to be the likelihood of K or A injury to an unrestrained occupant and .087 (1-e) is the likelihood of injury for the restrained occupant.

We assumed that the AIS$\geqslant$2 injury rate for restrained occupants is .08(1-e). We also assumed that the AIS$\geqslant$2 injury rate for persons who had K or A police-reported injuries was .577 (regardless of restraint system). Therefore

$$.08(1\text{-}e) = w_1 p_1 + w_2 p_2 = (.087(1\text{-}e))(.577) + w_2 p_2$$

and

$$p_2 = \frac{.03(1\text{-}e)}{w_2} = \frac{.03(1\text{-}e)}{.913 - .087e}$$

Substituting these values of w_2 and p_2 into the formula for CV_w and noting that $T = .08(1\text{-}e)$, we obtain

$$CV_w^2(T) = \frac{1}{.08(1\text{-}e)}(w_2)\frac{.03(1\text{-}e)}{w_2}(1\text{-}p_2)\frac{1}{.06x}$$

$$= \frac{6.25(1\text{-}p_2)}{x}$$

$$= 6.25 \left(\frac{.883 + .117e}{.913 + .087e}\right)\frac{1}{x}$$

Finally,

$$CV^2(T) = CV_B^2(T) + CV_w^2(T)$$

$$= .001 + \left(27.3 + 6.25\left(\frac{.883 + .117e}{.913 + .087e}\right)\right)\frac{1}{x}$$

Data from the Continuous Sampling Subsystem of NASS are used to calculate "C", the AIS $\geqslant$ 2 injury rate for the control group of unrestrained occupants of manual belt equipped model year 1980 and 1981 cars of the same size categories as the automatic restraint equipped cars.

The coefficient of variation of the control group is:

$$CV(C) = .07$$

Calculation of Required Sample Size

Using the equation for the variance of observed effectiveness [Equation (1)]

$$V(e) = (1-e)^2 [CV^2(T(X)) + CV^2(C)]$$

we solve for "X" using the formula for CV(T) and the value for CV(C) established above, i.e.

$$CV^2(T) = .001 + (27.3 + 6.25 \frac{[.883 + .117e]}{.913 + .087e}) \frac{1}{X}$$

$$CV^2(C) = (.07)^2$$

Substituting into Equation (1), for initial results for the air bag system:

$$(.1)^2 = (1-.43)^2 \left[.001 + \left(27.3 + 6.25 \frac{.883 + .117(.43)}{.913 + .087(.43)} \right) \frac{1}{X} + (.07)^2 \right]$$

Therefore X = 1344 AIS $\geqslant$ 2 injuries

In other words, initially stable NASS results on air bag system effectiveness will be available after 1344 AIS $\geq$ 2 injuries have occurred in the United States.

For refined results on the air bag system, and making similar substitutions into Equation (1), x=2930.

For the air bag alone, and again substituting into Equation (1), x=1528 AIS $\geq$ 2 injuries for initial results and x = 3438 AIS $\geq$ 2 injuries for refined initial results.

On the assumption that the effectiveness of the automatic belt system will be an average of 40 percent during 1981 - mid 1983, and again substituting into Equation (1), x = 1528 AIS $\geq$ 2 injuries for initial results and x = 3438 AIS $\geq$ 2 injuries for refined results.

For the automatic belts when used, x = 981 AIS $\geq$ 2 injuries for initial results and x = 2015 AIS $\geq$ 2 injuries for refined results.

Finally, for the air bag plus lap belt, x = 415 AIS $\geq$ 2 injuries for initial results and x = 783 AIS $\geq$ 2 injuries for refined results.

Calculation of Expected Completion Dates

Table 8 recapitulates the required numbers of AIS $\geq$ 2 injuries in the United States.

TABLE 8

AIS $\geq$ 2 INJURIES REQUIRED IN THE UNITED STATES FOR STABLE NASS RESULTS

	Air Bag System	Air Bag Alone	Auto. Belt System	Auto Belt When Used	Air Bag + Lap Belt
Initial	1344	1528	1528	981	415
Refined	2930	3438	3438	2015	783

The number of anticipated front-seat occupant AIS $\geq$ 2 injuries in the United Sates are shown in Table 9.

TABLE 9

CUMULATIVE EXPECTED AIS > 2 INJURIES IN THE UNITED STATES

Expected by	Air Bag System	Air Bag Alone	Auto. Belt System	Auto Belt When Used	Air Bag + Lap Belt
10-1-82	400	360	980	655	40
1-1-83	675	610	1690	1130	65
4-1-83	1100	990	2830	1890	110
7-1-83	1670	1510	4410	2940	160
10-1-83	2390	2160	6420	4280	230
1-1-84	3270	2960	9000	6000	310

It is evident that even initially stable results on the air bag plus lap belt cannot be achieved during the time frame of the NASS Special Study on automatic restraints. Allowing a 3 month lag time from the occurrence of the injuries shown in Table 9 to their availability on NASS, we obtain the expected completion dates in Table 10.

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TABLE 10

EXPECTED COMPLETION DATES FOR
ANALYSIS OF EFFECTIVENESS
(Based on NASS data)

	Air Bag System	Air Bag Alone	Auto. Belt System	Auto Belt When Used
Initial results	3rd Quarter 1983	4th Quarter 1983	1st Quarter 1983	1st Quarter 1983
Refined results	1st Quarter 1984	N.A.	3rd Quarter 1983	3rd Quarter 1983

SAMPLE SIZE REQUIREMENTS
FOR STATE ESTIMATES

Approach

Each of the 50 States and the District of Columbia maintain accident data files. As we have just seen, NASS will take considerable time until sufficient accident experience is achieved to make defensible estimates of the injury reducing effectiveness of automatic restraint systems. In order to have more timely estimates, it would be desirable to acquire accident data from the States to supplement NASS data.

Approximately 60 percent of all accidents occur in about ten (10) States. By examining data from five to six of these 10 States, NHTSA could capture about 40 percent of the nation's accidents.

The initiation of a Limited Accident Reporting System (LARS) would reduce the error rates found in unmodified State data tapes on variables such as the VIN (See Chapter 4, Project No. 3.). But even with LARS it will only be possible to measure injury reduction by the K+A criterion, not the AIS. Usually, though, K+A and AIS $\geq$ 2 injury reduction are about the same. The sample size calculations that follow do not take into account possible biases that might result from State-to-State differences in the interpretation of what is an "A" level injury.

If all of the States whose data we will be using maintain records on uninjured as well as injured occupants, the following model can be used for estimating injury reducing effectiveness: The injury rate "T" for automatic restraints is the number of towaway-involved front-seat occupants with K or A injury divided by the total number of towaway-involved front-seat occupants. (If one or more of the States does not maintain records on uninjured occupants, we shall let "T" be the number of towaway-involved front-seat occupants with K or A injury divided by the total number of towaway-involved vehicles. Use of this alternative approach would not require sample sizes much different from the ones calculated below.)

The probability of a K or A injury to a towaway involved occupant is binomial. The observed accident and injury experience is viewed as a sample of a hypothetical infinite population. Therefore, the observed "x" K or A injuries among "n" involved occupants is a sample from an infinite binomial population with $p = x/n$. Using this model, we can find the coefficient of variation, CV(T) as a function of "x":

$$CV^2(T) = \frac{p(1-p)/p^2}{n} = \frac{(1-p)}{np} = \frac{(1-p)}{x} = \frac{[1-.087(1-e)]}{x}$$

$$= \frac{.913 + .087e}{x}$$

where .087 is the K+A injury rate for unrestrained occupants (see "Assumptions") and e is the effectiveness of the automatic restraint system in question.

The same model and data source are used to calculate "C," the injury rate for the control group of unrestrained occupants. The control group will consist of manual belt equipped model year 1981 cars of the same size categories as the automatic restraint equipped cars. Since the control group includes some manual restraint users, the observed injury rate must be adjusted upwards to give the unrestrained injury rate.

The coefficient of variation of the control group is:

$$CV(C) = .02$$

Calculation of the Required Sample Size

Using the equation for the variance of observed effectiveness [Equation(1)]:

$$V(e) \cong (1-e)^2 [CV^2(T(x)) + CV^2(c)]$$

we solve for "x" using the binomial model discussed above, i.e., $CV^2(T) = (.913 + .087e)/x$; $CV^2(C) = (.02)^2$.

Substituting into Equation (1), for initial results for the air bag system:

$$(.075)^2 = (1 - .43)^2 \left[\frac{.913 + .087\ (.43)}{X} + (0.2)^2\right]$$

Therefore: x = 57 K or A injuries

In other words, initially stable results on air bag effectiveness will be available after 57 K or A injuries have occurred in the States whose data we are using.

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For refined results on the air bag system, and making similar substitutions into Equation (1), x =131.

On the assumption that the effectiveness of the <u>automatic belt system</u> will be an average of 40 percent during 1982, and again substituting into Equation (1), x = 63 K or A injuries for initial results and x = 145 K or A injuries for refined results.

To calculate the effectiveness of the air bag alone, the air bag plus lap belt, and the automatic belt when used, we will not be able to rely on State data unless the States we are using report belt usage in the automatic restraint vehicles.

Calculation of Expected Completion Dates

Table 11 recapitulates the required numbers of K or A injuries just calculated.

<div align="center">

TABLE 11

K + A INJURIES
REQUIRED FOR STABLE RESULTS

</div>

	Air Bag System	Automatic Belt System
Initial	57	63
Refined	131	145

The number of anticipated front seat occupant K+A injuries in States comprising 40 percent of the nation's accident population are shown in Table 12.

TABLE 12

CUMULATIVE EXPECTED K+A INJURIES IN
STATES WITH 40 PERCENT OF THE
NATION's ACCIDENTS

Expected by	Air Bag System	Automatic Belt System
1-1-82	11	27
4-1-82	44	107
7-1-82	98	240
10-1-82	174	426

Allowing a 3 month lag time from occurrence of the injuries shown in Table 12 to their availability from LARS, we obtain the expected completion dates in Table 13.

TABLE 13

EXPECTED COMPLETION DATES FOR
ANALYSIS OF EFFECTIVENESS
(based on LARS data)

	Air Bag System	Automatic Belt System
Initial results	3rd Quarter 1982	2nd Quarter 1982
Refined results	4th Quarter 1982	3rd Quarter 1982

If unmodified State data types are used instead of LARS, the lag time could be as great as 1 year. Up to 9 months might have to be added to the completion dates shown in Table 13.