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DOT HS-802 340

EVALUATION METHODOLOGY FOR FEDERAL MOTOR VEHICLE SAFETY STANDARDS

Volume I: Executive Summary

Contract No. DOT-HS-6-01519

May 1977

Final Report

PREPARED FOR:

U.S. DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
WASHINGTON, D.C. 20590

Prepared for the Department of Transportation , National Highway Traffic Safety Administration under Contract No: DOT HS-6-01519. The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the National Highway Traffic Safety Administration.

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT HS-802 340		

4. Title and Subtitle	5. Report Date
Evaluation Methodology for Federal Motor Vehicle Safety Standards Volume I: Executive Summary	May 1977 6. Performing Organization Code
7. Author(s) R. L. Braun, R. H. Cronin, N. A. David, A. V. Fend, J. R. Norman	8. Performing Organization Report No.
9. Performing Organization Name and Address The Transportation Center Stanford Research Institute 333 Ravenswood Avenue Menlo Park, CA 94025	10. Work Unit No. 11. Contract or Grant No. DOT HS-6-01519
12. Sponsoring Agency Name and Address Department of Transportation National Highway Traffic Safety Administration 400 Seventh Street, S.W. Washington, D.C. 20590	13. Type of Report and Period Covered Final Report Sept. 1, 1976 to Mar. 31, 1977 14. Sponsoring Agency Code

15. Supplementary Notes

None

16. Abstract

This report, Volume I Executive Summary, summarizes the results of a 6-month study to determine feasibility and appropriate evaluation schemes in a real-world environment for four Federal Motor Vehicle Safety Standards (FMVSS): FMVSS 301--Fuel Integrity; FMVSS 208--Occupant Protection; FMVSS 214--Side Door Strength; and FMVSS 215--Exterior Protection.

Based on a review of the literature, background material, specifications, compliance tests, and available evaluation methodologies, feasibility was established for the evaluation of FMVSS 301, 208, and 214. However, no evaluation scheme was uncovered that should be expected to provide conclusive results in FMVSS 215--Exterior Protection. Alternative plans that rely on qualified, indirect surveys or insurance data are the only potentially acceptable approaches if FMVSS 215 is to be evaluated.

Within an augmented National Crash Severity Study (NCSS) program, detailed evaluation plans for FMVSS 301, 208, and 214 are described and recommended to NHTSA. Probability of successful evaluation ranges from good to fair, costs range from a low of $37,400 to a high of $1,378,200 and schedules from a few months to three years.

Volume II, Technical Findings, describes the overall study details and individual implementation plan for evaluation.

17. Key Words	18. Distribution Statement
Evaluation Methodologies Motor Vehicle Safety Standards Field Accident Investigations Implementation Plan for Evaluation	Document is available to the public through the National Technical Information Service, Springfield, VA 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED	27	

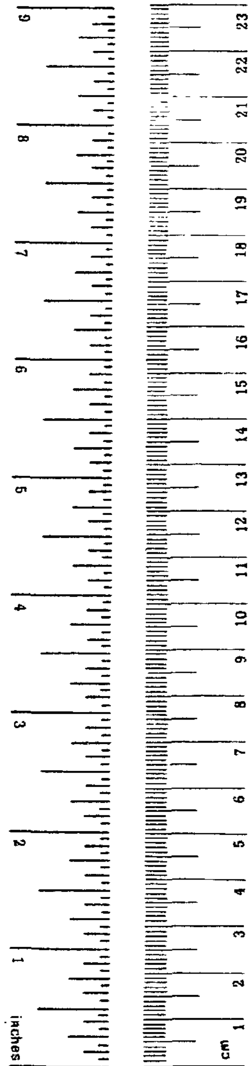
Form DOT F 1700.7 (8-69)

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

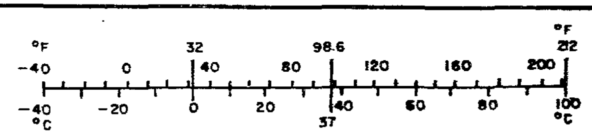
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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ILLUSTRATIONS

PREFACE

This report documents the experimental designs developed by Stanford Research Institute (SRI) under contract DOT-HS-6-01519 to evaluate four Federal Motor Vehicle Safety Standards (FMVSS):

- FMVSS 301--Fuel System Integrity
- FMVSS 208--Occupant Protection
- FMVSS 214--Side Door Strength
- FMVSS 215--Exterior Protection.

It provides in a single-source document, the major findings of this development contract.

The intent of the study was to identify how the actual effectiveness of these four standards can be determined in relation to mitigating the effects of real-world accidents. This study was directed and coordinated by the Program Planning and Evaluation Division of the National Highway Traffic Safety Administration (NHTSA). The support and contributions of the NHTSA staff members in Washington D.C. are gratefully acknowledged.

INTRODUCTION

SRI developed the data in this report as part of a study to determine feasible techniques to evaluate the four FMVSSs. This development program was conducted between 1 September 1976 to 31 March 1977. This volume summarizes the evaluation plans developed. Volume II, Technical Findings, describes the development process and the major findings in this study in detail.

BACKGROUND

Some 40 FMVSSs have been issued under the National Traffic and Motor Vehicle Safety Act of 1966. They are intended to improve motor vehicle safety by establishing minimum practicable requirements, based on objective criteria, for motor vehicle performance. However, questions have been raised about the cost effectiveness and public acceptance of certain of these standards. These questions, together with recent concerns about energy and economic problems, have indicated the need to evaluate the effectiveness of the standards in terms of costs and benefits.

NHTSA has endorsed an evaluation concept for the FMVSS and has established a policy that stipulates that management decision-making will, in part, be based on field evaluations of the performance of new and existing standards. The FMVSS evaluation program began with the formulation of detailed plans for the evaluation of these four standards:

- FMVSS 301--Fuel System Integrity
- FMVSS 208--Occupant Protection
- FMVSS 214--Side Door Strength
- FMVSS 215--Exterior Protection.

The issues addressed by each of these standards, including intended safety and economic benefits, are briefly discussed below.

FMVSS 301--Fuel System Integrity

Motor vehicle fire, although involved in relatively few accidents (accounting for about 1% of all fatalities), is disproportionately feared by the public because such fires are often spectacular and lethal. It is difficult even to identify the number of fire involvements; and much more difficulty is encountered in measuring the number and extent of injuries, the physics of real-life accidents, and the sources of fuel leakage and of ignition. The incorporation of fuel evaporation emission control systems on many 1970 and later vehicles has added complexity to fuel systems. Some of these changes help to prevent fuel leakage, but added fuel system components also offer more opportunities for damage to those parts.

FMVSS 301 is intended to limit fuel spillage during and after motor vehicle crashes to reduce deaths and injuries occurring from vehicle fires. To minimize fire hazards caused by collisions, the standard specifies requirements for the integrity and security of fuel tank filler pipes and fuel tank connections. The objective of this standard is to establish a reasonable test of a vehicle's ability to withstand impacts without fuel loss or spillage.

FMVSS 208--Occupant Crash Protection

The purpose of FMVSS 208 is to reduce fatalities and injury severity of vehicle occupants by specifying vehicle crash-worthiness requirements in terms of forces and accelerations measured on anthorpomorphic dummies to test crashes. The standard also specifies equipment requirements for occupant restraint systems that prevent occupant ejection and that reduce or eliminate secondary impacts between vehicle occupants and the interior of the passenger compartment or other objects.

The present form of the standard requires that one of three options be provided for each vehicle: a completely passive system for front, side, and roll-over crash protection; a passive restraint system for frontal crashes, with lap belts for side and roll-over crashes; or a lap/shoulder belt system at front outboard positions with lap belts for all other positions. Because almost all vehicles provide only active systems that require deliberate action by the occupants, the potential benefits of FMVSS 208 are not automatically obtained, as is the case with most of the other motor vehicle safety standards.

According to a recent NHTSA summary on seat belt effectiveness, studies since 1960 indicate a 40% effectiveness in preventing crash related deaths for lap belt only use and 60% of lap/shoulder belt use. For an estimated 1975 restraint use rate of 20% (11% lap only and 9%

lap/shoulder) about 3000 lives were saved in that year. If the use had been 60% lap/shoulder and 10% lap only, a 1975 saving of 12,000 lives is estimated to have been possible. An ignition interlock system, designed to force the attachment of seat belts before the vehicle could be started, was implemented in 1973 for 1974 models. But Congress voided the requirement in 1974 and also required that future occupant restraint system requirements other than seat belts were to be submitted for its approval before rule making took place.

Currently under consideration is a passive restraint system called the air bag, a cushion system that rapidly inflates when impact involving sufficient force to require occupant protection takes place. An agreement was reached between former Secretary of Transportation Coleman and the automotive industry to make substantial numbers of automobiles with passive restraint systems available to the public at reasonable costs. When the systems are placed in operation, the way in which they function should provide a basis for research about their effectiveness in real-life incidents.

FMVSS 214--Side Door Strength

Researchers, the automotive industry, and the public have been aware for more than 10 years of the special vulnerability of vehicle occupants to injury from accidents involving vehicle side structures. Emphasis on this vulnerability was provided by the aggressively shaped vehicles and roadside objects of the era, which sometimes provided spectacular (and thus "newsworthy") penetration of the relatively slim and often relatively weak side structures of passenger vehicles. This vulnerability was reflected in the announcement of proposed rule making "requirements to limit the amount of intrusion or penetration on exterior impact."

FMVSS 214 specifies strength requirements for side doors of passenger cars to minimize the safety hazard caused by intrusion into the passenger compartment in a side impact accident. The first beam-type side door structures appear in some 1969 models of General Motors Corporation Research, both completed and in progress and docket submissions on

FMVSS 214 indicated the general nature of, and the resulting injury severity from, accidents involving vehicle side structures. However, the precise role of penetration or intrusion in injury severity has not been clearly established, even up to the present, except in those relatively few cases when severe or fatal injuries were primarily caused by a particular penetrating object.

FMVSS 215--Exterior Protection

The automobile bumper was originally created to protect motor vehicles from low-speed damage. The bumper, a beam held by spring-like supports, although generally unsophisticated was effective. The system did not absorb energy (unless parts were permanently bent or broken) but stored energy and then released it in a rebound motion. By combining an extended position and high-strength materials, low-speed collision forces were spread over a sufficient time and space to prevent severe damage. When bumper heights matched, they served as a reasonable "Braille parking device."

As modern automobile designs became more stylish, bumpers, which were redesigned to more attractively match vehicle shapes, lost much of their protective nature. They were moved closer to body sheet metal and other vulnerable parts, and were often made of lighter weight materials as they grew in size. Increased low-speed collision damage of bumpers and other unprotected parts resulted, as well as increasing cost to the motoring public both directly and indirectly through increasing insurance costs.

The purpose of FMVSS 215 is to prevent low-speed collisions from impairing the safety operation of vehicle systems and to reduce the frequency of override or underride in high-speed collisions. The standard's performance requirements specify that certain safety systems whose failure to operate would impair vehicle safe operation must be undamaged under accident conditions. In addition to the safety benefits derived, this standard has reduced the economic loss resulting from damage to passenger vehicles involved in low-speed accidents.

In addition to this standard, Title I of the Motor Vehicle Information and Cost Savings Act calls for bumpers whose design will reduce economic loss. A new bumper standard, planned to become effective in 1978 and 1979, will combine the Title I and FMVSS 215 requirements.

TECHNICAL OVERVIEW

Approach

This study began with a review of the four FMVSSs. Background material, specifications, requirements for compliance testing, and literature in the traffic safety field relating to the evolution of vehicles and the standards were investigated. The review served as the basis for selecting measures of effectiveness, and for the identification and examination of alternative evaluation methodologies in subsequent tasks.

Each standard was then the object of a sequence of four study tasks. The first was a feasibility study to determine if a practicable evaluation plan could be devised for the standard. This study was based on a qualitative and quantitative analysis of data and methodologies, either available or that could be developed, compared with estimated evaluation costs. An evaluation methodology was selected for each standard; a preliminary evaluation study design and implementation plan were then developed for the selected techniques. After review of these plans by NHTSA, a final evaluation study design and implementation plan were developed for each standard.

Study Design Plans

A general summary of the final design plans for each standard is presented here.

FMVSS 301--Fuel System Integrity Study Design

FMVSS 301 is intended to reduce deaths and injuries occurring from vehicle fires by limiting fuel spillage during and after motor vehicle crashes. Therefore, to establish the effectiveness of the standard, an integral part of the evaluation plan must consist of direct observation and analysis of essential cause, effect, and explanatory variables. These will include:

(a) The national distribution of all accidents categorized by impact force vector, vehicle types, age, and the extent and location of damage.

(b) The frequency of occurrence, source, and extent of fuel leakage expressed as a function of the variables listed in (a) above.

(c) The frequency and extent of fire that is initiated or augmented by fuel spillage.

(d) The ignition sources of such fuel fed fires.

(e) The injuries by type and fatalities that occur as a direct consequence of fires.

The following study conditions have been established:

- Data collection will be restricted to 1974 through 1979 models.
- The effectiveness of FMVSS 301 will be based on a comparison of pre-1977 and post-1976 models (pre- and post-rear barrier test).
- The effectiveness of the standard will be based primarily on the frequency of postcrash fuel leakage and the frequency of fuel-fed fires. Burn-related injuries and fatalities will also be measured, but sample sizes will not be increased to ensure that an observed differential in these infrequent events is statistically significant.

The restriction of data collection to the 1974 to 1979 models acknowledges that the age of a vehicle may correlate with postcrash fuel leakage. The February 5, 1975 status report from the Insurance Institute for Highway Safety (IIHS), for example, states that study results reveal a high correlation between the probability of fire and vehicle age, possibly reflecting vehicle deterioration over time. The IIHS-sponsored study is not confined to postcrash fuel-fed fires, and it is likely that much of this correlation is accounted for by noncrash-induced electrical malfunctions, carburetor fires, and the like. But the possibility of a postcrash fuel leakage correlation with age exists, and a thorough study to separate the effects of model year and age would require unacceptable time for data collection. Thus, we have restricted our attention to 1974 to 1979 models and have assumed that fuel leakage dependence on age is minimal, or nonexistent during the first 3 years of a vehicle's life.

Several alternative sampling plans were evaluated. Based on a trade-off analysis that took into account data quality, administrative difficulties, and cost, the method selected is investigation of a sample of 2400 tow-away accidents to evaluate differential in fuel leakage, and a 100% sample of accident-fire events (see Figure 1).

The procedural steps require the selection of a random sample of 1200 tow-away accidents involving 1974 to 1976 models and a comparable sample of 1200 1977 to 1979 vehicles to determine if postcrash fuel leakage between the two groups differs markedly. The determination could be made during 1 year in a fully operational NCSS program. Concurrent with this random sampling, all crash-fire occurrences will be investigated. The completion of these investigation will require 3 years of NCSS operation. However, a logical decision point occurs when the analysis of fuel leakage in the sample of 2400 tow-aways is complete. If no significant difference in fuel leakage is detected between pre- and post-standard vehicles, we recommend that sampling of fire events be discontinued because the effectiveness of the standard will be established only if both fuel leakage and fire incidents are reduced. If a significant difference in fuel leakage does exist, the investigation of fires must continue.

FMVSS 208--Occupant Crash Protection Study Design

A basic level of effectiveness for existing lap and lap/shoulder restraint systems has been clearly established by completed research studies. Future studies should concentrate on a determination and quantification of the degree of reduction in injury severity. The differences in injury severity (none to fatal) that we wish to detect are as follows:

- Those that occurred with no protection and with lap only restraints.
- Those among concurrent versions of lap only, lap/shoulder, lap airbag, and airbag only restraints.

Briefly, we recommend that for active restraints, certain results documented by HSRC and HSRI be accepted and further quantified (e.g., confidence limit determination), that certain hypotheses be studied by

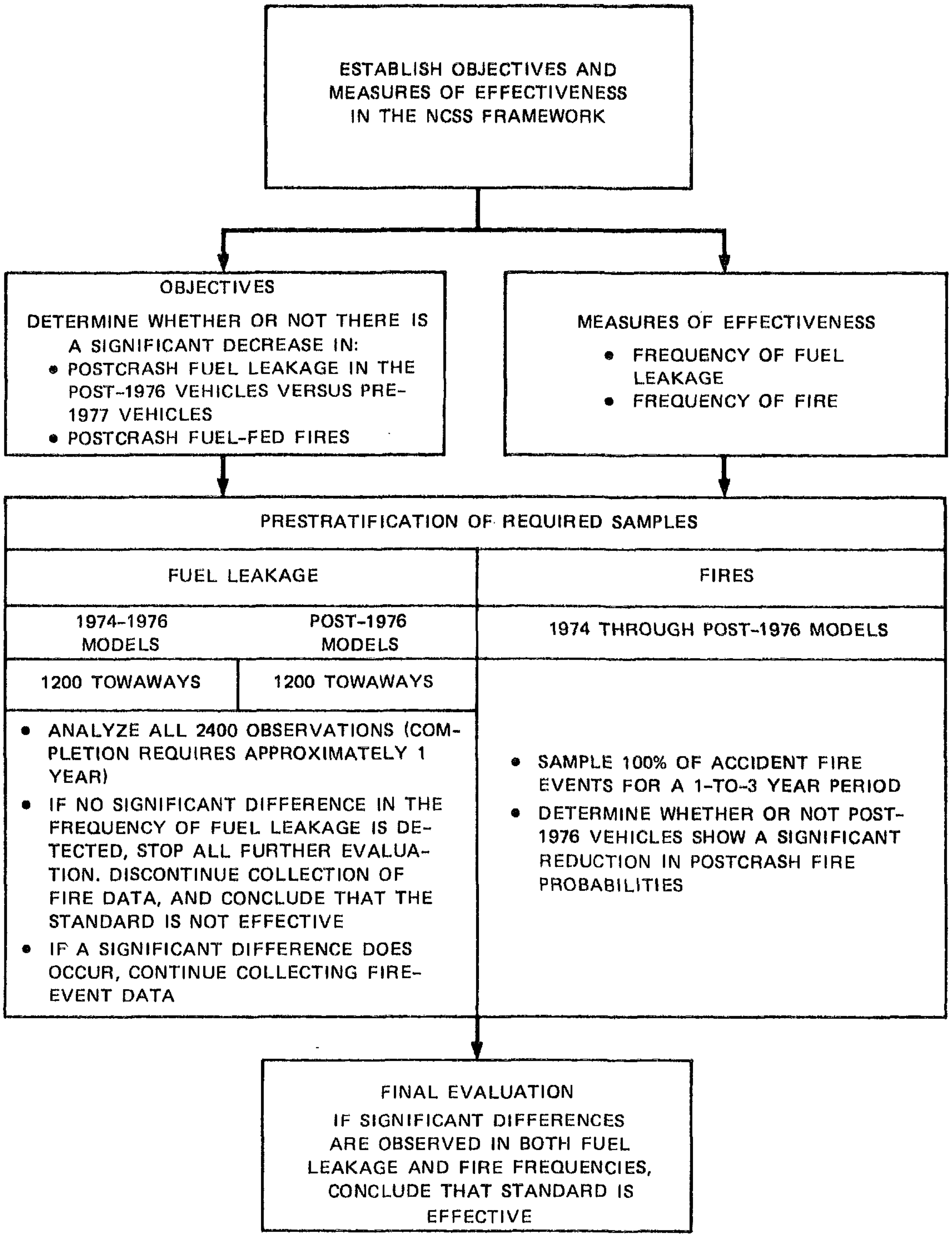

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FIGURE 1 FMVSS 301 EVALUATION PLAN

using existing RSEP and MDAI files, that other hypotheses be studied by using NCSS data, and that an overall update be made within NCSS and finally repeated in NASS. Analysis of passive restraints will also involve accident analysis but must await sufficient usage.

The considerable analysis of active restraint factors has been conducted for front seat occupants. The study design here is to produce confidence intervals for existing estimates, produce new estimates based on restratification of existing data, along with confidence intervals, for the front seat occupants. New data collection will be required for rear seat occupants and continuing case-by-case evaluation of certain anomalies is suggested. Major design factors are:

- Front seat injury severity
- Rear seat injury severity
- User factors
- Type of injury
- Collision factors
- Restraint system factors.

Although not extensively reviewed in this report, a number of studies have been made of characteristics of individuals who tend to use restraints and of those who tend not to use them. For example, SWRI cites that use is declining, use is less on weekends and in rural areas, with variation by vehicle ownership, occupant position, and model type. In short, reasonable evidence is available to suggest the hypothesis that there are differences in driving and driving characteristics between users and nonusers that <u>may</u> relate directly to accident and injury severity. Currently, however injury is being directly related to belt use only. A multivariate analysis of driver characteristics is proposed, and the analysis may be undertaken for new variables already available in existing files:

- Driver characteristics
- Accident characteristics.

SRI recommends that the analysis of ACRS effectiveness be studied as part of the proposed NHTSA Demonstration Program. The procedure will generally follow that outlined for active restaint factors, with a few differences because of the characteristics of ACRS and because of the additional comparisons that must be made because of the number of alternative systems available at that time:

- Front seat injury severity
- User factors
- Type of injury
- Collision factors
- Restraint system factors.

In addition to these measures, the hypotheses developed above should be reexamined within NCSS on a regular tabulation basis by model year, and this study would continue in NASS. Because it is anticipated that each model year will have developed further restraint systems, along with other injury reduction oriented safety modifications, continuation would be warranted. For 1977 to 1981, the generation of estimates would be tabulated for no restraints, lap, and lap-shoulder for 1972 to 1981 models. For 1982 on this would be revised to include no restraints, lap/shoulder, lap/ACRS, and ACRS for models for 1974 on.

FMVSS 214--Side Door Strength Study Design

To determine the effectivness of FMVSS 214, the results of analysis must demonstrate that the extent of side door intrusion incurred by vehicles in compliance is significantly reduced when compared with pre-standard vehicles. A related reduction in occupant injury severity must also be shown. Based on these considerations and an assessment of alternative methodologies, a three-stage evaluation plan is recommended (see Figure 2). The first stage is an extended compliance test applied to pre-standard vehicles; the second stage is a program of static and dynamic testing; and the third stage is accident sampling and analysis.

To achieve the objectives, it is recommended that all compliance test data on post-standard vehicles be collected, and that a sample of pre-standard vehicles be subjected to the same testing procedures as those for post-standard cars. If the pre- and post-standard crush

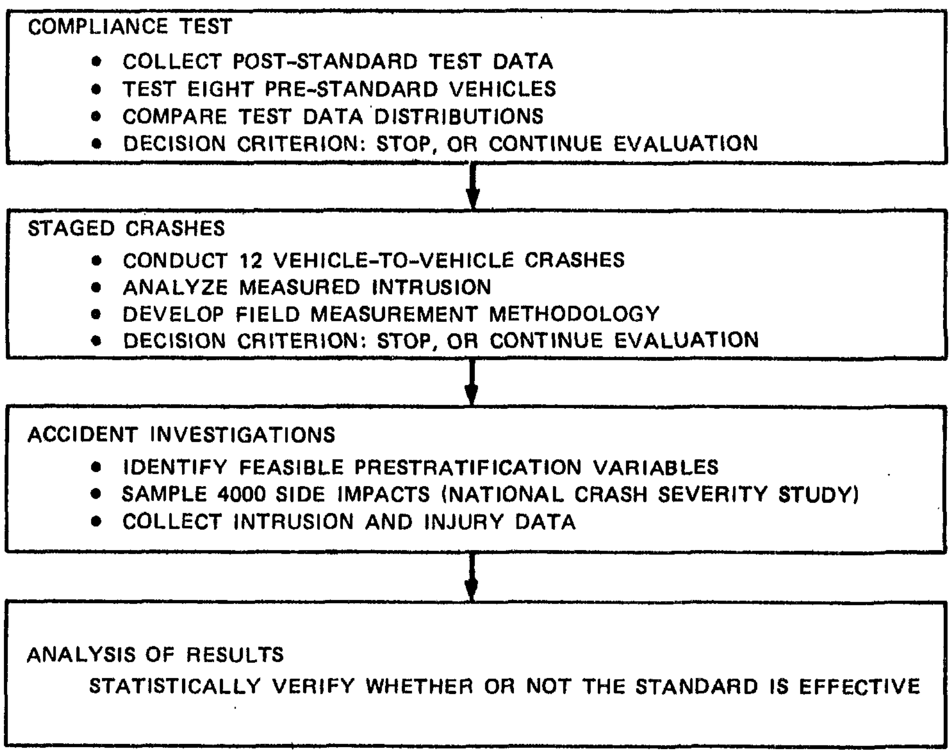

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FIGURE 2 FMVSS 214 EVALUATION PLAN

resistance values differ significantly, we would conclude that differences in intrusion between pre- and post-standard vehicles exist and can be measured, and that the evaluation plan should continue to the next procedure, which involves staged crashes. However, if few significant differences in compliance test results between comparable pre- and post-standard vehicles are observed, it would then be concluded that minimal intrusion differentials occur and that the measurements required in the real-world to demonstrate the standard's effectiveness would not be possible. Under these circumstances, the effectiveness of the standard insofar as intrusion is concerned would be essentially zero. If this is the case, the evaluation should be terminated because further work would probably produce inconclusive results.

If compliance test results provide prior evidence of an intrusion differential, the second phase of evaluation should involve vehicle-to-vehicle staged crashes. These controlled tests should be designed to:

- Determine whether or not intrusion differs measurably between pre- and post-standard vehicles under fixed crash conditions.
- Develop and determine the precision of field-measuring procedures.
- Provide a numerical basis for calculating the correlation between compliance test data and measured crash-induced intrusion.

If the staged crash experiment demonstrates that differences in intrusion do occur between pre- and post-standard vehicles, the final stage of the evaluation must be field accident investigation. The investigation will determine the relationship between injury severity, as measured by AIS, and intrusion. It will also determine the degree of reduction in injury probability attributable to FMVSS 214

The most critical problem that must be addressed in the accident sample design is that of prestratification. It is clear that prior stratification of the accident population into subsets in which pre- and post-standard vehicles exhibit the greatest difference in intrusion and injury severity can greatly reduce the required sample size. These prestratification criteria should be developed from the knowledge gained from compliance testing and from staged crashes. Although prestratification presents no conceptual difficulties, operational problems may occur because the selective investigation of certain accidents requires the cooperation of investigating police. However, it should be possible to presratify the population by identifying accidents by impacted vehicle (pre- and post-standard), impact speed (15 to 35 mph and above), and angle of impact. These are approximations, and, as stated before, the specific prestratification rules should be determined from the results of previous testing.

FMVSS 215--Exterior Protection Study Design

The purpose of FMVSS 215 is to reduce damage incurred in low-speed collisions and to reduce the frequency of override and underride in collions at all speeds. Although the existing compliance and barrier tests present convincing evidence that the standard is potentially effective in reducing damage in selected low-speed collisions to date, no adequate data are available for estimating total benefits, particularly over the real-world service life of affected vehicles.

A serious problem preventing adequate evaluation of FMVSS 215 in the past has been the lack of data describing the characteristics of low-speed crashes in the real-world environment. The desired data would identify the frequency of occurrence and the extent of damage (including cost to repair) for each vehicle model as a function of: vehicle age; location, angle, and speed of impact; type of object impacted; and setting.

A second major problem encountered in an attempt to evaluate FMVSS 215 is that no single type of existing data sources (e.g., insurance, police, or special study motor vehicle accident files) contains information for all accidents that may have involved bumpers. Five categories identify all incidents of bumper area involved accidents as a function of dollar loss:

- Damage reported to insurance companies and repaired.
- Damage reported to insurance companies and not repaired (although payment for repairs was made by an insurance company).

- Unreported and unrepaired vehicle damage.
- Unreported damage repaired by owner or another party.
- No damage incidents.

The major task for this evaluation plan is, therefore, to obtain the best estimates for the size of these categories and to compare such data for pre- and post-standard vehicle model years. Furthermore, great care must be taken when examining such reductions (when found) to identify the portion of the reduction that is attributable to effects of the bumper standard.

The only technique we have determined to be potentially acceptable at reasonable cost for estimating the characteristics of all bumper-area involved impacts is a large survey (25,000) of vehicle owners or principal operators conducted at locations that minimize driver inconvenience and maximize the probability of unbiased responses. Motor vehicle inspection facility locations may contribute to both objectives by allowing the survey to be conducted as vehicle operators are already waiting in line for inspection, and by taking advantage of the pre-inspection environment that is expected to be conducive to reasonably accurate responses to survey questions.

Having obtained the survey data for bumper-area involved impacts and anlyzed the results, we anticipate that a careful comparison of these results with existing insurance and staged crash data (augmented by the technical judgement of qualified automotive engineers and damage evaluators) will produce reasonable estimates of bumper involvement percentages for varied angles of impact and damage cost categories for each model year to be evaluated. If the survey results obtained from vehicle operators are consistent with insurance data in the areas of overlap between the two data bases, then a reasonable basis will have been established for placing confidence in the unreported categories.

If this evaluation basis is successfully established, the most serious objections to previous analyses of bumper system benefits will be eliminated (see Figure 3). Total direct benefits for FMVSS 215 can then be determined by comparing pre- and post-standard model year vehicles.

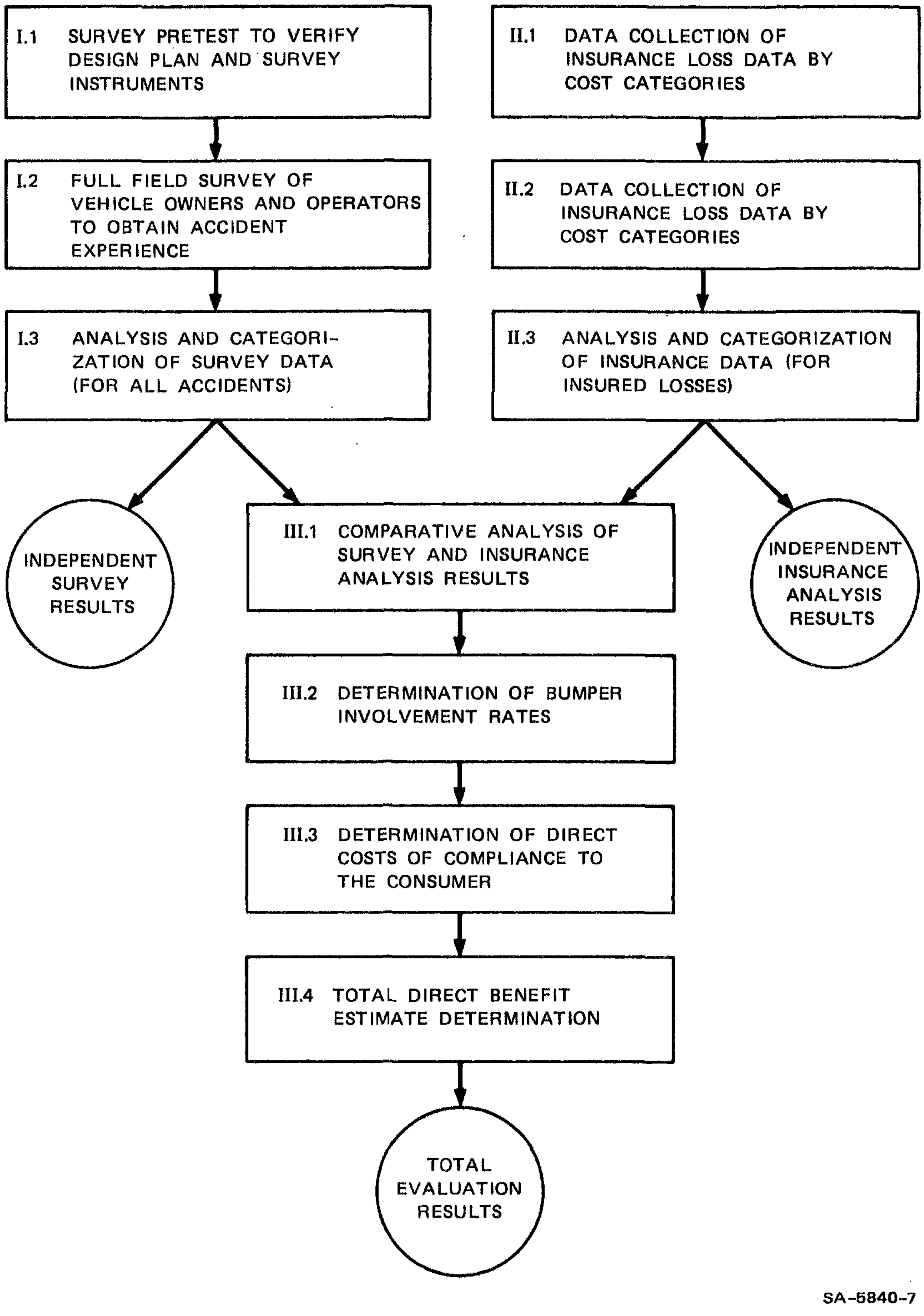

FIGURE 3 OVERVIEW OF EVALUATION STUDY DESIGN FOR FMVSS 215

The ensured loss differences for all cost categories would then be calculated. The estimates of unreported damage loss (both owner-repaired and unrepaired) obtained from the analysis of a broad-based survey of vehicle owners would then be added proportionately.

CONCLUSIONS AND RECOMMENDATIONS

This section summarizes the general conclusions concerning evaluation methodologies reached during the study, with specific conclusions for each FMVSS examined. Evaluation plan recommendations are also outlined for each standard.

Study results in the current literature reflect attempts to explicitly evaluate the overall effectiveness of the referenced standards. None of these studies, however, has produced conclusive evidence of effectiveness because of:

- Inadequate accident investigation sample sizes.
- Nonrepresentative sample data.
- Other data bases used in analysis that were not representative of all of the factors required in evaluation.

In our assessment of methodologies suitable for evaluating the various standards, we concluded that in-depth accident investigations should be an integral part of any definitive evaluation plan. This conclusion resulted from our conviction that a prerequisite for the acceptance of study results by the mixed community of analysts, consumers, and manufacturers must be a demonstration of effectiveness in terms of statistically significant highway accident data.

Computer simulations and analytic models have recognized utility as design tools and in exploratory studies. Controlled compliance tests and staged crashes were determined to be of considerable value when employed with other evaluation methods. Vehicle-to-vehicle staged crashes can certainly provide precise information about selected accident types; however, the cost of replicating a reasonably representative set of real-world conditions is usually prohibitive.

Within the context of this study, the following list ranks the value and credibility of the various evaluation methodologies considered.

- In-depth accident investigation.
- Controlled testing including barrier, staged crashes, and similar tests.
- Surveys of consumers and of damage observed at check points.
- Insurance claim data file analyses.
- Computer simulations and analytic modeling.
- Analysis of data bases other than accident investigations (e.g., fire department, and the like).

Feasibility was established for the evaluation of FMVSS 301--Fuel System Integrity, FMVSS 214--Side Door Strength, and FMVSS 208--Occupant Protection after determining that valid accident investigation data would provide a sufficient base for evaluation, because all of the relevant cause and effect variables were amenable to direct highway observations, and required sample sizes that were not prohibitively costly.

We conclude that no evaluation scheme based on current methodologies and feasible data collection procedures should be expected to produce conclusive results regarding FMVSS 215--Exterior Protection. The primary difficulty is procedural inability to obtain direct observations on low-speed, low-damage accidents; in addition, such accidents are frequently unreported to police or insurance companies. Alternative plans that rely on qualified indirect surveys or insurance data are the only approaches that can be undertaken if FMVSS 215 is evaluated.

A summary assessment of the major characteristics of the evaluation plans for each standard follows here. Two factors are presented for each standard:

- Probability of successful evaluation
- Estimated cost of evaluation.

A successful evaluation is an analysis that produces statistically meaningful results, based on observations of all relevant cause, effect, and explanatory variables. The results must be reported in a manner that is understandable by the technically oriented and nontechnical communities. Estimated costs are the total values based on costs estimates for each task in the implementation plans.

	FMVSS			
	301	208	214	215
Probability of success	Good	Good	Fair	Poor
Cost	$1,003,000	$294,000	$37,400 to $1,378,200	$383,000

In accordance with study requirements, all evaluation plans were developed separately and independently, with the understanding that only one of these might be programmed for implementation. However, if more than one of the evaluation plans is implemented, there are both technical and economic reasons for recommending a program that provides for a simultaneous evaluation of the several standards. For example, in measuring the relationship between side door intrusion and injury severity (FMVSS 214), the occupant's use of restraints (FMVSS 208) must also be taken into account to eliminate the effects of confounding factors. In general, the data requirements for the various standards overlap.

One of NHTSA's accident investigation studies NCSS, provides a timely and useful framework for the more sharply focused data collection evaluation requirements. Data collection procedures can also be easily modified in regard to sample sizes, type of accidents, and organization of the data to satisfy evaluation plans that are developed. Evaluation plans for FMVSS 301, 208, and 214 can be recommended to NHTSA without qualification, and all can be implemented within an augmented NCSS program. A fourth evaluation plan, based on qualified, indirect surveys and insurance data, is the only feasible approach for FMVSS 215.