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THE U.S. GOVERNMENT'S AUTOMOTIVE SAFETY PROGRAM; A PRELIMINARY EXAMINATION

by

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PREFACE

This paper is one of a number of M.I.T. Energy Laboratory Working Papers prepared as part of the Energy Laboratory project "Regulating the Automobile." The project is supported by the Division of Policy Research and Analysis of the National Science Foundation. Four efforts comprise the project: (1) an analytical comparison of the three areas of automotive regulation--safety, fuel economy, and air pollutant emissions; (2) an examination of the politics of automotive regulation, focusing on why we regulate the way we do; (3) a study of uncertainty in emissions regulation; and (4) an analysis of the impact of the fleetwide fuel economy regulations on the structure of the automotive industry.

The present paper was written in support of the comparison of regulatory regimes. The emphasis is on describing the automotive safety regulatory system--as it was instituted by Congress and has been administered by the Executive Branch. Two aspects of the system, regulation and support for research and development, are examined by looking in detail at two technological concepts, the air bag and the research vehicles. Some very preliminary analysis of the system's handling of these concepts is presented.

Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the author and do not necessarily reflect the views of the M.I.T. Energy Laboratory, the Massachusetts Institute of Technology, or the National Science Foundation.

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1. INTRODUCTION

The purpose of this paper is to present and make a preliminary analysis of the role which the federal government has played in the development of motor vehicle safety and effects it has had upon technical developments in the automotive safety field. The scope of this paper will be limited to motor vehicle technology, rather than safety advances in the overall system of motor vehicle transportation (which would include highway safety features).

Section 2 of this paper will be a chronological presentation of federal motor vehicle safety legislation (1958-1976), and a discussion of the constellation of events which surrounded the passage of this legislation into law. Safety standards (regulations created under federal agency), as distinguished from public law (legislation passed by Congress and signed by the President), will also be presented.

In Section 3 two features of the U.S. Government's automotive safety program are presented and discussed in more detail. Each is an attempt to stimulate innovations in passenger car safety, but through very different means. In the safety vehicle programs--the Experimental Safety Vehicle (ESV) and Research Safety Vehicle (RSV) programs--the government has funded R&D in an attempt to bring about major changes in automotive safety technology. In the air bag program the government has sought, by regulation, to force the final development and actual adoption of a safety innovation.

Some preliminary conclusions concerning these programs are presented in Section 4.

2. FEDERAL LEGISLATION OF MOTOR VEHICLE SAFETY

The earliest legislation which called for motor vehicle safety requirements came under the Interstate Commerce Act. This Act provided for Secretarial powers to establish "reasonable requirements"[1] for the safety of private carriers of property by motor vehicle, and carriers of migrant workers.

In 1962, amidst widespread concern over brake fluid quality, Congress pointed the general terms of the Interstate Commerce Act into a specific safety domain by passing an act requiring that hydraulic brake fluid sold or shipped in commerce for use in motor vehicles meet certain specifications prescribed by the Secretary of Commerce.[2] Although at the time this Act was passed 27 states had legislation to protect motorists from substandard brake fluid, only ten of these states were deemed to have "effective" laws.[3]

In 1963 Congress passed a law designed to allay fears that the budding demand for seat belts would result in improper, poorly made equipment. Public Law 88-201 mandated that the Secretary of Commerce prescribed "minimum standards" for seat belts (manufactured or imported) for use in interstate commerce.[4] In so much as Public Law 88-201 dealt with the constructional quality of belts and related hardware, rather than with "such traditional state matters as installation and use," the Senate Committee of Commerce anticipated that it would "furnish a new area for effective federal-state cooperation."[5]

On March 2, 1966, President Johnson delivered to Congress a message on transporation and traffic safety, together with the proposed Traffic Safety Act of 1966. In his address, Johnson urged that the Secretary of Commerce be given authority to determine necessary safety performance criteria for all motor vehicles, as well as authority to expand federal traffic research programs, including the development of a national highway safety research and

test center. In response, the House Committee on Interstate and Foreign Commerce held seven days of hearings, calling upon various distinguished witnesses whose expertise was thought to be of the widest range within the automotive safety field. The Committee was confronted with what they considered to be disturbing evidence "of the automobile industry's chronic subordination of safe design to promotional styling; and of an overriding stress on power, acceleration, speed, and ride, to the relative neglect of safe performance or collision protection."[6]

Federal standards for the safety of ships on the high seas antedated the Civil War; federal standards for the safety of trains were established at the turn of the century; and seminal standards regulating the aviation industry were promulgated in 1926. Yet, prior to the National Traffic and Motor Vehicle Safety Act of 1966, the automobile had remained essentially free of regulatory controls. When the Senate, by a 76-0 roll-call vote, passed the Safety Act, a new era in regulatory politics had begun.

All safety legislation passed prior to the National Traffic and Motor Vehicle Act of 1966 was effectively repealed by that Act.[7] All legislation enacted following the passage of the 1966 Act pursuant to, and consistent with, the powers vested in that Act. Table 1 presents all major safety legislation affecting motor vehicle design, performance and repair.

Out of the House Committee on Interstate and Foreign Commerce hearings emerged at least six separate but related issue-areas or domains for which the government would be held responsible under the new Act: 1) the federal government would be responsible for the "unconditional imposition" of mandatory safety standards at the "earliest practical date"[8] to mitigate the highway death and injury toll; 2) the role of individual states in setting standards

Table 1

MAJOR FEDERAL LEGISLATION CONCERNING VEHICLE SAFETY AND DAMAGABILITY

Name	Identification	Effective Date	Agency of Administration	Key Provisions of the Act
Interstate Commerce Act (Amendments)	P.L. 81-138 63 Stat. 280	June 29, 1949	Interstate Commerce Commission	Established "reasonable requirements" for safety of common carriers, private carriers of property by motor vehicle, and carriers of migrant workers.
Hydraulic Brake Fluid Safety Standards Act	P.L. 87-637 77 Stat. 437	Sept. 5, 1962	Interstate Commerce Commission	Required that hydraulic brake fluid sold or shipped in commerce for use in motor vehicles meet certain specifications prescribed by the Secretary of Commerce.
Seat Belts Act (Amendments to Interstate Commerce Act)	P.L. 88-201 77 Stat. 361	Dec. 13, 1963	Interstate Commerce Commission	Required that seat belts manufactured or imported for use in interstate commerce meet "minimum standards" prescribed by the Secretary of Commerce
National Traffic and Motor Vehicle Safety Act of 1966	P.L. 89-563 80 Stat. 718	Sept. 9, 1966	Department of Commerce (National Highway Safety Agency)	Placed major responsbility for motor vehicle and highway safety in the hands of the federal government, and committed the government to a broadly-based program designed to promote highway safety through systematic testing and research, public information services, and the development and enforcement of mandatory safety standards.

Table 1 (Continued)

Name	Identification	Effective Date	Agency of Administration	Key Provisions of the Act
Federal-Aid Highway Act of 1970 (Title II)	P.L. 91-605 84 Stat. 1739	Dec. 31, 1970	Department of Transportation (National Highway Traffic Safety Administration)	Replaced the National Highway Safety Agency with NHTSA, and transferred the administratio from the Department of Commer to the Department of Transportation.
National Traffic and Motor Vehicle Safety Act Amendments of 1972	P.L. 92-548 86 Stat. 1159	Oct. 25, 1972	Department of Transportation (NHTSA)	Expanded the operational capabilities of the National Traffic and Motor Vehicle Safety Act of 1966 by providing for a greatly expanded budget, and created specific provisio for exemption from NHTSA standards by the automotive industries.
Motor Vehicle Information and Cost Savings Act	P.L. 92-513 86 Stat. 947	Oct. 20, 1972	Department of Transportation (NHTSA)	Required that federal bumper standards be set to reduce damage and economic loss resulting from automobile accidents, and established a mean for providing consumers with safety and damagability information.
Motor Vehicle Schoolbus Safety Amendments of 1974	P.L. 93-492 88 Stat. 1970	Oct. 27, 1974	Department of Transportation (NHTSA)	Effectively repealed NHTSA's Standard 208 (the seat-belt ignition interlock system), a declared such systems to be a consumer option. Required hearings prior to the setting of passive restraint standard of NHTSA.

would be consultative--the federal government must assume overriding responsibility for defining the parameters of both its own and the states' role in standard setting; 3) the federal government would develop a major independent technical capacity, sufficient to perform comprehensive research on accident and injury prevention, and adequate to test and contribute to the quality of the automobile industry's safety performance--"a technical capacity capable of initiating innovation in safety design and engineering and of serving as a yardstick against which the performance of private industry can be measured; and finally, a technical capacity capable of developing and implementing meaningful standards for automotive safety";[9] 4) vigorous competition in the development and marketing of safety improvements would be maintained; 5) mandatory procedures would be imposed to ensure such notification of consumers and correction of all safety-related defects; and finally 6) the federal government would assume responsibility for providing adequate consumer information so that the consumer might make more educated decisions in evaluating the comparative safety of competing car models.

In drawing up these far-reaching regulatory guidelines, the Committee remained acutely sensitive to the possible abuses of regulatory power inherent in such legislation. Thus the Committee made it clear that it was not empowering the Secretary to take over the design and manufacturing functions of private industry. Rather, the "Safety Act" was designed to further industry efforts to produce motor vehicles which would be in the first instance not "unduly accident prone", and perhaps even more significantly, vehicles which, when involved in accidents, would prove crashworthy enough to enable their occupants to survive with minimal injuries:

> The Secretary could thus, for example, be concerned with the measurable performance of a braking system, but not its design details. Such standards will be analogous to a building code which specifies the minimim load-carrying characteristics of the structural members of a building wall, but leaves the builder free to choose his own materials and design. Such safe performance standards are thus not intended or likely to stifle innovation in automobile design.[10]

Thus, with the passing of the Safety Act, a congeries of broad policy standards were drawn up in the automotive safety area, to be applied to ongoing technological safety developments in both government and industry. Furthermore, as we shall see, these guidelines would serve as a catalyst for technological change itself.

In 1972 and 1973 the purposes of the Safety Act were furthered by the passage of the National Traffic and Motor Vehicle Safety Act amendments of 1972[11] and the Motor Vehicle Information and Cost Savings Act of 1973.[12] The former public law expanded operational capabilities under the Safety Act of 1966 by appropriating large sums of money, and also made provision for the Secretary to exempt a motor vehicle from any motor vehicle safety standard established pursuant to the Safety Act of 1966, if annual production levels were below 10,000 units, and if compliance would cause such manufactuers substantial economic hardship.

Initial investigation of the issues prompting the consideration of the Motor Vehicle Information and Cost Savings Act were undertaken by the Antitrust and Monopoly Subcommittee of the Senate Judiciary Committee, in a three-year study of automobile repair problems. During that study the Committee's Chairman received more than 8,000 letters of complaint from irate automobile buyers who complained about the "fragility"[13] of their cars. The initial Subcommittee investigation disclosed that Americans spend an estimated $25-30 billion a year for automobile repairs. Various studies presented at the

hearings showed that an estimated $8-10 billion per year was being charged for work that was never done, was unneeded, or was improperly performed.[15] In light of this and other evidence received during extensive hearings, the Subcommittee extracted four basic consumer needs which it deemed worthy of redress: 1) the need to reduce the incidence of property loss resulting from motor vehicle accidents; 2) the need to foster competition between automobile makers so as to promote the construction of safer, less fragile, and more easily repairable motor vehicles; 3) the need to facilitate inspection and repair of vehicles by encouraging their diagnostic inspection; and 4) the need to prevent odometer tampering.

The Motor Vehicle Information and Cost Savings Act requires that federal bumper standards be set in order to reduce damages and economic loss resulting from automobile accidents. In addition, the law established an Automobile Consumer Information Study to determine how to provide consumers with meaningful information about the operating costs and safety characteristics of particular vehicles, thereby encouraging automobile manufacturers to compete to produce cars with operating cost and safety characteristics that exceed required standards.

In Title I of the Act, economic loss resulting from accidents was to be lessened by providing for the promulgation and enforcement of bumper standards for all motor vehicles manufactured in, or imported into the United States.[15] The Motor Vehicle Information and Cost Savings Act thus not only sought qualitative improvement of safety-related equipment which was part of motor vehicles manufactured or imported into the United States, but simultaneously the Act sought to implement a series of post-crash cost reduction measures, or measures which prescribe:

> a minimum performance standard established for the purpose of increasing the resistance of passenger motor vehicles or passenger motor vehicle equipment to damage resulting from motor vehicle accidents or for the purpose of reducing the cost of repairing such vehicles or such equipment damaged as a result of such accidents.[16]

The intent of the Motor Vehicle Information and Cost Savings Act was thus to reduce accident-related costs normally absorbed by the consumer, whether these accident-related costs be a direct result of damage to safety-related equipment or not.

In addition to this regulatory authority regarding the setting of bumper standards, the Secretary was also given investigative authority which might indirectly influence motor vehicle design. The Secretary was directed and empowered by the Act to investigate the damage susceptibility of passenger motor vehicles, their degree of crashworthiness, the ease of diagnosis and repair of their mechanical and electrical systems, and their operating costs relative to such factors. Such information would thus be made available to the consumer, so that he might make a more informed choice when purchasing an automobile and its optional equipment. It may be noted within the context of the Act that "damage susceptibility" is defined as "susceptibility to physical damage incurred by a passenger motor vehicle involved in a motor vehicle accident", and "crashworthiness" as "the protection that a passenger motor vehicle affords its passengers against personal injuries or death as a result of a motor vehicle accident."[17]

The Secretary of Transportation delegated his authority under the Act to the National Highway Traffic Safety Administration (NHTSA), which has since issued bumper damagability standards for all motor vehicles. The standards require that passenger cars be able to meet specified damagability criteria for impact with a fixed barrier in accordance with the procedures

outlined by the regulation.*[18]

The latest piece of major legislation in the regulation of automotive safety came in 1974, when both houses of Congress overwhelmingly repealed NHTSA Federal Motor Vehicle Safety Standard (FMVSS) 208 which called for a three-point lap and torso belt with ignition interlock system, effective August 15, 1973.** In offering the repeal amendment for the Senate (subsumed under S 3934, the Federal Aid Highway Amendments of 1974), James L. Buckley of New York echoed the sentiments of many Congressmen, stating: "I recommend the use of seat belts but I strongly condemn the administrative mandate of an interlock which forces us to use them...I view such coercive measures...as an intolerable usurpation by government of an individual's right under the guise of self-protection."[19] Characteristic of the press reaction was an editorial published in Fortune describing the interlock as "a result of technocratic tunnel-vision that seems to afflict some officials at NHTSA." With the interlock, said the editorial, "the citizen has to pay to be annoyed."[20]

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*As NHTSA is the motor vehicle safety standard-setting body, its power vis-a-vis the automotive industry has accumulated rapidly as the safety standards it has mandated have proliferated. Under Title II, Section 201 of the Highway Safety Act of 1966, the National Highway Safety Agency was established under the aegis of the Department of Commerce. As NHTSA's precursor, the National Highway Safety Agency was headed by an administrator who was appointed by the President, and held accountable to the Secretary of Commerce. The provisions of the 1966 Safety Act were to be carried out by the Agency, in consultation with the Federal Highway Administrator. The National Highway Traffic Safety Administration (NHTSA) was established under the Federal-Aid Highway Act of 1970, Title II, as amended under Section 202 of that Act. The new administration (NHTSA) was transferred to the Department of Transportation in 1970 and now acts under the aegis of the Secretary of Transportation. NHTSA is responsible for all matters pertaining to the design, construction, maintenance, and operation of highways as well as matters pertaining to the safety of motor vehicles and their operation.

**After attaching an amendment to H.R. 5529 (the Motor Vehicle Schoolbus Safety Amendments of 1974), the House voted 339-49 to make such safety devices optional.

In addition to suspending FMVSS 208, the Federal-Aid Highway Amendments of 1974 also required that the government hold public hearings before requiring passive restraint systems (air bags) in cars. The Department of Transportation was considering imposing such a requirement for model year 1974 automobiles for that time.

Table 2 presents all safety regulations, with amendments promulgated by NHTSA, as of this writing. The 100 series, "Accident Prevention Standards," contains twenty different sets of specifications designed to mitigate the possibility of accident through technically improved safety-related hardware. The qualitative improvements called for by 100 series do not go beyond the state-of-the-art. "Crash Protection Standards," contained in the 200 series, include a number of requirements designed to protect motor vehicle occupants during the crash sequence. As noted, bumper standards (FMVSS 205) were promulgated as a result of the Motor Vehicle Information and Cost Savings Act of 1973. The 300 series, "Post-Crash Protection Standards," has only recently received a great deal of attention from NHTSA, as requirements have been designed to protect vehicle occupants immediately after the event of a crash impact.

Table 2

MOTOR VEHICLE SAFETY STANDARDS PROPOSED OR PROMULATED BY NHTSA

Accident Prevention Standards

Standard Number	Requirements	Effective Dates(s)
101	Requires that essential controls be within reach of a belted driver, and that such controls have adequate identification.	Jan. 1, 1968
	Expands requirements of 101 and requires illumination of essential controls.	Jan. 1, 1972
102	Requires that transmission shift control include "neutral" between "forward" and "reverse," and that an interlock prevent starting the engine in "forward" or "reverse," and that engine braking be provided in one of the lower gears at speeds lower than 25 MPH.	Jan. 1, 1968
103	Requires that windshield defrosters and defoggers be provided as standard equipment.	Jan. 1, 1969
104	Expands requirements of Standard 103, calling for high performance wipers.	Jan. 1, 1969
105	Requires foot-operated service brakes and parking brakes having specific performance capabilities, a hydraulic brake failure warning light, etc.	Jan. 1, 1968
106	Specifies rigorous brake-hose capabilities and procedures for brake-hose testing.	Jan. 1, 1968
107	Requires that auto surfaces which may reflect sunlight into a driver's eyes have a dull finish.	Jan. 1, 1968
108	Requires specified headlights, turn signals, stop lights, back-up lights, side parker lights and reflectors, hazard warning signals etc. With amendments significantly improving equipment effectiveness and reliability.	Jan. 1, 1973 Proposed, 1976
109	Requires rigorous tire performance capabilities and uniform labeling.	Jan. 1, 1968
110	Specifies requirements for tires and rims as new car equipment.	Jan. 1, 1968

Table 2 (continued)

Standard Number	Requirements	Effective date(s)
111	Requires rear-view mirrors with unobstructed field of view. Amended to minimize the effect of in-vehicle structures.	Jan. 1, 1968 Proposed, 1976
112	Requires "fail-safe" operation of headlight concealment devices.	Jan. 1, 1969
113	Requires double latches on certain types of hoods which may be susceptible to inadvertent opening.	Jan. 1, 1969
114	Specifies requirements for theft protection to reduce the incidence of accidents resulting from unauthorized use of motor vehicles. A key interlock system must be provided whereby removal of key will prohibit activation of vehicle and steering.	Jan. 1, 1970
115	Requires vehicle identification numbers be affixed to each car.	Jan. 1, 1969
116	Requires specific hydraulic brake fluid capabilities.	June 3, 1963
116a	Updated version of 116, a more rigorous standard.	March 1, 1972
117	Specifies performance and uniform labeling requirements for re-treaded tires.	
118	Requires that key be in ignition for the operation of power windows.	Feb. 1, 1971
	Crash Protection Standards	
201	Requires that upon crash impact compartment doors remain closed, requires padded interiors.	Jan. 1, 1970
202	Requires effective head restraints.	Jan. 1, 1969
203	Requires energy-absorbing steering columns.	Jan. 1, 1968
204	Specifies requirements limiting the rearward displacement of the steering control into the passenger compartment to reduce the likelihood of chest, neck, or head injury.	Jan. 1, 1968

Table 2 (continued)

Standard Number	Requirements	Effective date(s)
205	Specifies glazing material for windshields and windows.	Jan. 1, 1968
206	Enumerates requirements for door locks, latches, and hinge systems.	Jan. 1, 1968 (autos), Jan. 1, 1972 (trucks)
207	Specifies seat anchorage capabilities.	Jan. 1, 1972
208	Requires lap belts or lap/shoulder belts for each passenger seat. Requires three point lap and torso belts in front seats together with a warning system. Requires lap and shoulder belt with ignition interlock in front seats. Requires passive restraints for all seats. Repealed.	Jan. 1, 1972 Aug. 15, 1973 Aug. 15, 1975 Dec. 18, 1974
209	Sets performance capabilities for seatbelts and related assemblies.	March 1, 1967
210	Sets performance standards for assembly anchorages.	Jan. 1, 1972
211	Protects pedestrian by prohibiting wheel projections.	Jan. 1, 1968
212	Specifies windshield mounting requirements.	Jan. 1, 1970
213	Specifies child seating systems.	Jan. 1, 1971
214	Specifies side door strength capabilities.	Jan. 1, 1973
215	Requires front bumpers that will withstand a 5 MPH crash, and rear bumpers that will withstand a 2-1/2 MPH crash. Requires both front and rear bumpers to withstand 5 MPH crashes. Requires protection of non-safety, as well as safety components. Also specifies bumper height requirements for standardization.	Sept. 1, 1972 Sept. 1, 1973 Feb. 27, 1975
216	Requires minimum roof strength capabilities.	Jan. 1, 1972 Aug. 14, 1977

Post-Crash Protection Standards

Standard Number	Requirements	Effective Date(s)
301	Requires integrity for fuel tanks and related equipment.	Jan. 1, 1968
302	Limits the flammability rate of vehicle interiors.	Sept. 1, 1973

3. FEDERAL ATTEMPTS TO STIMULATE SAFETY INNOVATION

Consistent with the guidelines established in the Safety Act of 1966, NHTSA established a series of objectives which thrust both the development of an Experimental Safety Vehicle (ESV) and the air bag to the fore. The following sections of this paper will trace the development of such safety innovations while highlighting reasons for critical priority-setting changes by NHTSA in these two key areas of technological concern.

3.1 The Safety Vehicle R&D Programs

When, after much initial resistance, it became clear to the automobile industry that passage of the National Traffic and Motor Vehicle Safety Act was imminent, the industry's first reaction was to grant large sums of money towards safety research. By April, 1966, General Motors has granted M.I.T. $1 million, Ford established plans for a multi-million dollar research center in Dearborn, Michigan, and in a united effort, the industry gave $10 million to the University of Michigan for research in automobile safety.[21] As consistent with the intentions of the Safety Act, however, NHTSA began its own research program and attempted to establish its role as an independent and objective research organization.

The early federal (NHTSA) regulations had one essential characteristic: "They represented state-of-the-art industry practice. They were easy to meet, and the vehicle design changes required by them were cheap and incorporable into production with only short lead time.[22] However, the goals of the federal government were soon to supercede the state-of-the-art. Research and development thus became a paramount concern, and the Experimental Safety Vehicle (ESV) program was the logical outgrowth.

Conceived under the 1966 Safety Act, the purpose of the Experimental Safety Vehicle Program was "to test, on an experimental basis, new ideas of automotive safety incorporated in a complete vehicle."[23] The principal objectives of the program were fourfold: 1) to demonstrate the "feasibility" of advanced automotive safety performance by designing, fabricating, and testing experimental vehicles; 2) to stimulate public awareness of safety and the economic advantages of advanced automotive safety design; 3) to apply program results to the formulation of new or improved motor vehicle safety standards; and 4) to encourage the automotive industry to increase and speed up its efforts in automotive safety research and development.[24]

The program began in 1968 when three contract studies investigated feasible approaches to applying the "total systems engineering concept" to the development of an experimental safety vehicle (such a concept had previously been applied by the aviation industry to the design of safety aircraft).[25] Stated contractor Fairchild-Hiller:

> The criteria for experimental safety cars can be realistically defined only as part of an overall systems concept for safe human transportation. The concept must recognize the contributing roles of the driver, the environment, and the vehicle in any accident situation. Each of these factors can help to prevent accidents, and, when an accident cannot be prevented, help reduce the severity of the accident.[26]

Between 1970 and 1971 the Department of Transportation contracted with Fairchild-Hiller, American Machine and Foundry, General Motors, and Ford to build prototype experimental safety vehicles of the family sedan type. The non-automotive contracts were competitive in that the contractor which produced the superior ESV would receive a follow-up contract for further ESV production and design, while the General Motors and Ford contracts were non-competitive and completed for nominal fees of one dollar each. The conclusions of the

seminal studies, which were done under the above contracts, were to form the basis for developing program objectives and prototype performance specifications for the ESV.

Assessment of the four prototype vehicles was done by an independent contractor in May and December of 1972, and July, 1973. By June, 1973, however, the Department of Transportation announced, to the dismay of all contractors involved, its decision not to build additional family sedan prototypes as previously scheduled. The decision by NHTSA was attributed to its recognition of the growing trend toward domestic use of smaller vehicles. Costs to NHTSA of developing and testing the family sedan prototypes totaled $14.6 million through fiscal year 1973, while an ESV evaluation project completed in the latter part of that year totaled an additional $56,000.[28*]

The four initial prototype vehicles were tested by NHTSA against a set of total systems performance specifications and capabilities which stipulated requirements in the areas of crashworthiness, accident avoidance, post-crash factors, and pedestrian safety. The prototypes were viewed by NHTSA as a moderate success in that all met or exceeded existing and proposed safety standards issued through mid-1970.[29] The vehicles were especially successful in the highest priority area of crashworthiness.[30]

Under the ESV plan as formulated by Fairchild-Hiller, critical elements of automotive safety were defined and organized into five major categories

*In addition to maintaining an ESV program in the United States, the Department of Transportation was and is involved in an international program under the sponsorship of NATO. Between 1970 and 1972 the international program began under the guidance of the United States and West Germany, while international experimental safety vehicle conferences have met yearly since 1971. The focus, however, has shifted away from the initial ESV concept.

within which vehicle safety could be examined and evaluated as a total system. These elements were: 1) accident avoidance, 2) crash injury reduction, 3) pedestrian injury reduction, 4) post-crash protection, and 5) non-operating safety. As tested by NHTSA, ESV prototypes contained injury reduction specificiations requiring occupant survival without serious injury in a variety of crash modes. Accident avoidance criteria requiring braking, handling, and visibility specifications were met or exceeded, while post-crash demands requiring improved levels of fire prevention and emergency escape were also met. Fire prevention requirements, including fuel line and related sub-system integrity, and pedestrian safety specifications, were seen to be successfully incorporated in the Fairchild and all other ESV's.

The design of ESV's reflected new safety ideas, with materials and processes within the current state of the art for fabrication and testing. The safety administration and its research and development efforts in particular distinguished between two major systems to be simultaneously developed--crashworthiness systems and operating systems. "Safety standards applicable to crashworthiness systems establish requirements for optimum crash and post-crash protection of vehicle occupants, pedestrians, and cyclists. Safety standards for operating systems try to avoid crashes and to reduce impact speeds when accidents occur."[31] The parallel but interrelated pursuit of these two sub-systems (crashworthiness and operating), and their unity in a "total vehicle system," was the operational strategy of the NHTSA ESV research program.

The program, however, was established not only to meet, through improved efforts in research and development, extant NHTSA regulations through the production of experimental safety vehicles, but the program also sought to influence

the establishment of new safety regulations which may be applied to the mass market vehicle. According to the General Accounting Office,[32] the great failure of the ESV program was NHTSA's inability to apply program results to the formulation of new or improved safety standards. At the heart of this failure lay, the GAO claimed, at least four contributing factors: 1) ESV prototypes demonstrated higher levels of safety performance than required by NHTSA, buy NHTSA's Research and Developmemt Office had not made "the necessary analyses of test results to identify achievements that could be applied to safety standards. Instead, the Office's efforts focussed on determining whether the prototypes met performance specifications and on optimizing these specifications toward the planned fabrication of additional vehicles;" 2) NHTSA did not have a coordinated program plan for establishing safety standards which delineate the research requirements for each standard, nor did it have an efficient mechanism by which periodic updates of the plan could be made possible;[33] 3) a review of selected research findings showed that many years had elapsed between the completion of ESV-related projects and the formulation of safety standards; NHTSA lacked the procedural speed necessary "to insure that the results of motor vehicle safety research and development projects [were] promptly used to support new or improved safety standards;"[34] and 4) the ESV program directed itself toward the design and production of a relatively large, family-sedan type vehicle--the very rapid and apparently unforeseen shift from such vehicles to the more compact "economy" type automobile, made such research inappropriate.

The National Highway Traffic and Safety Administration was not unaware of the deficiencies of the ESV program. By 1974 it actuated an important directional change focussing on a broader, more technically (though not administratively) ambitious concept with an extended time frame--that of the Research

Safety Vehicle (RSV). "The objective of the Research Safety Vehicle project is to provide research and test data applicable to automobile safety performance requirements consistent with environmental policies, efficient energy utilization, and consumer economic considerations."[35] Unlike the ESV program, which sought incremental safety-related changes through support of improved safety hardware, the RSV is a program designed to operationalize a whole systems approach to automobile design. Accordingly, it is recognized by both NHTSA and RSV contractors that in the performance of RSV related research and development tasks, contractors may introduce considerations and factors not currently utilized or applied in NHTSA standards for automobile safety, while many factors extending well beyond a strict consideration of safety are to be investigated. As such, the RSV program is a decidedly advanced state-of-the-art project which seeks to provide major input for developing new safety standards for the 1980's, including damagability requirements conceived under the Motor Vehicle Information and Cost Savings Act. It does not, however, like its precursor (the ESV), attempt to influence near-term design changes for mass market vehicles.

The overall RSV program is being implemented in a series of four successive and distinct phases which take the following summary form. Phase I: Begins with program definition, by identifying ranges of vehicle characteristics suitable for an automobile that could be introduced by the mid-1980's, taking into account causal accident factors, auto usage trends, driver population trends and materials shortages. During Phase I (which officially began January 18, 1974) these data are being used to develop acceptable ranges for automobile characteristics, including dimensional estimates, vehicle system characteristics, and productability factors. A candidate vehicle made by the Chrysler

Corporation was selected to provide "a concrete basis" for further evaluation, while preliminary design is currently undergoing advanced change. The final part of Phase I calls for the development of a proposal for Phase II. Phase II: Begins only after the successful completion of Phase I, and consists of three interrelated parts--the performance of systems engineering and integration analysis, the development of a total vehicle design, and finally, the development of a proposal for Phase III. Phase III: Consists of two stages--the refinement and optimization of vehicle design established in Phase II, and the fabrication of test vehicles. Phase IV: Is scheduled as the final stage in the RSV program, intended to test and evaluate vehicles (anticipated to be competitively awarded to a contractor other than those who may be awarded either Phase I, II, and III).[36]

Calspan, contractor for the program, cites figures presented in the 1968 National Personal Transportation Study, and reported that it foresees no short-term alternatives "to the passenger vehicle domination of the transport scene"--a full 92% of all "person trips" were taken via automobile, taxi, or truck, while only 8% of such trips were taken via mass transit, schoolbus, motorcycle or airplane.[37] Because of this finding and an expected greater emphasis on conservation and efficiency, it is believed that future automobiles will be designed "more in relation to mission rather than apparent current American practice of emphasizing appearance, style, status, etc."[38] It is believed that this trend will result in essentially two basic automobile types--the family car, and cars designed for individual purposes such as shopping, commuting, etc. The development of either of these two basic vehicle types will be pursued during Phases II and III, although it is presently believed that the family type vehicle (seating 4-5 persons) will receive priority.

To be a viable program and provide impetus to mass market motor vehicle design, the RSV project is intended to produce a vehicle which is basically compatible with automotive mass production methods. The major requirement satisfied by the Chrysler base vehicle was that it not exceed 2500 pounds in weight, and that it be able to seat five. In addition, Phase I findings indicate that as recycling is the key that best resolves that materials shortages forecast by Calspan for the next 25-50 years, the following hypotheses will be taken into RSV production consideration: 1) A high automobile replacement rate is consistent with the necessity for a continuously improving fuel economy and associated weight reduction; 2) a high replacement rate is consistent with evolving engine technology; 3) recoverability of resources should be an automobile design consideration; 4) it is appropriate to consider recycling technique improvements as a legitimate part of the energy/ecology/economy/safety system; and 5) radical departures from current material usage practices in automobiles could lower resource recovery efficiency.[39]

The major "developmental effort" envisioned for the RSV is in the domain of safety, particularly crashworthiness. A soft face bumper concept which will improve damagability as well as provide pedestrian protection will be employed, while the bodily structure directly behind front and rear bumpers will provide energy dissipation during collisions. As of June, 1975, it was not known what type of primary restraint system would be utilitzed, although it was certain that lap belts would be essential, either with or without air bags.

At this time it is not possible to evaluate the progress being made in the technical developments of RSV's. It is clear, however, that the program has received much greater care in its formulation and inception than that of its precursor, the ESV.

3.2 The Air Bag

Along with direct government R&D support (as with the ESV) regulatory mandate has served as a catalyst for technological advance in automotive safety. The case of the air bag is perhaps the most interesting example. The profound complexity of the air bag issue, however, both as a technological quandry and as a potential imposition on the consumer-driver's life-space, has created more problems than it has solved. Today, at least nine years after the development of the device, the "great air bag debate" continues.

The modifications of FMVSS 208 promulgated on October 1, 1971, required a "passive restraint" system for all automobile occupants in all seats, effective August 15, 1975. Although this standard has since been repealed, or rather delayed (as litigation and recent hearings have led both industry and government to believe), the automobile industry and in particular air bag suppliers, have expended great effort in perfecting the air bag apparatus.

The occupant restraint system is the most important element of the crash injury reduction system.[40] Unless vehicle occupants are somehow restrained, it is impossible to prevent serious injury even in relatively low-speed collisions. Restraint systems are classified as either active or passive. An active system, such as the seat (lap) belt, requires (by definition) some action or initiative on the part of the occupant, while the passive system requires no action by the occupant(s)--it deploys automatically under crash conditions. The air bag is the most prominent example of a passive restraint system.

"A restraint system should be designed to minimize the crash-induced peak deceleration force on the occupant. Ideally, the restraint system should

utilize the available distance between the occupant's seated position and the internal structure to decelerate the occupant, absorb his kinetic energy, and prevent his striking the structure with injurious force."[41] In order to accomplish this, the air bag must be rapidly deployed after an initial crash impact. This rapid deployment implies a number of problems, some technological and some socio-economic. The technological problems arise out of the complexity of the device with "triggers" air bag deployment:

> Porous cloth bags, normally folded and in containers in front of automobile occupant positions, are connected to manifolds through which nitrogen or other gases can be admitted. Nitrogen is stored at about 2000 pounds pressure in flasks that are connected to the manifolds; in addition, pyrotechnic gas generators are provided as supplementary sources of gas to the manifolds. Sensors, which are expected to be integrating accelerometers, are provided to determine whether an impact of potentially serious magnitude occurs. When an impact above threshold is sensed, valves are activated to release the stored nitrogen into the bags and, when the impact magnitude exceeds a second, higher threshold, the pyrotechnic gas generators are also fired.[42]

The air bags are then filled with gas and deploy abruptly in front of the vehicle occupants to cushion them and prevent them from striking the vehicle interior. The entire process of sensing and inflation must take place in about 55 milliseconds to protect occupants in a 30 mile-per-hour crash, as required by FMVSS 208.[43] Aside from the inherent complexity of the device itself additional problems occuring with sudden deployment are: 1) the creation of pressure levels strong enough to spring doors and back windows, and 2) the accompanying sound levels which may be injurious to occupants; seat belts would still have to be worn.* Other technological problems associated with use of the air bag are

*An additional observation to be made is that the air bag itself cannot provide adequate side-impact and rollover protection, despite technical compliance with FMVSS 208.

the following: 1) out-of-position occupants would not be protected; 2) braking prior to impact may thrust occupants forward and restrict deployment; 3) the out-of-position child remains especially unprotected by the system; 4) in side impact, intrusion could occur before, and interfere with air bag deployment; 5) the air bag could not reasonably be deployed below 10 M.P.H., a speed at which serious injury may still take place; and 6) "inadvertent" actuations of the air bag could be hazardous.[44]

Especially problematic to production is insuring a system of quality control and reliability. One industry specialist has pointed out that even if 99.4% of all air bags did prove reliable, 66,000 automobiles per year would have defective equipment.[45] This last "technological" problem brings us into the realm of the socio-economic--lack of quality control and reliability, which has created a great fear among manufacturers of liability suits. This problem has already surfaced and is plaguing a program established by General Motors, whereby automobile buyers paid at their own option to have air bags installed in select new car models. Thus far four lawsuits among manufacturers have actually been filed, the most prominent of which is an $8.3 million suit filed by a Buick owner who alleges his air bag did not inflate in a near-fatal collision.[46] Ten other lawsuits involving air bags are under consideration, with plaintiffs trying to get out-of-court settlements. The ratio of law suits to air bag deployments is so high that continuation of the option has been ruled out by G.M.[47*]

Other socio-economic factors which even further heighten the complexity of the air bag issue are: 1) were the yearly fleet of new automobiles to be completely air-bag-equipped, the junking of worn-out automobiles would involve safely de-

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*As of 1976, there have been approximately 60 air bag deployments and about 12,000 sold.[48]

tonating or otherwise disposing of the air bag activators--an expensive and hazardous enterprise; 2) the cost of the air bag system is high--somewhere between $100 and $348;[49] 3) the potential benefit of the air bag system, using the "optimistic" predictions by NHTSA, is substantially less than the potential benefit (as established) by experimental evidence) of 100 percent usage of the three point harness system.[50]

In May, 1975, NHTSA held its most extensive hearings on the air bag issue. In five days more than fifty witnesses were heard. The automotive industry remained, as it has for the past six years, adamantly opposed to the latest NHTSA suggestion that passive restraints be included in all automobiles, effective 1977, while air bag suppliers, the insurance industry, Ralph Nader, and former G.M. vice president John DeLorean urged NHTSA to mandate the air bag. General Motors, which again publicized the failure of their own optional air bag program, was the principal party to testify against such a mandate. Intense as these hearings were, conclusive evidence as to the desirability of mandating the air bag was not received. Secretary of Transporation William T. Coleman could only propose yet another one-year extension of the requirements of the present standard.

4. PRELIMINARY ANALYSIS

In light of evidence presented in the foregoing two sections of this paper, it is necessary to analyze the role of NHTSA as a federal regulatory agency with respect to its treatment of the ESV program and of the air bag. Rather than presenting a series of post facto alternatives, the writer would like only to point out some of the salient characteristics of the regulatory system, as it did behave.

4.1 The Safety Vehicle Programs

1) From its inception, the ESV program lacked a clear definition of its costs, its lifespan, and most importantly, its goals. Did it, or did it not intend to influence motor vehicle safety standards? While the program claimed this as one of its fundamental goals, such an attempt was never clearly made. Whether program results could yield applicable information is questionable. as the program was geared not toward the marketable utilization of findings and improved hardware, but toward a superior technological exemplar.

2) Whether it be from lack of systematic analysis or bureaucratic/human oversight, the ESV project was unable to take into account the critical shift toward smaller cars, publically cited by NHTSA as perhaps the most crucial factor in the termination of the program. Again, as the program's functional direction was one which aimed at the design and assembly of a super vehicle, it did not adequately examine the whole constellation of macro socio-economic factors (including public opinion) which inevitably influence the outcome of such projects.

3) The program was unable to adequately and imaginatively evaluate the advances that were forwarded by the ESV program in the making of federal

regulatory law. While NHTSA officials were concerned with the application of research findings to public safety, the sentiment was not so salient among ESV technicians and engineers. This disparity of concerns among the principal actors involved (administrators and technicians), led to discontinuities in the translation of technological change into regulatory mandate.

4) As expressed in the RECAT report prepared for the Office of Science and Technology, there was a lack of procedural coordination between the regulatory and research arms of NHTSA. This lack of coordination created a great time lag between the completion of experimental research and its review for potential utilization and application by the regulators at NHTSA.

NHTSA was not unaware of the difficulties which arose during the course of the ESV program. Its reaction to such failure was one of tacit recognition, followed by early abandonment of the project. The object-lesson was costly, but NHTSA successfully made the transition to a broader, more meticulously planned concept, that of the RSV. While the ESV program lacked self-evaluation, the RSV phase-by-phase plan is replete with self-evaluation mechanisms. Impetus toward the creation of the potentially promising RSV grew only out of the apparent failure of its precursor.

4.2 The Air Bag

1) Over six years ago, in its evaluation of the air bag as a system of passive restraint, an Arthur D. Little report stated "The concept is interesting but must be developed further before its practicability can be determined. A passive restraint system, one that requires no action on the part of the occupants, may be a necessity if seat belt usage, as indicated by various studies,

does not increase significantly."[51] The call for more research has been the shibbolith of those for and against the device, six years ago and today. While automobile industry spokesmen claim that use of the device as currently developed would be irresponsible--real fleet data is sorely needed--NHTSA officials seem ready to accept the device as is. Yet they too concede that more "real" data is needed. When will such data be collected and evaluated, and why was preparation for the collection of such data not made in 1974 or 1975 when the FMVSS 208 mandate was postponed and hearings held?

2) Rather than encouraging rapid technological development of the air bag through monetary or other incentive; NHTSA sought technological development through the promulgation of standards which required technological advance. In effect, this legally mandated requirement was not encouraging, but coercive. By mandating FMVSS 208, NHTSA naively felt it could speed up technical accomplishment. This did not occur.

3) NHTSA actually did promulgate regulations requiring passive restraints, when in fact experimental evidence was inconclusive and almost completely lacking. Had not litigation prevented the regulation from coming into effect, hazardous and irresponsible conditions might have ensued.

4) While advocating use of the air bag system, NHTSA ignored its own cost-benefit analyses which showed the three-point harness system to be a) equally if not more safe, b) more reliable, and c) more cost-effective.[52] One crucial problem it seems is that there is insufficient experimental evidence to establish the true efficiency of the air bag system in preventing automobile fatalities and injury--and at the same time, NHTSA has neglected to make provision for the obtainment of such evidence.

5) As if Congressional and citizen outcry over the starter-interlock had not occurred, NHTSA had ignored questions of public opinion. Until June, 1976, prior to the release of Secretary Coleman's untitled Department of Transportation report,[53] consideration of philosophical problems concerning consumer freedom of choice played no official role in NHTSA's decision to mandate passive restraints (i.e., the air bag).

At least in the ESV safety vehicle domain, NHTSA has made substantial accomodation to the tacit recognition of failure. In the domain of the air bag, however, vivid memories of the starter-interlock debacle remain, and administrators are operating with a necessary modicum of caution. Importantly, public opinion will now be considered.[54]

NOTES

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